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An Australian Cost Curve for Greenhouse Gas Reduction

McKinsey&Company

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McKinsey & Company has worked with leading institutions and experts over the past 2 years to develop an understanding of the costs and potential of different options for reducing greenhouse gas emissions—first at a global level, then through country-specific analyses including efforts in the UK, the US and Germany. This report presents the Australian perspective. It links environmental with economic outcomes in a way that allows fact-based decision making on the most efficient means of reducing the nation's greenhouse gas emissions as we transition to a carbon-constrained economy.

Emission-reduction measures have been evaluated both for their potential impact on avoiding greenhouse gas emissions in 2020 and 2030 and their associated implementation costs. It is not expected that this analysis will be the final word on how to reduce emissions or meet targets; rather it should be understood as a factual basis upon which to guide Australia's policy choices and inform business leaders on an effective response to the challenge of climate change.

We would like to thank our team of co-authors Liana Downey, James Slezak, Jonathan Michael and Alex Wonhas—as well as the many others who made valuable contributions to this work.

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An Australian Cost Curve for Greenhouse Gas Reduction

INTRODUCTION

Australia's recent ratification of the Kyoto Protocol forms a binding commitment to stabilise greenhouse gas (GHG) emissions at 108 percent of 1990 levels by 2012. Failure to do so will have real consequences in the upcoming commitment periods, and current projections indicate that Australia will need to strengthen its efforts to meet this target. Furthermore, the growing consensus among scientists, policy makers and business leaders is that the challenge of climate change is real and increasingly urgent, and that further proactive measures must be taken beyond 2012 to prevent a drastic change in the global climate. Given this, it is likely that we will see more stringent targets for all Kyoto members (eg 25–40 percent below 1990 levels by 2020).

This raises important questions for policy makers and business leaders in Australia. In particular, how can short-, mid- and long-range targets be met while limiting the impact on the Australian economy? Today, policy makers are investigating the best mechanisms to enable this change. Many business leaders are rightly focused on exploiting the commercial opportunities created by this change while maintaining national and international competitiveness. Given this, government and business together with the broader public stand to benefit from a thorough understanding of the GHG abatement potential in Australia and the relative cost of available opportunities.

This report addresses the questions of 'how much, when, and at what cost?'. It is divided into the following sections:

- Summary of findings
- Overview of the modelling approach
- Overview of abatement measures by sector
- The Australian greenhouse gas abatement cost curve
- Economic impacts and scenarios
- Implications for Australia
- Conclusion.

The follow-up question 'how do we make this happen?' is not the focus of this report.

SUMMARY OF FINDINGS

A significant reduction in Australian GHG emissions is achievable—30 percent below 1990 levels by 2020 and 60 percent by 2030 without major technological breakthroughs or lifestyle changes. These reductions can be achieved using existing approaches and by deploying mature or rapidly developing technologies to improve the carbon efficiency of our economy. They require significant changes to the way we operate in key sectors, for example, changes in our power mix, but can be achieved without major impact on consumption patterns or quality of life.

Reducing emissions is affordable—with an average annual gross cost of approximately A$290 per household to reduce emissions in 2020 to 30 percent below 1990 levels.[1] This compares to an expected increase in annual household income of over A$20,000 in the same time period. Such a reduction would require implementing all opportunities with a cost of A$65 or less per tonne of carbon dioxide equivalent (CO_2e), at a gross cost to the Australian economy of approximately A$2.9 billion per year in 2020. Although the marginal cost of the required abatement will be A$65 per tonne CO_2e, a large share of opportunities represents net savings to the economy. We estimate that by 2020, almost 80 Mt, or 25 percent of the total reductions potential, can be realised with positive returns. Most of these positive-return (or 'negative-cost') opportunities are energy-efficiency measures related to improvements in buildings and appliances. Many can be categorised as market failures arising from misaligned incentives, for example, those between builders and tenants, where it benefits the tenant but not the builder to install insulation or energy-efficient lighting. For 2020, the remaining 75 percent of opportunities examined have a volume-weighted average cost of ~A$45 per tonne of CO_2e. For 2030, almost 20 percent of the measures examined present net economic benefits, with the remaining 80 percent having a volume-weighted average cost of ~A$40 per tonne of CO_2e.

Achieving significant emissions reductions requires prompt action from government, business and consumers. To unlock Australia's emissions-reduction potential we recommend that the Federal Government take three key steps: set an aggressive but realistic GHG reduction target for 2020; accelerate the implementation of an integrated set of policies; and proactively support the global framework. The policies should include rapid pursuit of negative-cost opportunities through regulation and incentives, fast-tracking the commercialisation of key technologies, accelerating effective information campaigns to drive changes in consumer behaviour, and establishing an integrated national scheme to motivate carbon reduction while maintaining the competitiveness of key industries. Participating in the global framework will involve supporting existing initiatives such as the Clean Development

1 All costs in this document are expressed in 2007 Australian dollars. Average household costs are based on extrapolations using Australian Bureau of Statistics forecast growth rates.

Mechanism, part of the UN Framework Convention on Climate Change (UNFCCC) process. These mechanisms will enable Australia to access cheaper abatement opportunities available internationally. Business in turn will need to aggressively reduce its own carbon footprint, pursue new carbon-related business opportunities and constructively contribute to the policy debate, ensuring that long-term thinking underpins its strategic response. Consumers will also need to understand the imperative, identify and act upon their individual opportunities to reduce emissions, and maintain pressure on government and business to accelerate progress.

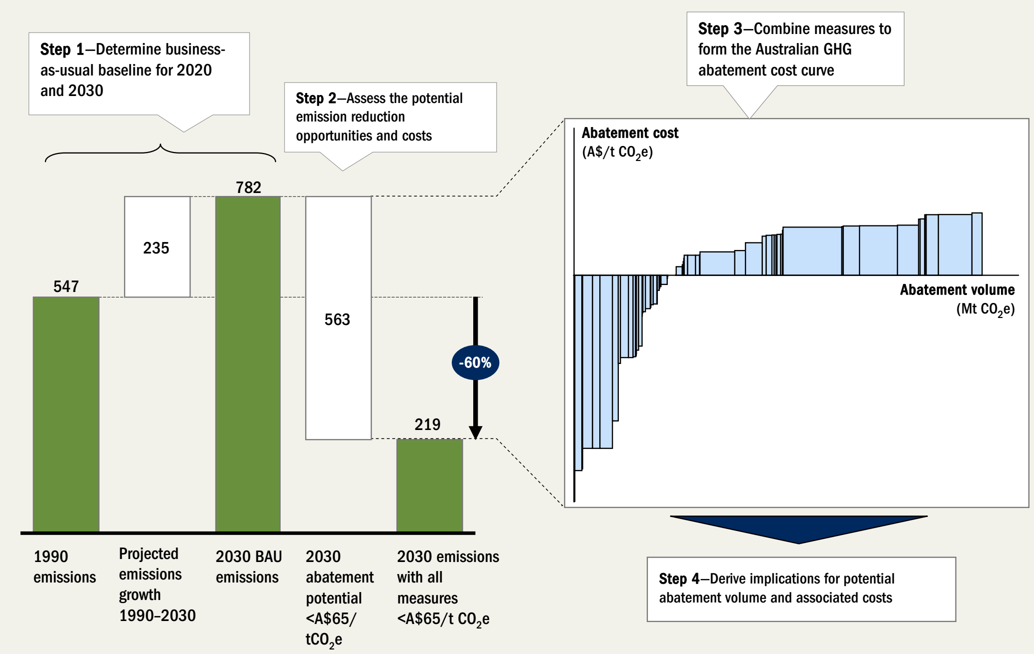
OVERVIEW OF THE MODELLING APPROACH

To arrive at these conclusions, the costs and abatement potential of more than 100 abatement measures across six industry sectors have been analysed using a four-step process (Exhibit 1). First, a 'business-as-usual' baseline was determined for current and future emissions. Second, a range of emissions-reduction opportunities was identified and fact-based estimates were made of the costs and potential abatement volume presented by each opportunity. Third, these costs and volumes were combined to form the Australian GHG abatement cost curve. The fourth and final step was to analyse the impact of likely regulatory and technological scenarios on the costs and abatement potential, and quantify the likely economic implications for Australia.

Exhibit 1

The Australian greenhouse gas abatement cost curve was developed in a 4-step process

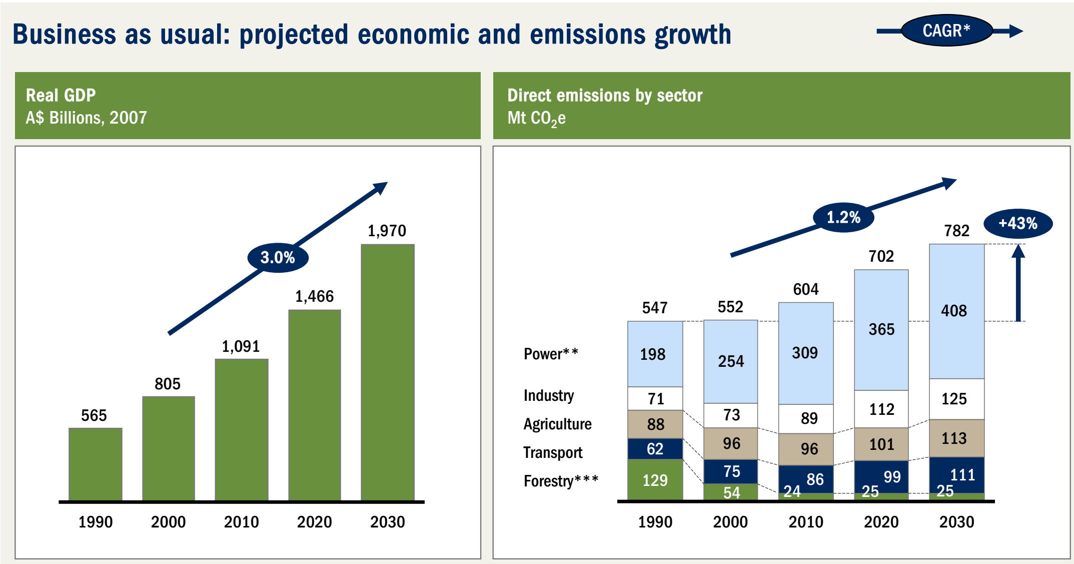
Mt CO_2e/year



Source: McKinsey Australia Climate Change Initiative; Australian Department of Climate Change

Step 1: A business-as-usual baseline was determined using Department of Climate Change projections for 2020. For 2030, these projections were extrapolated using assumptions and methodology consistent with the Department's approach. These forecasts represent the emissions trajectory that would occur under present trends and with all government policies in place as of 2006, but with no additional efforts made to address climate change; so for example, the new Federal Government's policy to increase national mandatory renewable energy targets (MRET) is not included in the baseline. Emissions are forecast to grow substantially under current trends to 702 Mt by 2020, or 28 percent above 1990 levels, at a rate of 1.2 percent per year (see Exhibit 2). This compares to a projected economic growth rate of 3.0 percent, meaning that the carbon intensity of the economy (ie the economic output per unit of carbon emissions) will continue to decline, consistent with the standard long-term trend resulting from business-as-usual economic development. This trend is driven by the relative growth of the services sector and other business-as-usual decarbonisation effects. Australia's emissions are projected to continue growing at a similar rate through to 2030, rising to 782 Mt, or 43 percent above 1990 levels.

Exhibit 2



* Compound Annual Growth Rate, 2000–2030
** Direct emissions from the power sector can also be regarded as indirect emissions from downstream power-consuming activities (eg power use in the building and industry sectors)
*** Net emissions after subtracting growth in carbon sinks (eg new plantations) from emissions due to land clearing; Kyoto accounting method used
Source: McKinsey Australia Climate Change Initiative; Australian Department of Climate Change; Australian Bureau of Statistics

This baseline accounts for direct emissions—thus the power sector includes all emissions from power-generation activities, regardless of the downstream end user of the power.

Step 2: Potential emissions-reduction opportunities and costs were assessed. We looked at a range of abatement opportunities including renewable energy sources, alternative fuels, energy-efficiency measures and new technologies, to examine ways that GHG-generating activities can be replaced by emissions-reduced or 'carbon-neutral' alternatives. The scope of the measures considered were those requiring deployment of present-day technologies, as well as a limited number of maturing emerging technologies. Speculative technologies or those requiring significant future breakthroughs were not included in the scope, nor were those requiring any significant lifestyle changes. For example, fuel substitution and improved efficiency in private vehicles was in scope, but promotion of public transport or bicycle riding to replace those vehicles was not. Similarly, efficiency in residential air conditioning was in scope, but reduction in the use of air conditioning was not.

Although we considered a wide range of abatement opportunities, we concentrated on measures with abatement costs up to A$65 per tonne CO_2e (corresponding to approximately €40), since this is the range in which reliable research and information has been developed both locally and globally.

For each opportunity analysed, the abatement cost is taken to be the additional cost to society of implementing the opportunity compared to the cost of the activity that would otherwise occur in the business-as-usual case. For example, the abatement cost of wind power is driven by the additional generation cost over and above the average generation cost of power assets in the business-as-usual case, as well as by the quantity of emissions that can be avoided with each unit of wind-energy production. These costs are modelled on a full cost basis over the lifecycle of the asset or opportunity. It is important to note that we do not make any assumptions about who bears these incremental costs. Whether they are subsidised by governments, passed through to consumers or paid for by businesses, we assume that the underlying economic cost remains the same.

While these are likely to constitute the vast majority of costs to the Australian economy, they do not include difficult-to-quantify transactional costs, such as the management time required to implement such changes. Furthermore, they are gross costs, that is, we have not built in the likely cost of a 'do-nothing' scenario, such as the costs induced by a decline in agricultural production or the destruction of the Great Barrier Reef. Nor have we attempted to quantify anticipated value creation in the economy through the pursuit of new business opportunities. Opportunities involving lifestyle or behavioural shifts were out of scope not because they are undesirable, but because their costs or benefits are largely non-financial and thus difficult to quantify. In fact, many of these out-of-scope shifts may be attractive and some are likely to occur automatically in response to carbon price signals in the economy. It is our belief that on balance, our modelling is conservative given the likely combination of negative and positive impacts from the aforementioned factors.

The volume of each initiative is its potential to reduce greenhouse gas emissions. This has been estimated as a 'technical' potential and is not a forecast, but rather an estimate of what is deemed feasible in the timeframe of the cost curve. Volumes are sensitive to the order of implementation, since, for example, energy demand reduction initiatives reduce the total amount of energy produced, and hence the additional abatement potential of the power sector.

Analysing the in-scope measures involved making a range of assumptions, including power capacity forecasts, expected learning curves and initial generation costs. Where applicable we tailored the insights from McKinsey's global studies for use in the Australian context (eg global capital investment costs and learning curves are assumed for onshore wind and solar photovoltaic). Thus, our assumptions are consistent with recent McKinsey global studies, as well as those undertaken in the UK, the US and Germany. These assumptions have been reviewed by scientists, academics and industry. Where possible, unique Australian considerations (such as the potential for geothermal power penetration, or for increased effectiveness of solar-photovoltaic assets due to local sunshine intensity), have been factored into underlying cost and volume calculations. Our assumptions were also guided by a range of existing publicly available documents, detailed in Appendix B to this report. While the Australian team did not undertake a bottom-up analysis of every abatement measure, we believe this work provides a robust fact base from which further sectoral analyses may be built.

The emissions-reduction opportunities considered were both direct and indirect. The power sector (along with forestry, agriculture and transport) primarily produces direct emissions from its production activities. Abatement opportunities in the building sector, however, represent the potential to reduce energy demand, for example, through better insulating homes to require less heating. These are regarded as indirect abatement opportunities. Almost all opportunities considered in the building sector, and a significant proportion of those in the industry sector, are indirect. If implemented, they would reduce the power sector's direct GHG emissions.

Step 3: Measures were combined to form the Australian greenhouse gas abatement cost curve. The various abatement measures were ordered from lowest to highest cost, adjusted to eliminate double counting, and their costs and volumes plotted to form the Australian greenhouse gas abatement cost curves for 2020 and 2030.

Step 4: Implications for total potential abatement volume and associated costs to the economy were derived. We used the cost curves for 2020 and 2030 to calculate the abatement levels achievable and the associated cost. We modelled the likely costs of the range of reduction targets proposed by the Intergovernmental Panel on Climate Change, and currently the subject of international negotiations. We also calculated the cost per household, as well as the total gross cost to Australia for achieving the stated emissions reductions.

Using this fact base, we extracted insights to form high-level recommendations for government, business and consumers. We reiterate, however, that the intent of this report is to answer the question 'what is possible when, and at what cost?' Further work is required to give more detailed, sector-specific answers to the question 'how do we make this happen?'

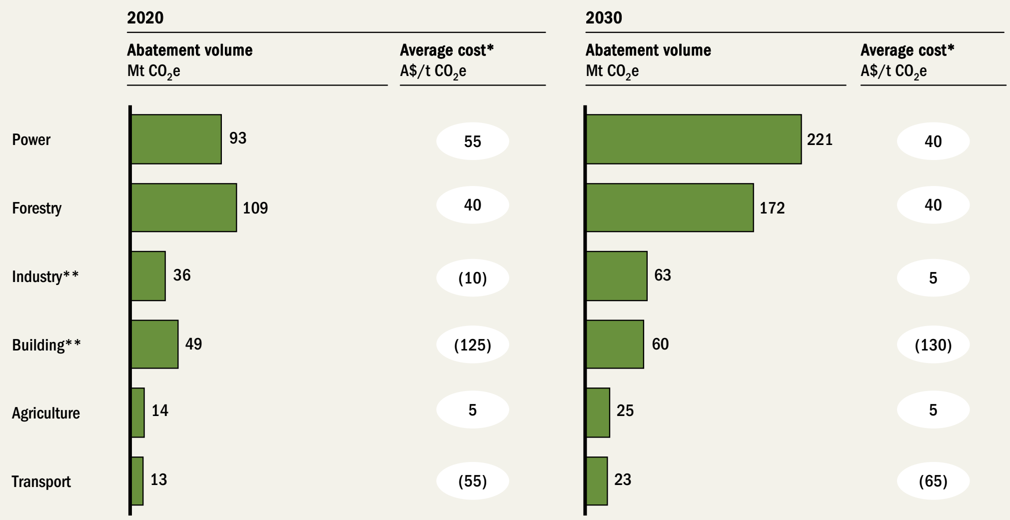
OVERVIEW OF ABATEMENT MEASURES BY SECTOR

We analysed abatement opportunities grouped into six industry sectors: power, forestry, industry, building, agriculture and transport. We identified significant opportunities in each of these sectors to contribute to the reduction of GHG emissions, and investigated large numbers of abatement opportunities within each sector. This section provides an overview of the most significant opportunities by sector in 2030.

By 2030, power offers the greatest volume of abatement potential, at 39 percent of the total, followed by forestry with 31 percent, and building and industry with 11 percent each. In 2030, the building sector has the lowest average cost opportunities at a net benefit of A$130 per tonne CO_2e, followed by transport at A$65 per tonne CO_2e, and industry and agriculture at a net cost of A$5 per tonne CO_2e (see Exhibit 3).

Exhibit 3

Emissions reduction opportunities and cost by sector



* Volume weighted costs to the economy—does not necessarily represent loss of profit to individual businesses
** Opportunities in the building sector, and a proportion of those in industry, are measures to reduce energy demand and thereby indirectly reduce emissions in the power sector
Source: McKinsey Australia Climate Change Initiative

Within the power sector, significant abatement opportunities are in carbon capture and storage (CCS) for coal and gas, onshore wind and geothermal. The large size of the carbon capture and storage opportunity is driven by substantial coal-fired power generation in Australia today (approximately 75 percent of production). While CCS is currently in its technological infancy, it is a rapidly developing technology. Our assumptions have been guided by the best available views on its viability and likely learning curve, but significant uncertainty remains. We have modelled a significant uptake of CCS only by 2030. We assume a penetration of under 10 percent of coal-fired energy production in the preceding decade, predominantly at test sites and through retrofitting of newer plants located near suitable geological features. In our base scenario we assume that the technology matures successfully, so that by 2030, two-thirds of coal-fire power plants in operation employ CCS technology. Given that around half the plants operating today will have reached the end of their usable life by that point, this may not require early retirement of any assets.

Onshore wind is currently the most cost-effective of the renewable-energy technologies after hydroelectric power. Unlike hydroelectricity, which we assume cannot feasibly be expanded, onshore wind capacity in Australia has room to grow. Barring major technological breakthroughs in other areas, it is expected to remain relatively cost-competitive through to 2030, by which point we assume it has the potential to capture over 15 percent of energy production. We have assumed that **offshore wind** will not gain significant market share by 2030. Although it can benefit from greater wind intensity, capital and maintenance costs are higher, and providing access to the existing grid is cost-intensive.

Geothermal power generation is a rapidly maturing baseload technology that offers significant abatement potential in Australia if successfully deployed. In the Australian context, this opportunity predominantly relates to the use of hot dry rocks. In our base scenario we assume that geothermal energy production is successful in Australia, ramping up from 2010 to 2030 to supply just under 8 percent of the country's energy production by 2030.

In contrast to our overseas studies, we have excluded **nuclear power** from the Australian cost curve. This is because it appears highly unlikely that regulatory approval would be granted to build such a facility by 2020, and because political and environmental considerations, rather than economic ones, will drive this decision in future years. Since nuclear technology is nonetheless relevant and within the scope of our model, we have assessed its impact in an alternative scenario (see section titled 'Economic Impacts and Scenarios').

Opportunities in the **forestry sector** account for over 100 Mt of abatement by 2020, and over 170 Mt by 2030, driven by very high historic rates of land clearing in Australia. Although these rates are declining, the Department of Climate Change projects that land clearing will continue to account for 45 Mt of CO_2 emissions per year in the foreseeable future, mitigated in part by 20 Mt sequestered in managed forests and plantations (these estimates form part of the business-as-usual baseline). **Avoiding deforestation** in Australia is a large, immediate and perishable opportunity to reduce

GHG emissions. In addition, the quantity of land that has previously been cleared presents large opportunities for **replanting**, for example, on marginal crop and grazing land, and is a relatively cost-competitive abatement measure.

The **industry sector** accounts for more than 60 Mt of opportunities in 2030. Significant opportunities lie in improving electric motor efficiency and reducing fugitive emissions of methane from natural gas production and the mining of black coal. Methods of improving the efficiency of **electric motor-drive systems** include the use of control mechanisms more sensitive to variations in load, which are thus more energy efficient. Abatement measures for **fugitive methane emissions** include recovering methane from mines, and replacing or upgrading those technologies which account for significant quantities of methane leakage in their normal practice. Many abatement opportunities in the industry sector represent net gains to the economy, reflecting the fact that they are often efficiency improvements or reductions in the waste of useful gases.

By 2030, a total of 60 Mt of carbon-reduction opportunities can be found in the **building sector**, all at low or negative cost. Most of these opportunities (~50 Mt) will be available by 2020 and many can be implemented today. Significant opportunities include improving **commercial air handling, air conditioning** and **residential water-heating systems**. Australia's relatively low level of insulation creates significant opportunities for increased energy efficiency in residential and commercial buildings. Other major areas of opportunities include reducing energy consumption through improvements in **lighting** and mandating that appliances have energy-efficient **stand-by features**. Many of these efficiency measures are 'perishable'—once a building is complete, it is generally much more expensive to retrofit. Two of the key levers here are better aligning tenants' and developers' incentives to improve energy efficiency, and using direct regulation to establish appropriate building codes and standards.

The **agriculture sector** accounts for 25 Mt of greenhouse gas abatement opportunities in 2030. The main opportunities in agriculture are changes in tillage, improved fertilization techniques and methane capture from landfills. The use of conservation tillage—the cultivation of soil with reduced or no ploughing prior to planting—helps reduce losses of atmospheric CO_2 by ensuring residual plant matter (which has sequestered CO_2) stays in the topsoil. Additional benefits of conservation tillage include a reduction in soil erosion and improvement in water quality—both important side benefits for Australia. Improvements in livestock feed can also reduce methane emissions at a relatively low cost while also improving agricultural efficiency.

Technical greenhouse gas abatement measures in the **transport sector** account for 23 Mt of potential emissions reduction by 2030, 95 percent representing net economic gains. The primary opportunities identified are in biofuels and increased fuel efficiency. **Fuel efficiency** is likely to be driven by technology improvements, such as reducing vehicle weight, improving aerodynamics and engine temperature management, and the treatment of exhaust fumes at the source to reduce emissions. Abatement will also result from the application of electric plug-in technologies to commercial vehicles, such as heavy and medium trucks, buses and mini buses. Plug-in hybrid vehicles offer longer term potential if performance improves and Australia's electricity supply becomes less carbon-intensive. In addition to the technical measures considered in this study, large opportunities would be expected from the promotion of structural shifts in the transport sector, such as increased investment in public transport, and increased use of freight rail; however, these opportunities are outside the scope of our analysis.

THE AUSTRALIAN GREENHOUSE GAS ABATEMENT COST CURVE

Aggregating these opportunities in the form of a cost curve allows for analysis of the potential for emissions reductions in Australia at a given point in time. The cost and potential volume of each opportunity is plotted left to right in order from lowest to highest cost to form the Australian greenhouse gas abatement cost curve, shown for 2020 and 2030 in Exhibits 4 and 5 respectively.

Exhibit 4

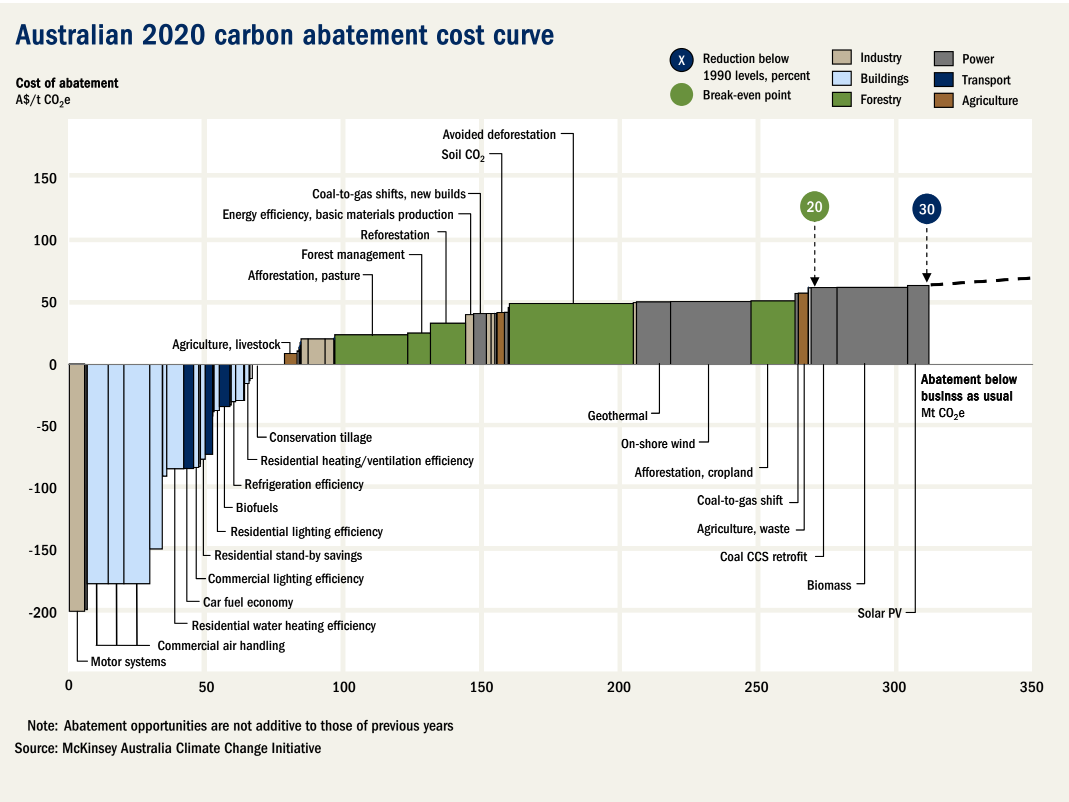
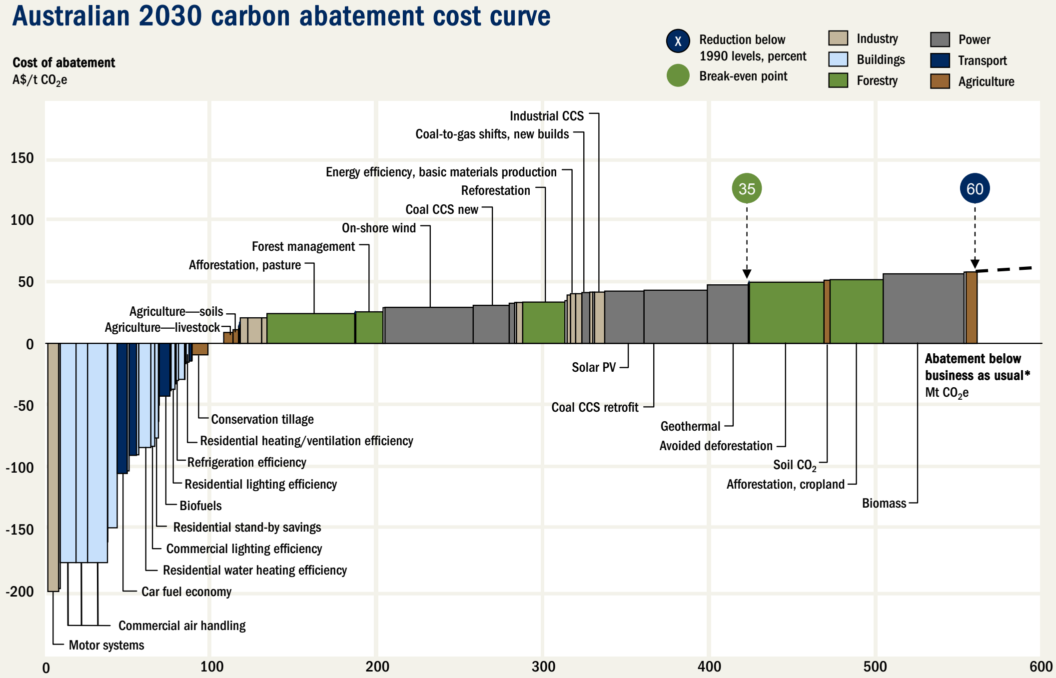


Exhibit 5

Australian 2030 carbon abatement cost curve



Note: Abatement opportunities are not additive to those of previous years
Source: McKinsey Australia Climate Change Initiative

These cost curves suggest three major conclusions:

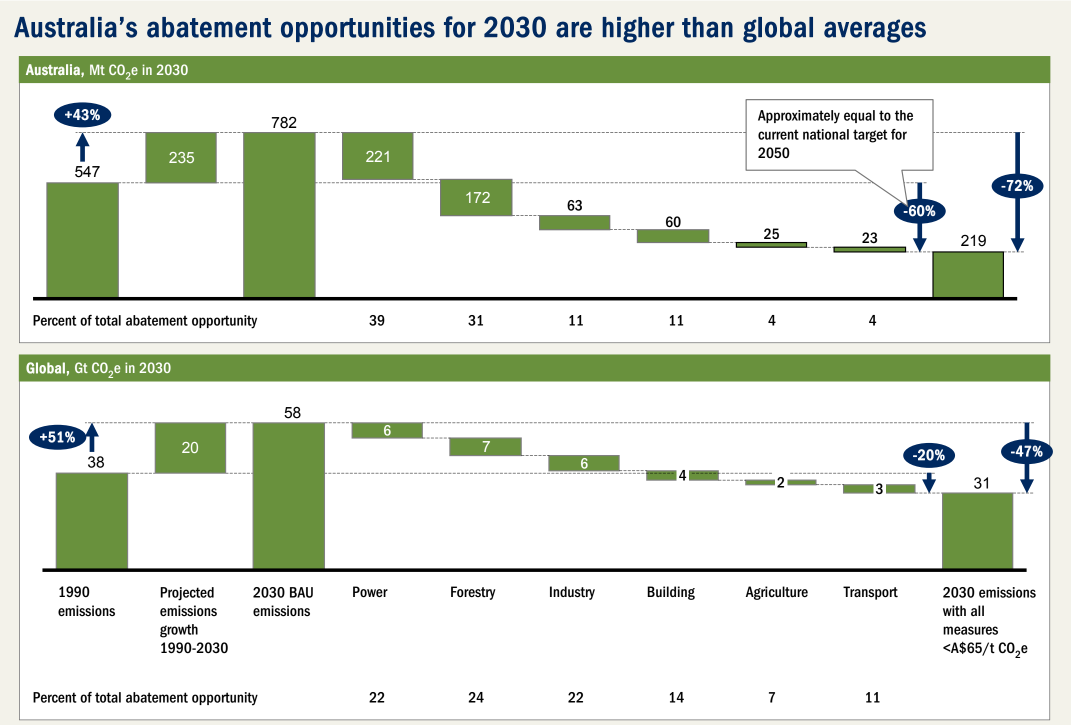
- **Significant reductions in greenhouse gas emissions are achievable.** The analysis implies that implementing all measures below A$65 per tonne of CO_2e would reduce emissions to 60 percent below 1990 levels in 2030, assuming full realisation of the identified opportunities in the given timeframe. This is approximately equal to the current national target for 2050
- **Significant quantities of 'negative-cost' opportunities are available.** These opportunities would allow Australia to reduce emissions in 2020 by 20 percent below 1990 levels at no net cost to the economy. This is because the contribution to the economy of the negative cost opportunities is enough to pay for other abatement measures up to a marginal cost of A$62 per tonne CO_2e, representing 270 Mt of abatement. For 2030, an equivalent analysis suggests reductions of 35 percent are achievable at no net cost. This is shown on the curve as the 'break-even' point—the point at which the sum of the negative and positive costs from left to right is zero
- **The long-term marginal cost of abatement is likely to be close to A$60–70 per tonne CO_2e.** This assumes the establishment of systems that efficiently allocate the burden of GHG reductions (such as proposed cap-and-trade schemes), and a national policy to reduce emissions significantly below 1990 levels by 2020.

> It also assumes all relevant opportunities are captured. The relative flatness of the right-hand side of the cost curves suggests that this marginal cost will not be overly sensitive to small differences in abatement targets. Although a robust forecast of carbon prices under a national emissions-trading scheme (ETS) cannot be made before details of such a scheme are known, this analysis can be taken as an indicative first-order estimate.

It is important to note that sectors and actors will not necessarily share the burden and benefits of abatement equally; there are likely to be winners and losers. For example, depending on the nature of government initiatives, tenants may be the beneficiaries of energy savings derived from improved insulation. However, an uneven distribution of costs within each sector of the economy is to some degree necessary to create incentives that will drive carbon abatement behaviour.

Development of the Australian greenhouse gas abatement cost curves has been undertaken as part of a global McKinsey & Company effort to understand GHG abatement. Comparing Australia's 2030 cost curve to its global counterpart, we see that Australia has a greater than average opportunity for greenhouse gas reduction by 2030, with relatively higher contributions in power, forestry and agriculture than average (see Exhibit 6). Australia has the opportunity to reduce GHG emissions by approximately 70 percent below business-as-usual levels in 2030 by implementing the full set of abatement measures for costs under A$65. The equivalent global analysis implies average reductions of only around 50 percent below business as usual.

Exhibit 6



Source: McKinsey Australia Climate Change Initiative; Australian Department of Climate Change

ECONOMIC IMPACTS AND SCENARIOS

We have assessed the aggregate economic impacts of the range of abatement opportunities using two measures: gross cost per household, and overall impact on forecast gross domestic product (GDP). Our cost-per-household calculation aggregates the full set of costs included in our analysis for a given set of measures on the curve, and divides it by the forecast number of households. This calculation suggests that achieving a reduction in Australian GHG emissions of 30 percent below 1990 levels will cost A$290 per household (per year) in 2020, and reductions of 60 percent below 1990 by 2030 would cost A$590.

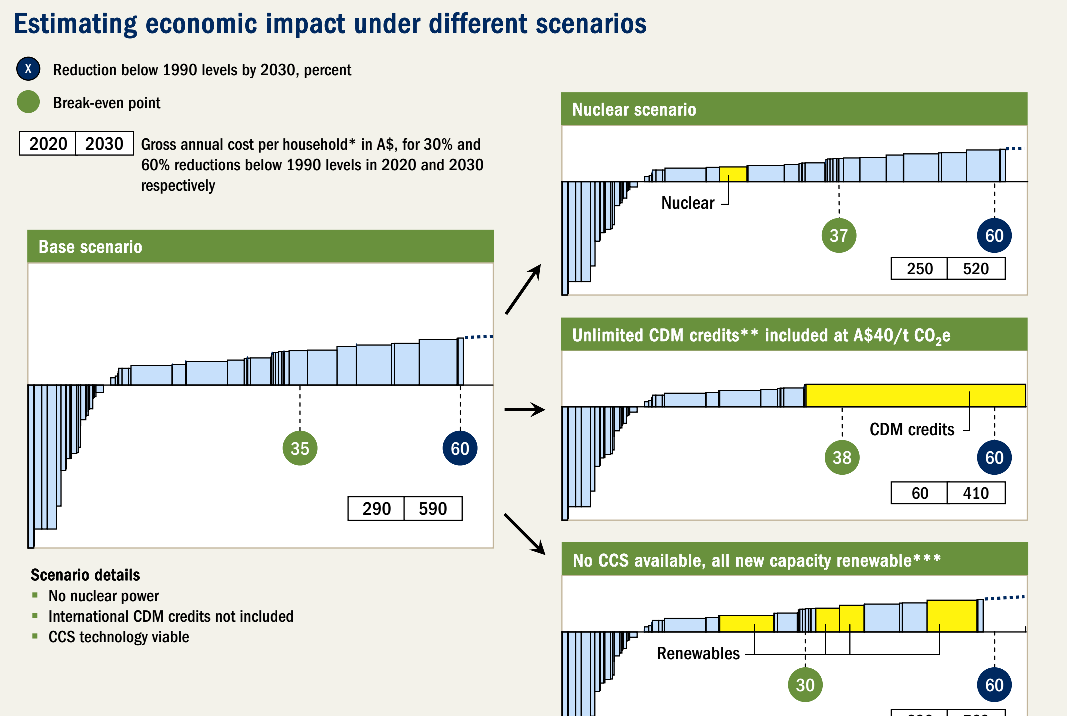
For comparison purposes, these costs can be expressed as a proportion of forecast Australian GDP. In these terms, the total 2020 cost of A$2.9 billion represents 0.20 percent of the forecast GDP for that year, and the 2030 cost of A$7.0 billion represents 0.35 percent. Australia's GDP would grow 0.02 percent more slowly each year to reach this lower figure. We used a baseline GDP growth rate in the do-nothing scenario of 3.00 percent per year from today through to 2030 implying that this rate would fall to 2.98 percent under the reduction targets identified.

As noted earlier, this static microeconomic analysis does not build in the costs of a do-nothing scenario, nor the value created through new business opportunities or the benefits of potential behavioural shifts, and does not imply that these costs will be borne directly by the average household, since tax, subsidy and redistribution effects have not been considered. Similarly, as discussed in the section titled 'Overview of the modelling approach', the costs described are technical, measurable costs to the economy. They do not include transaction costs (such as setting up and monitoring emissions reductions systems), nor do they reflect issues such as short term supply/demand imbalances.

Many assumptions in the Australian greenhouse gas abatement model could turn out differently depending on government policies or technological progress. So in addition to our base scenario, we selected three alternative scenarios to better understand the impact of other technological or regulatory outcomes (see Exhibit 7). These scenarios are driven by key high-level assumptions, and our intention is to estimate an approximate 'size of the prize'.

The first of these is the possibility of introducing **nuclear power** in Australia. Nuclear power is a mature abatement opportunity that offers effectively carbon-neutral energy production, but generates very long-term radioactive waste and presents a unique risk profile. As noted before, although its economics may be competitive, its political and environmental viability is doubtful in Australia. In general, adding any additional means of reducing emissions is expected to lower the overall cost of abatement. Thus, we find that nuclear power penetration of around 10 percent (in production terms) by 2030 would reduce the cost to the economy of abatement by 12 percent under a 60 percent reduction target, and would increase the reduction that could be achieved at no net cost to the economy to 37 percent, from 35 percent, below 1990 levels.

Exhibit 7



* Assumes 10.1 million households in 2020, 11.9 million in 2030
** Credits from international Clean Development Mechanism projects
*** CCS abatement opportunity replaced with increased renewables penetration in the power sector
Source: McKinsey Australia Climate Change Initiative

Our work focused on implementing abatement opportunities in Australia, but a rapidly growing international market exists for **carbon credits**. The UNFCCC Clean Development Mechanism (CDM) rewards investment in certified developing-world abatement projects with Certified Emissions Reductions that may be counted at full value towards Australia's emissions quota. This mechanism can allow more economically efficient reductions by making cheaper abatement opportunities available in developing, non carbon-constrained countries (Indonesia may be one prime candidate for Australian CDM investment due to its high rate of deforestation activities, which generate very low incomes relative to the carbon abatement opportunities they represent). If CDM credits were available to Australia at A$40 per tonne in unlimited quantities, we find that the 2020 cost of abatement could be reduced by almost 80 percent, and the 2030 cost by over 30 percent. This cost would rise if constraints exist in the use of these mechanisms, for example, if only limited quantities could be purchased or counted towards the national abatement quota. It would of course also be affected by the eventual price of the available credits. Global cost curve modelling implies that relatively large quantities of reduction opportunities exist in developing countries below A$40 per tonne of CO_2e.

The third scenario considered is one with **no CCS technology**. In this scenario, we assume that the full volume of CCS power sector abatement in the base case is replaced by renewables, which would require all new and replacement power-generation capacity to be renewable. This results in a 2020 economic cost that is virtually unchanged compared to the base scenario since CCS opportunities are negligible in this scenario already, but an increase in the 2030 cost of close to 30 percent. The reduction quota achievable at no net cost to the economy in 2030 falls to 30 percent. Under this scenario, the penetration of renewable power generation would need to be above 35 percent in 2020, rising to two-thirds by 2030; however, existing coal-fire power plants would not necessarily need to be retired before the end of their useful life. The additional renewable generating capacity required is assumed to come from a combination of wind, biomass, geothermal and solar. For comparison purposes, the base case requires a renewables penetration of just below 35 percent by 2020, rising above 50 percent by 2030, in order to achieve reductions of 30 and 60 percent below 1990 levels in each respective decade at the lowest potential cost.

Note that we have not investigated whether the resulting power mix will match energy demand profiles, nor the question of whether the location of renewable sources can be aligned with the energy demands of the different states.

IMPLICATIONS FOR AUSTRALIA

Significant greenhouse gas emissions reductions are achievable and affordable, but prompt action is required. Reductions of 30 percent below 1990 levels by 2020, and 60 percent by 2030 are possible without major technological breakthroughs. The cost of this reduction trajectory would amount to ~A$290 per Australian household in 2020. Here we present preliminary conclusions on the actions required given these findings.

Government response

The Australian cost curve work implies three important steps for government:

- **Set an aggressive but realistic target for GHG reduction soon.** A medium-term greenhouse gas reduction target is an important first step in providing much-needed certainty for business. While setting a target alone will not result in carbon reduction, it will enable businesses to understand the magnitude and timing of change that will be required, and thus to begin to prioritise emissions-reduction strategies. Under emissions trading schemes, a target is a crucial driver of carbon prices. Uncertainty in the price of carbon exacerbates the risk to investors in abatement technologies, ultimately reducing the capital available for necessary new ventures. Any government action that sends clear price signals to the market will reduce this uncertainty. Carbon prices will not be entirely determined by the target, but will be affected by a range of regulatory details as well as the overall speed and effectiveness of the national climate change response

- Rapidly develop and implement an integrated set of policies to capture the full set of abatement opportunities. A range of measures are required to capture different sections of the curve, specifically:
  - **Rapidly pursue negative-cost opportunities**—standards and/or incentives should be established to address current market imperfections indicated by the opportunities on the left-hand side of the abatement curve. These are primarily in the building sector, but also include the promotion of energy-efficient appliances in households. Each year we delay producing energy-efficient buildings and motor vehicles the greater the volume of negative-cost opportunities we lose. The cost of creating a new energy-efficient asset is typically a fraction of the cost of retrofitting it later, or retiring an asset before its useful life is over. In addition, an aggressive energy-efficiency program would reduce demand for fossil fuels and the need for new power plants. Strong policy support and private-sector innovation will be required to address fundamental market barriers. Policy support may consist of standards and/or incentives to promote carbon-efficient buildings, appliances (eg with reduced energy consumption stand-by features) and vehicles (eg hybrids or plug-ins)
  - **Fast-track the commercialisation of promising technologies**—ensure government funding (including new sources such as proceeds from sales of carbon credits) supports research and development of low-emissions technologies (such as carbon capture and storage, biomass, geothermal, solar, improvements in vehicles, industrial processes and appliances). The aim should be to fast track development and deployment to the point that technologies become cost-competitive. Support could take the form of direct subsidies or other financial incentives such as investment tax breaks. Regulatory standards can also be used as means of driving technology development. Priority should be given to the most cost-effective, high-volume emissions-reduction opportunities. Sequencing implementation is an important factor, and real effort will be required to make the right choices. Other factors to consider include the time horizons for development of technologies, as well as the order in which abatement opportunities appear on the curve
  - **Accelerate practical information campaigns to induce a change in consumer behaviour**—while progress has been made on some dimensions (eg energy-efficiency ratings) consumers would benefit from a reliable, systematic approach to emissions reporting across a wider range of products

– **Establish a national emissions-reduction scheme (such as an emissions-trading scheme, carbon tax or hybrid approach) as early as possible**—we recommend taking a 'learn as we go', rather than a 'wait and see' approach, leveraging existing national studies and global experiences. Unnecessarily complex schemes present a real risk of introducing costly delay. Industry-specific regulatory frameworks may be useful for capturing opportunity in the middle of the curve, and for guiding these sectors through the structural changes needed, when economic uncertainties might otherwise delay action; two key examples are a rapid ramp up of mandatory renewable energy targets and strict land clearing regulation.

- **Participate in and support the existing global framework.** Australia can play an important leadership role in discussions on climate change among developing countries. Investing in Clean Development Mechanism projects will provide the option of purchasing lower cost CO_2e abatement credits, thus serving as a safety valve for Australian carbon prices without needing to implement an official price ceiling. They also offer the benefit of closer cooperation with regional neighbours. In addition, participating in these international schemes provides an export market for locally developed emissions-reduction technologies (eg coal carbon capture and storage).

Business response

Over and above complying with relevant new regulation, we believe companies should respond to the climate change challenge in three ways:

- **Reduce carbon footprint.** Within the last year, significant progress has been made across a range of industries in quantifying and understanding individual companies' contributions to GHG emissions. Companies should continue this work, moving beyond an offset-only approach to prioritising approaches which improve energy efficiency and significantly reduce overall emissions. We anticipate companies moving from a focus on direct emissions only to indirect emissions (taking into account energy consumption), to a holistic view of the entire product lifecycle (eg a construction company considering the overall lifecycle of a building from construction to demolition). Substantive untapped abatement opportunities are likely to be revealed through analysis of the carbon profile of the whole supply chain
- **Contribute to the policy debate.** The real challenge for Australian business is to productively contribute to the debate on climate change, which will shape our economic landscape in significant ways. Business can choose to respond reactively or proactively. Either way, business must think not only of protecting short-term interests but also of taking a genuinely long-term view, considering how firms can contribute to Australian and global prosperity well into the future

- **Identify and capture new business opportunities.** Climate change represents a significant external discontinuity and, as such, requires an appropriate strategic response. For many businesses, ensuring longer term competitiveness will require investment. It is likely that a number of the measures identified will ultimately be profit-generating businesses in their own right. Business will need to choose the right portfolio of investments (balancing short-term wins with high visibility and longer term higher risk/return investments) and decide how best to manage these efforts (eg at a corporate or business unit level). Business also has a leadership role to play to ensure Australia capitalises on our natural asset base in technologies such as CCS, geothermal and solar. A thoughtful and responsible use of green brands can also cater to an increasingly discerning consumer base.

Consumer response

Consumers have additional degrees of freedom to influence emissions, since individual preferences and behaviours are key drivers of their carbon footprint. As businesses increase the range of climate-friendly options and governments help provide consumers with better information, consumers should make informed choices about their own consumption. Lobbying and voting will also continue to be an important component of driving business and government actions.

CONCLUSION

Significantly reducing Australia's greenhouse gas emissions is achievable and affordable but requires rapid action. The scale of changes required is substantial. For the opportunities to be realised, government, business and consumers need to work together; effective action to reduce emissions is difficult to envisage without all parties playing a role. A collaborative domestic approach is required, but recognising the global nature of the challenge, Australia also needs to play a constructive role internationally.

The Australian and global cost curves allow government, business and consumers to answer three questions: what reductions can be achieved, how much would it cost, and what the most effective levers are.

By providing an objective view of the possibilities for carbon abatement and the forward-looking costs and opportunities by industry sector, this cost-curve analysis can inform the next steps in reducing GHG emissions in Australia. These steps include, but are not limited to: setting an aggressive but realistic target; rapidly establishing a national regulatory framework; further assessing the distribution of costs and benefits by sector; and more detailed sector-level analyses of sequencing and dependencies by business and industry bodies to build on this effort. Australia has unique challenges and unique opportunities to reduce its impact on climate change. Understanding them is an important first step.

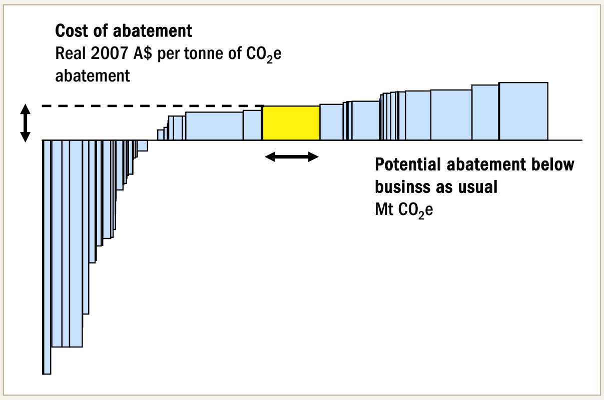
APPENDIX A—HOW TO READ AN ABATEMENT COST CURVE

Exhibit A

Two dimensions

Each bar represents one opportunity to reduce greeenhouse gas emissions, or a group of closely related opportunities (eg, 'residential lighting efficiency')

- Width—amount of CO_2e that could potentially be reduced per year by implementing this opportunity
- Height—average cost of avoiding one tonne CO_2e with this opportunity, relative to the activities that would otherwise occur in the business-as-usual case.



Negative and positive costs

- Negative costs (those below the horizontal axis) indicate a net financial benefit to the economy over the lifecycle of the abatement opporunity
- Positive costs (above the axis) imply that capturing the opportunity would incur incremental lifecycle costs compared to the business-as-usual or 'do nothing' case

Source: McKinsey & Company

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