

INDEPENDENT EXPERT PANEL

Interim Emissions Reduction Targets for Victoria (2021-2030)



FINAL REPORT

Author

Independent Expert Panel on Interim Emissions Reduction Targets for Victoria
(2021-2025, 2026-2030)

Editor

Secretariat to the Independent Expert Panel

Acknowledgement of Traditional Owners

In the context of climate change policy, we, the Panel, acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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FOREWORD

The Victorian *Climate Change Act 2017* has established in law a Statewide target of net zero greenhouse gas emissions by 2050 and requires the Premier and the Minister responsible for climate change to set five-yearly interim emissions reduction targets to establish the pathway to meet this long-term goal.

We, the Independent Expert Panel (the Panel), have been appointed to advise the Victorian Government on the first two interim targets for 2021-2025 and 2026-2030, opportunities to reduce emissions across the Victorian economy, and trajectories to net zero emissions by 2050.

Victoria has chosen to join the international community supporting the Paris Agreement on climate change because without strong action by all governments, businesses and communities across the globe to reduce emissions, climate change poses a very significant threat to us all. The world's scientists have been clear that actions taken in the next decade will be crucial in determining whether or not the global temperature increase is kept to well below 2°C above pre-industrial levels.

Interim targets provide an opportunity for the Victorian community to chart a course to a prosperous, low-emissions future. Measures to reduce emissions not only contribute to a safer climate, but also generate multiple other benefits for Victorians including new jobs in low-emissions industries, cleaner air to breathe, and greater productivity. A low-emissions future is also important for the continued prosperity of sectors that are particularly climate-dependent, such as agriculture and tourism.

The transition to a low-emissions economy is underway and gathering pace in Victoria and across the world with renewable energy generation is now cheaper than new gas or coal-fired generation. Victoria's abundance of wind and sun means the state is well placed to capitalise on the transition, with a significant pipeline of large-scale clean energy projects already supporting more than 10,000 jobs. Access to lower-cost renewable energy is already helping to secure the place of energy intensive industries in Victoria's economy and will be a key component in the low-emissions transition in transport and buildings.

Our consideration of targets is done against a backdrop of accelerating technological change, and of growing investor, business and community action. These drivers and trends will continue, regardless of the targets and policies set by governments. In this context, 10 years is a long time, and 30 years is a generational change. We have only to look back over the past 30 years to see just how much social and technological change is possible in the course of three decades.

Given the benefits, Victoria should not hesitate to accelerate its transition to a low-emissions future. Victorian Government leadership can ensure that this transition is aligned with the State's other goals, including health, mobility, productivity, industry development and job creation. As with any significant change in the economy, the transition will have real impacts on some individuals, families, communities and businesses. It will be important for the government to build on existing best practice to support impacted individuals and ensure a just transition.

In this report we present the Victorian Government with our recommendations for interim targets for 2021-2025 and 2026-2030, indicative trajectories to 2050, advice on opportunities to reduce Victoria's emissions and the other evidence we have considered to arrive at the recommended targets. We are confident that the report provides a sound foundation for the Victorian Government to set targets that are achievable, will support Victoria's continued prosperity, share the benefits and challenges fairly across current and future generations, and ensure Victoria plays its part, as a member of the global community, in limiting dangerous climate change.

We have enjoyed the opportunity to develop the recommendations in this report and would like to thank the Premier of Victoria and the Minister for Energy, Environment and Climate Change for entrusting us with this important task, the stakeholders and members of the community who have engaged in this process, the experts who have provided valuable analysis and advice and the Secretariat for supporting us.

The Hon. Greg Combet AM
Dr Penny Whetton
Dr Lorraine Stephenson

EXECUTIVE SUMMARY

Setting interim emissions reduction targets under the *Climate Change Act 2017*

Through the *Climate Change Act 2017* (the Act), Victoria has committed to setting five-yearly interim greenhouse gas emissions¹ (emissions) reduction targets on the path to net zero emissions by 2050. Through the Act, Victoria also recognises and supports the Paris Agreement on climate change, in which the international community committed to “holding the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C” (the “Paris goal”).

The Premier and the Minister for Environment, Energy and Climate Change must set Victoria’s first two interim targets (for the periods 2021–2025 and for 2026–2030) by 31 March 2020. The Act requires the Minister to seek independent expert advice before setting these targets.

The Independent Expert Panel (the Panel) were appointed to provide that advice, specifically on:

- recommended interim targets for 2021–2025 and for 2026–2030;
- indicative trajectories for Victoria to achieve the long-term target of net zero emissions by 2050 based on the recommended interim targets; and
- potential opportunities to reduce emissions across the Victorian economy.

The role of emissions reduction targets

The transition to a low-emissions economy is already underway and is gathering speed around the world, driven by technological advances, changing consumer preferences, business and investor action, public policies and the desire to avoid dangerous climate change. This presents both opportunities – such as new jobs and industries, significant health benefits, and improved productivity – and a risk of being left behind. Interim targets can help Victoria to prepare for and successfully navigate this period of significant change.

Interim targets are part of the Victorian Government’s role in planning for the future, as it does in other areas such as the economy, jobs, transport and water supply. Setting strong targets now can maximise the benefits and minimise the costs to Victoria of transitioning to a net zero emissions economy by 2050. Victorian targets can also influence the approach of the Commonwealth and of other states, territories and jurisdictions.

Interim targets can provide a clear signal to business and investors and drive Victorian policy to reduce emissions through energy efficiency, renewable energy, industry policy and urban and public transport planning to name but a few areas. Targets can also help ensure Victoria’s long-term prosperity by improving Victoria’s attractiveness to – and competitiveness in – low-emissions industries.

The solution to tackling climate change can only be global. Targets can help ensure that Victoria contributes its fair share to the action being taken by the international community to limit global warming and therefore avoid the worst impacts of climate change (**Box ES1**).

Box ES1. Action by others

Nations representing about 90% of global emissions, including Australia, have joined the Paris Agreement, and have established emissions reduction targets to support the Paris goal. Many sub-national jurisdictions are demonstrating leadership in their countries by setting their own emissions reduction targets, such as British Columbia (40% below 2007 levels by 2030), California (40% below 1990 levels

by 2030), Wales (45% below 1990 levels by 2030) and Scotland (66% below 1990 levels by 2032). Like Victoria, New South Wales, Queensland, South Australia and Tasmania have committed to net zero emissions by 2050, while the Australian Capital Territory brought its deadline forward to 2045. Together these jurisdictions represent over 80% of Australia's emissions.

The Panel's advice to the Victorian Government

Interim targets


The Panel recommends interim targets of:

- 32-39% below 2005 levels in 2025
- 45-60% below 2005 levels in 2030

These targets build on the progress that Victoria is already making; emissions are projected to fall to 18% below 2005 levels in 2020.

These targets are environmentally and economically responsible. They will enable Victoria to capture the economic, social and environmental benefits of a transition to net zero emissions, provide flexibility to manage uncertainties and impacts on specific communities, and are consistent with the international commitment to keep global temperature increases to well below 2°C.

Even in the short time of the Panel's deliberations there have been significant developments in the prospects for and the urgency of emissions reduction. As such, the Panel recommends that in 2023 the Victorian Government reviews its interim target for 2030 to take into account developments in climate science, technology, global action and further progress in reducing Victoria's emissions.



As required by the Act, the Panel's choice of interim targets is a pragmatic one that considers a broad range of factors. It is important that, in addition to setting a clear pathway to net zero emissions, interim targets:

- are achievable given what is known today about available technologies, behaviours, costs, markets, and economic and social impacts;
- secure the potentially significant benefits from reducing emissions while allowing impacts to be managed; and
- maintain environmental effectiveness by ensuring Victoria contributes its fair share to the achievement of the Paris goal.

The sections below set out the Panel's conclusions on these issues based on the evidence set out in this report.

Achievability

Victoria has already made good progress to reduce emissions. Victoria's emissions have decreased since 2005 and are projected to fall further to 18% below 2005 levels by 2020.

The Panel has considered a broad range of evidence on the opportunities to further reduce Victoria's emissions over the coming decade. This includes new analysis on the potential for emissions reduction in Victoria; recent modelling of Victoria's electricity sector; and advice from a range of sector and climate policy experts.

The Panel concluded that Victoria's emissions will continue to fall under existing policies, and there are many attractive opportunities for the Victorian Government to accelerate these reductions to 2030 while growing the economy. These opportunities are across all sectors, but in the electricity and land sector in particular. Based on this evidence, this report presents illustrative estimates of emissions reduction opportunities that, if realised, could reduce Victoria's emissions by 45% and potentially

as much as 60% or more by 2030. Substantial policy action will be required to achieve these emissions reduction. However, analysis also shows that strong emissions reduction can be achieved at low overall economic cost and offer significant potential co-benefits.

The Panel has also considered evidence on strengthening private sector action on climate change – such as Meat & Livestock Australia's commitment to a carbon-neutral red meat industry by 2030 and National Australia Bank ceasing lending to all new thermal coal projects – and on the rapidly falling costs of low-emissions technologies — for example, the cost of batteries, which are essential to support electric vehicles and renewable energy technologies, fell 73% between 2010 and 2016.

Based on consideration of this evidence, and on the high level of support in the Victorian community for action to reduce emissions, the Panel is confident that the Victorian Government can drive emissions reduction to meet, and likely surpass, the lower end of the recommended target range of 45% below 2005 levels in 2030.

The higher end of the range – 60% below 2005 levels in 2030 – could be reached with strong policy action at both the state and Commonwealth levels. Continued rapid technology development may also allow emissions to be reduced more easily and cheaply than analysis suggests today. Indeed, the Panel received expert advice that analysis has consistently underestimated the decline in the cost of low emission technologies, and has consistently failed to capture the potential for other rapid or disruptive changes to emissions in the past.

While the emissions reduction implied by these target ranges may appear ambitious now, they will take place in the context of remarkable technological change and of growing business

and community action. In this context, 10 years is a long time, and 30 years is generational change. The rise of smart mobile phones and the internet have shown that when technology development aligns with consumer preferences and falling costs, adoption can be rapid and can transform the way we live. These trends are clearly visible now in record-breaking installation of solar and wind generation. Batteries and electric vehicles may not be far behind. The electric and autonomous vehicle technologies we see now are a significant leap forward from those in a 1990 model internal combustion engine car. By the time Victoria reaches net zero emissions in 2050 the world will look very different from now.

Benefits and costs

The Panel is confident its recommended targets will allow Victoria to maximise the opportunities and minimise the costs of reducing emissions on the path to net zero emissions by 2050. The recommended targets will require upfront investment to unlock greater benefits now and in the future.

Several authoritative studies, and recent experiences in places like California and the United Kingdom show that strong emissions reduction and robust economic growth can go hand in hand. Being low-emissions can be part of Victoria's future competitive advantage, by hosting energy intensive industries powered by renewables, and other businesses capitalising on a strongly growing global market for low-emissions goods and services.


The evidence is clear that the economic benefits for Victoria of avoiding climate change far outweigh the economic costs of reducing Victoria's emissions. Even if the long-term economic benefits of avoiding climate change are not accounted for, economic analyses have found that the overall cost to the economy of reducing emissions is low. In some cases, reductions may occur at no additional cost as

low-emissions technologies become cheaper than existing alternatives. For example, solar and wind are already the cheapest form of new electricity generation, even with the costs of firming, and electric vehicles are predicted to become cost competitive during the 2020s. In other cases, acting now to reduce emissions will provide savings to the community and economy. For example, improving the energy efficiency of Victoria's housing and vehicles can provide lifetime savings for households.

Under the right policies, bold action to reduce emissions globally could even boost global economic growth to 2030, given the falling costs of action and the strong benefits of investment in natural systems and more efficient infrastructure.

The recommended targets are more cost effective than targets that delay substantial emissions reduction until after 2030. Modelling commissioned for the Panel found that emissions reduction pathways to 2050 involving more emissions cuts by 2030 were cheaper overall to reach net zero emissions than those with less emissions reduction to 2030.

Accelerating emissions reduction in line with the recommended target ranges will allow Victoria to capture more of the potential co-benefits sooner. This includes improved health outcomes, as cutting emissions in the electricity generation and transport sectors also reduces air pollution. The health costs to Victoria of local air pollutants from electricity generation are currently estimated to be between \$420 million and \$600 million per year, and those from road transport are estimated to be between \$660 million and \$1.5 billion per year. Greater use of active transport (cycling and walking) and reduced consumption of animal products would provide further health benefits. Emissions reduction can also strengthen ecosystems and increase biodiversity.



The Panel recognises that the costs and benefits will be felt differently by households, businesses and regions across Victoria.

Some communities and sectors will receive an economic boost as actions to reduce emissions in Victoria provide additional growth opportunities for Victorian businesses. This can already be seen:

- New Victorian factories will open in Geelong and the Latrobe Valley to assemble and maintain wind turbines and electric vehicles;
- In the Northern Grampians Shire, the expansion of the Nectar Farms greenhouse facility and the construction of the Bulgana Green Power Hub to supply it with electricity is creating 600 direct jobs and more than 930 indirect jobs;
- The Victorian Renewable Energy Targets of 25% in 2020 and 40% in 2025 are expected to create up to 10,000 jobs in Victoria's renewable energy sector.

A low-emissions future, which avoids the worst impacts of climate change, will also be particularly important for the continued prosperity of other sectors like agriculture and tourism.

With the right policies and investments, emissions-intensive industries can also continue to have a strong place in the Victorian economy as they decarbonise. A switch to renewables is already providing lower bills and securing jobs for some industries; for example, investments in renewable energy are expected to reduce the cost of electricity at the Whyalla and Laverton steelworks by around 40%.

However, as with any significant change in the economy, some individuals, families and businesses will face real impacts during the transition to net zero emissions. It is important that Victoria builds on existing foundations to deliver a just transition for those affected.

The Panel strongly encourages the Victorian Government to work with affected communities to develop clear plans and measures to support local economic transition. The Panel and many stakeholders participating in the Panel's public consultation process identified the Latrobe Valley community as a key focus for government support, as the coal-fired power stations that have been a foundation of the region's economy reach the end of their operating lives. The Latrobe Valley Authority, established in response to the closure of the Hazelwood power station, has already put in place a range of transition support measures that can be built upon. Experience can also be drawn from other countries which are acting to ensure a just transition for coal mining regions, such as in the Ruhr region in Germany, the Netherlands, and Spain.

Climate science and emissions budgets

The world has already warmed by 1°C since pre-industrial times, and the impacts are being felt in Victoria and around the world through rising sea levels, declining rainfall, and more frequent and intense heatwaves and bushfires.

Climate change poses a significant risk to society. Scientists warn that if emissions continue to rise at the rate of recent decades, the world is at risk of experiencing food insecurity, widespread displacement of people due to extreme events, increased illness and death from heatwaves, extensive species extinction and ecosystem collapse.

Victoria and the international community have committed to the Paris goal and have begun to take action to limit dangerous climate change (**Box ES1**). Given the pressing threat to the globe that climate change represents, the Panel agrees that it is important for Victoria to contribute its fair share to limiting global temperature increase in accordance with the Paris goal. Only by doing so can Victoria expect others, particularly those with fewer resources, to strengthen their existing

actions. This is particularly important for Victoria given global action is needed to avoid the worst impacts of climate change, and Australia is one of the developed countries most vulnerable to these impacts.

With the Paris goal in mind, the Panel has developed a 2°C-consistent and a 1.5°C-consistent emissions budget for Victoria over the period 2017-2050. The Panel's thinking has been significantly guided by these emissions budgets, as they provide a tool for linking emission targets and trajectories to global temperature goals and for understanding the trade-offs between earlier and later action. The use of emissions budgets to guide decision making on interim targets was widely supported by stakeholders and individuals responding to the Panel's public consultation.

Understanding emissions budgets

The Panel worked with globally recognised experts to develop Victorian emissions budgets for 2017-2050 that represent Victoria's fair share of a global emissions budget. A global emissions budget is a science-based estimate of the cumulative amount of greenhouse gases that can be emitted worldwide while providing a certain likelihood (e.g. 50%, 90%) of keeping the increase in global temperature within certain limits above pre-industrial levels – in this case, to 2°C and 1.5°C.

Emissions budgets clearly show that the world cannot continue to emit at current levels if the Paris goal is to be achieved – and neither can Victoria. At 2016 emissions levels, the Panel's 2°C-consistent emissions budget for Victoria will be exhausted in 2032, and the 1.5°C-consistent budget will be exhausted in 2026. The global 2°C emissions budget will be exhausted in 2034 at current emissions levels.

As the consistency of Victorian action with the Paris goal depends on Victoria's cumulative emissions over time, it is the combination of Victoria's 2025 and 2030 emissions targets and of emissions trajectories to 2050 that determine the environmental effectiveness of Victoria's interim targets.


Based on its assessment of 2°C and 1.5°C emissions budgets for Victoria, the Panel is confident that a target range of 45-60% below 2005 levels in 2030 is consistent with the Paris goal while providing a feasible emissions reduction pathway and a steady transition of the Victorian economy to net zero in 2050.

To maintain environmental effectiveness and consistency with the Paris goal, determination of interim targets for 2035 and beyond should take into consideration the emissions budgets for Victoria developed by the Panel, revised as required to consider the most up-to-date climate science.

Consideration of higher and lower target options

In submissions to the Panel's issues paper, most business and energy sector stakeholders supported a 28% Victorian emissions reduction target in 2030 in line with the national target. This was based on a rationale of achieving national coherence, minimising compliance burdens, maintaining competitiveness of trade-exposed industries, and expectations that technology developments will make reducing emissions easier and cheaper in the future.

However, while national coherence can offer some benefits, the Panel's analysis shows that a 28% target for Victoria in 2030 would imply very rapid emissions reduction after 2030 if Victoria was to contribute its fair share to limiting warming to well below 2°C. This would shift a significant burden to Victorians in the future, and concentrate economic adjustment costs in the period after 2030. A 28% target is also



incompatible with pursuit of 1.5°C. Furthermore, expert advice found, based on existing analysis, that the 28% target option was likely to result in a higher overall economic cost to reach net zero emissions by 2050.

The Panel has also reflected on the fact that the Paris Agreement includes processes for review of each country's initial target with the aim of strengthening global emissions reduction pledges to align with the agreed Paris goal. It is therefore likely that over the next decade, Australia's national targets will become stronger than the current commitment of 26-28% below 2005 levels by 2030.

A target of 75% below 2005 levels in 2030 was supported by many individuals, councils and environment groups participating in the Panel's public consultation process. However, a target of 75% would imply very rapid emissions reduction in the period 2021 to 2030, which would concentrate economic adjustment costs in the period before 2030 and therefore place a substantial burden on current Victorians. A target of 75% is also higher than what would be required, on a straight-line basis, to be consistent with a 1.5°C goal (**Box ES2**).

Box ES2. Considering interim targets and trajectories for a 1.5°C world

The Intergovernmental Panel on Climate Change's Special Report on the impacts of global warming of 1.5°C shows that keeping warming to 1.5°C requires global emissions to fall at an unprecedented speed and scale, implying transformative change across all sectors of the global economy over the coming decade.

The Panel's work on 1.5°C emissions budgets shows that Victoria's share of global emissions reduction to secure an even chance of limiting warming to 1.5°C would imply a target of 67% below 2005 levels in 2030.

While climate science clearly demonstrates that a 1.5°C world would be much safer, with significantly lower impacts than 2°C of warming, it represents an ambition that has not fully crystallised yet. While the global community committed to "pursue efforts to limit temperature increases to

1.5°C", this has not yet been translated into commensurate commitments and action. Although evidence and experience are building around potential to rapidly reduce emissions, there are still significant uncertainties about the pace of change that can be sustained.

The Panel therefore recommends a range of actions that Victoria should take to increase potential for future emissions reduction that, alongside a review of the 2030 interim target by 2023, would preserve flexibility to join strengthening global action toward a 1.5°C goal.

By continuing and strengthening its emissions reduction efforts, Victoria can help build the required global momentum. Victoria's aim should be to limit overall cumulative emissions on a pathway to reach net zero as soon as possible, as part of a global coalition.

Balancing flexibility with certainty

In developing its advice, the Panel has focused on the transition needed in the Victorian economy over the decade from 2020 to 2030 on the way to achieving net zero emissions by 2050.

Recognising there is significant uncertainty about the timing of emissions reduction, the Panel derived its recommended interim target for 2025 by assuming steady or “straight-line” emissions reduction between projected emissions in 2020 and the 2030 target.

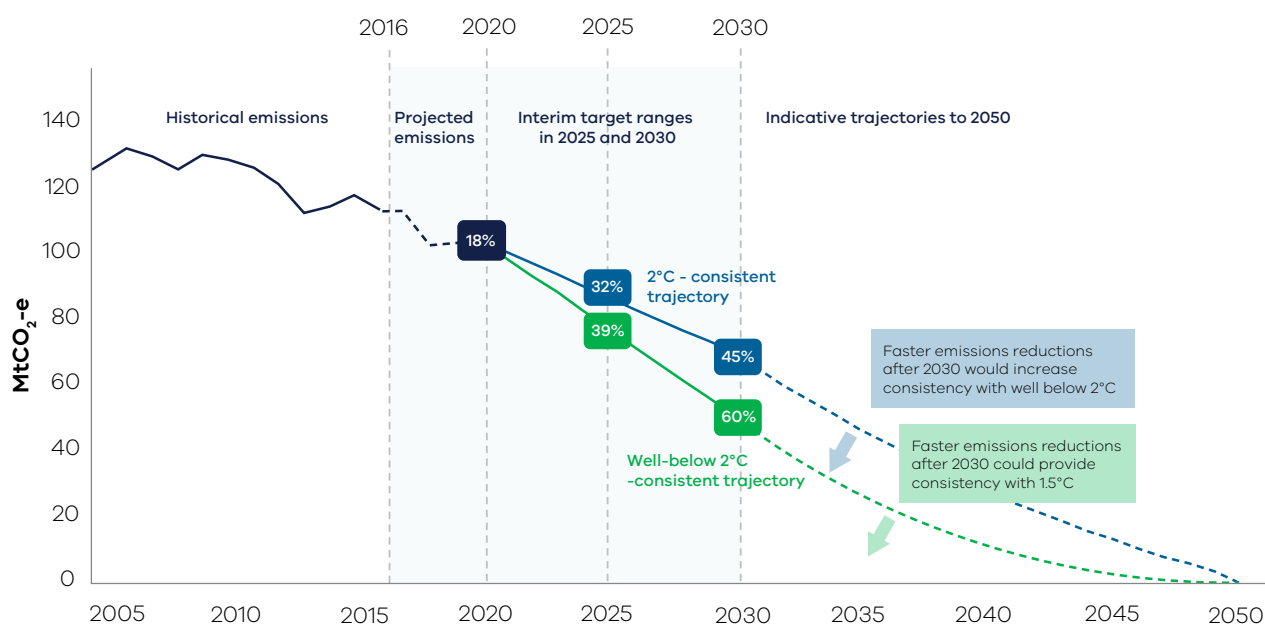
The Panel has recommended a target range at the end of each interim target period, as this balances flexibility to adjust to changing circumstances and a degree of certainty on the path to net zero emissions. A target range for a single year is also easy to communicate, widely supported by stakeholders, and consistent with Victoria’s 2020 target and the Commonwealth’s 2030 target. By providing a limit on emissions every five years, interim targets will help minimise Victoria’s cumulative emissions. Policy makers should also aim to minimise cumulative emissions by reducing emissions steadily throughout each target period.


Trajectories

The Panel has developed indicative emissions reduction trajectories from its recommended interim targets in 2025 and in 2030 to achieve the long-term target of net zero emissions by 2050. These trajectories have been guided by the Panel’s 2°C and 1.5°C emissions budgets for Victoria.

Figure ES1 illustrates the Panel’s indicative trajectories to net zero emissions by 2050.

Figure ES1: Indicative trajectories to net zero by 2050, consistent with the recommended interim target ranges





Under an emissions reduction target of 45% below 2005 levels in 2030, emissions reduction would need to accelerate slightly to reach net zero by 2050 to be consistent with 2°C. This is illustrated by the top blue line in **Figure ES1**. However, Victoria's emissions reduction would need to accelerate more rapidly if Victoria's emissions were to remain consistent with the Paris goal of well below 2°C, as indicated by the blue arrow.

If emissions reached 60% below 2005 levels in 2030 and continued to decline relatively steadily to reach net zero in 2050, as illustrated by the green line in Figure ES1 – this would be consistent with a well below 2°C outcome. Rapid emissions reduction after 2030 could bring consistency with 1.5°C within reach, as indicated by the green arrow.

Reaching 60% below 2005 levels in 2030 would also provide the flexibility to reduce emissions more gradually after 2030, which may help

manage the risks that remaining emissions are harder to reduce.

Whatever the level of emissions reduction achieved in 2030, the steeper the emissions trajectory post-2030, the higher the probability of Victoria acting in accordance with a lower global temperature goal and a safer climate outcome.

Within the recommended target ranges and these indicative trajectories to 2050, choices remain for the Victorian community about the specific pathway to follow. Different pathways imply different distributions of costs and benefits over time – whether economic adjustment costs are more concentrated or spread out, how the emissions reduction task is spread between Victorians now and in the future, and when the benefits of pursuing low-emissions policies – such as improved health and greater productivity – are realised.

Emissions reduction opportunities

There are opportunities to reduce emissions across all sectors of the Victorian economy by 2030, but decarbonising electricity generation is by far the largest opportunity. Transition of the electricity sector will be critical to achieving interim targets to 2030, particularly given this can unlock further reductions in other sectors through electrification of transport, buildings and industry. There are also opportunities to substantially increase the carbon sink provided by Victoria's land sector and to reduce agricultural emissions while improving productivity.

While emissions reduction will continue under current settings, further policy action will be needed to realise many of these opportunities. With net zero emissions by 2050 in mind, the Panel recommends that the Victorian Government takes actions now that will improve the potential to reduce Victoria's emissions more quickly or cheaply later.

A crucial consideration for developing interim targets, and one that the Panel is required by the Act to provide advice on, is the opportunities to reduce emissions in Victoria. The Panel has considered this issue in depth and has concluded that there are significant, cost-effective opportunities available across the Victorian economy to reduce emissions by 2030.

Transition of the electricity sector will be critical to achieving interim targets in 2030. The electricity generation sector accounted for more than half of Victoria's emissions in 2016 and, following the retirement of the Hazelwood power station, is projected to still account for 42% of the State's emissions in 2020. The sector also provides by far the largest emissions reduction opportunity in Victoria to 2030 and can unlock further reductions in vehicles, buildings and industry through switching from direct combustion of fossil fuels to low-emissions electricity.

Based on expert advice and consideration of a wide range of analysis, there is potential to cut electricity sector emissions significantly (models indicate by as much as 16-52%) over the decade 2020 to 2030, using commercially available technologies whose costs are falling rapidly. This can be done while ensuring that energy policy objectives regarding affordability, reliability and systems security continue to be met, although careful planning by the Victorian Government will be required.

The Panel recognises that this finding will understandably amplify concerns over the potential closure of further coal fired generation capacity in the Latrobe Valley in the coming decade. However, it is not within the Panel's role and responsibility to speculate about the likely responses of privately owned generation businesses to the Panel's recommendations, nor about government policy responses that have yet to be formulated.


The Panel does, however, strongly encourage the Victorian Government, the generation businesses, unions and the Latrobe Valley community to consult and collaborate in the formulation of policy responses and business decisions to achieve a planned and just transition. The Commonwealth Government and the National Electricity Market agencies clearly also have important roles to play in this regard.

There are also emissions reduction opportunities across all other sectors of the Victorian economy. To achieve the Panel's recommended target ranges and put Victoria on the pathway to achieving net zero emissions by 2050, reductions will be needed across these other sectors.

The next largest opportunity is Victoria's land sector with significant potential to increase the carbon sink from on farm forestry and changes in forest management on public land. Unlocking this opportunity is highly dependent on strong policy action.

Victoria's rapidly growing population is putting upward pressure on transport emissions. It is therefore critical that the Victorian Government puts in place strong policies and investments now to drive a transformation of the sector and reverse this trend. Support for low-emissions vehicles and public transport can reduce emissions by 2030, will be critical to achieving interim targets after 2030, and can provide substantial health benefits.

There are opportunities to reduce emissions in Victoria's agriculture sector while improving productivity, and to reduce emissions in the industry and buildings sectors through more efficient energy use and switching from gas to electricity as electricity supply decarbonises.



Victoria's Traditional Owners have a strong interest in and can support and benefit from actions to reduce Victoria's emissions. Traditional Owner groups are already undertaking activities that sequester carbon, for example by protecting, restoring or regenerating indigenous vegetation, and are interested in partnering in renewable energy projects. Emissions reduction policies should include early engagement and seek to support and overcome barriers to Traditional Owner involvement.

Offsets can also provide a cost-effective mechanism and additional flexibility to help meet Victoria's interim targets. However, priority should be given to transitioning Victoria's own economy, both because of the significant local benefits this brings, and to manage the risk of low cost offsets not being available in future years.

While the Panel's task is focused on Victoria's emissions reduction over the next decade, the Act requires the long-term target of net zero emissions by 2050 to be kept firmly in view. The Panel therefore recommends that the Victorian Government take actions now that will increase potential to reduce emissions more quickly later. This includes:

- creating a stable set of policies for emissions reduction across the economy now and into the future, including to drive transformation in the transport sector;
- supporting measures for emissions that are currently harder to reduce (e.g. in some parts of agriculture, industry and transport). This includes improving resource efficiency; growing the circular economy; and development of agricultural technologies, hydrogen and carbon capture and storage; and
- support for the development of other negative emissions technologies.

These actions are particularly important because without them, emissions reduction may become harder and more costly.

1. OVERVIEW: THE PANEL AND ITS TASK

SUMMARY:

- Victoria's *Climate Change Act 2017* (the Act) legislates a long-term target of net zero greenhouse gas emissions by 2050 for the State and requires five-yearly interim emissions reduction targets to be set to chart a course to achieve this goal.
- The Independent Expert Panel (the Panel) was appointed under the Act to provide advice to the Victorian Government on:
 - interim targets for 2021-2025 and for 2026-2030;
 - indicative trajectories for Victoria to reach net zero emissions by 2050; and
 - potential opportunities to reduce emissions across the Victorian economy.
- Victoria's interim targets play an important role in driving Victoria's transition to a low-emissions economy and ensuring that Victoria is contributing its fair share, as a member of the global community, to avoiding dangerous climate change.
- The Panel's advice is provided in this report.
- The Premier and Minister for Energy, Environment and Climate Change must determine interim targets for 2021-2025 and 2026-2030 by 31 March 2020.

Required advice on interim targets

Victoria's *Climate Change Act 2017* (the Act) recognises the Paris Agreement on climate change that commits to holding "the increase in global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C". The Act establishes a long-term emissions reduction target for Victoria of net zero greenhouse gas emissions by 2050. The Act also requires the government to set five-yearly interim emissions reduction targets, starting in 2021, and establishes a pledging model for action by government and the community to meet these targets.

The Act requires the Minister for Energy, Environment and Climate Change (the Minister) to seek independent expert advice when setting interim targets.

This report provides independent expert advice in relation to the first two sets of interim targets (for the periods 2021-2025 and 2026-2030), including on the following the mandatory elements:

1. One or more recommended interim targets for reducing greenhouse gas emissions² (emissions) for the interim target period, expressed against a 2005 base year. Each recommended interim target must constitute a greater reduction in emissions than any previous interim emissions reduction target;
2. Indicative trajectories for Victoria to achieve the long-term emissions reduction target (net zero emissions by 2050) consistent with each recommendation under item 1; and
3. Potential opportunities across the Victorian economy to reduce emissions in the most efficient and cost-effective manner in each interim target period.

The Minister and the Premier are responsible for setting the interim targets.

The Independent Expert Panel

The Independent Expert Panel was appointed by the Minister in October 2017. The Panel members are:

- The Hon. Greg Combet AM (Chair);
- Dr Penny Whetton; and
- Dr Lorraine Stephenson.

Further information about the Panel members is at [Appendix A](#).

The Panel's **terms of reference**, which reflect the requirements of the Act, is at [Appendix B](#).

Stakeholder engagement for this advice

The Panel has engaged with a wide range of stakeholders including businesses, researchers, non-government organisations, representative bodies, Traditional Owners and other relevant parties.

- The Panel held two stakeholder roundtables that brought together representatives from business groups, environmental and social non-government organisations, and peak bodies of key sectors.
- The Panel met with leading climate change policy and sectoral experts.
- The Panel visited the Latrobe Valley and held a roundtable with stakeholders from the region.
- From 29 March to 1 May 2018, the Panel invited submissions to an issues paper on setting interim targets. The Panel received 418 responses from 47 organisations and 371 individuals.
- The Panel also met with individual stakeholders from a range of sectors and received input from Victorian Government departments.

A list of organisations participating in these consultations and responding to the issues paper can be found at [Appendix C](#).

This engagement has been valuable to gather a range of views on interim targets and emissions trajectories, what evidence should be considered, what emissions reduction opportunities exist and potential impacts and opportunities of Victorian emissions reduction targets.

The role of state-based interim targets

The role of state-based interim targets, and how these fit within the national context, has been an important consideration for the Panel in coming to this task.

Many stakeholders participating in consultation with the Panel have been very supportive of Victoria establishing its interim targets. Some others, however, have suggested that there is no role for the Victorian Government to set emissions reduction targets – and that emissions reduction goals should only be set nationally – due to concerns about inefficiency and, if state and national targets differed, inconsistent investment signals and competitiveness impacts.

The Panel agrees that the state government faces constraints as it does not control all “policy levers” and that in some cases national action may be more practical or efficient. As such, an appropriate level of national action will also be required.

Nonetheless, the Panel is firmly of the view that Victorian interim targets can play an important role. Interim targets are part of the Victorian Government's role in planning for the future, as it does in many other areas such as on the economy, jobs, transport and water supply. Setting strong targets now can maximise the benefits and minimise the costs to Victoria of

transitioning to a net zero emissions economy by 2050. Victorian targets can also influence the approach of the Commonwealth and of other states, territories and jurisdictions.

Interim targets can provide a clear signal to business and investors and drive Victorian policy to reduce emissions through energy efficiency, renewable energy, industry policy and urban and public transport planning to name but a few areas. Targets can also help ensure Victoria's long-term prosperity by improving Victoria's attractiveness to – and competitiveness in – low-emissions industries.

Finally, the solution to tackling climate change can only be global. Targets can help ensure that Victoria contributes its fair share to the action being taken by the global community to limit global warming and therefore avoid the worst impacts of climate change. Only by doing so can Victoria expect others, particularly those with fewer resources, to strengthen their existing actions. This is particularly important for Victoria given that Australia is one of the developed countries most vulnerable to climate change impacts.³

Guiding principles and objectives

The Panel has condensed what it views as the role of Victoria's interim targets, informed by the *Climate Change Act 2017*, into two key objectives. These have framed the development of the Panel's advice. They are:

- **Set a clear pathway to net zero emissions by 2050 and drive Victoria's transition to a low-emissions economy** by giving investors, businesses, the community and the Victorian Government a credible and clear signal for planning, investment, innovation, behavioural change, and policy action.
- **Maintain environmental effectiveness** by ensuring that Victoria's emissions are reduced to net zero by 2050 in a way that is consistent with the international agreement to hold the global average temperature increase to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (as set out in the Preamble to the Act).

The Panel has also adopted a set of principles to guide its advice. These reflect and build upon the policy objectives and guiding principles in sections 22-28 of the Act that the Panel is obliged to consider. The Panel's principles are:

- environmental effectiveness;
- economic efficiency;
- equity;
- flexibility;
- investor certainty; and
- policy coherence.

Further details can be found in [Appendix D](#).

2. CONTEXT: CLIMATE SCIENCE AND IMPACTS

SUMMARY:

- The Earth has already warmed by 1°C since pre-industrial times due to human activities. The impacts of climate change are already being experienced in Victoria and around the world through rising temperatures, decreased rainfall, more extreme fire weather and heatwaves, and rising sea levels.
- The Intergovernmental Panel on Climate Change warns that if emissions continue to grow at the rate of recent decades, the world is at risk of food insecurity, widespread displacement of people due to extreme events, increased illness and death from heatwaves, extensive species extinction and ecosystem collapse.
- There are large differences in projected impacts between 1.5°C and 2°C, but even 1.5°C of warming could have significant impacts such as the loss of 70-90% of the world's coral reef cover. It is projected that at current rates of warming we could reach 1.5°C as early as 2030.
- In Victoria, unaddressed climate change is projected to significantly impact Victoria's infrastructure, water security, agricultural production, biodiversity, alpine and coastal areas, Aboriginal heritage, and the health of all Victorians.
- Strong global action to reduce emissions can help avoid the worst impacts and improve the prospects of the Victorian community being able to successfully adapt to the changes that do occur.

The world is warming

Climate change is already being observed and experienced around the world. January 2019 was the 409th consecutive month where global average temperatures exceeded the 20th century average⁴ - anyone under the age of 34 has never experienced a below-average monthly temperature. The Intergovernmental Panel on Climate Change's (IPCC) most recent report concludes that by 2017 the Earth had already reached 1°C of warming due to human activities compared to pre-industrial times⁵. Australia has warmed by more than 1°C⁶. Already, more intense heavy rainfall events, reduced growth of crops, shrinking glaciers and other impacts have been attributed to climate change⁷. Some warming is already locked in due to past emissions, but the extent of future warming after 2030 depends on how much greenhouse gases the global community emits now and in the future.

Global impacts could be severe

If warming continues at the current rate, the world is projected to reach the 1.5°C mark sometime between 2030 and 2052⁸. The IPCC's Special Report on the impacts of global warming of 1.5°C (2018) paints a stark picture of the dangers of reaching even 1.5°C above pre-industrial temperatures, only around 0.5°C warmer than today. In a 1.5°C world, more than 350 million additional people could be exposed to deadly heat stress globally;⁹ half the geographic range of 6% of insects, 8% of plants and 4% of vertebrates would disappear; and there is the possibility that Greenland and West Antarctic ice sheet instability would trigger multiple metres of sea level rise over the coming centuries.¹⁰

The IPCC report shows that no level of warming is safe and demonstrates the importance of limiting temperature increases as much as possible. For example, at 1.5°C, coral reefs are projected to lose 70-90% cover; at 2°C

of warming they would be lost completely.¹¹ Warming of 2°C would also see a greater risk of the multiple threats from climate change occurring in the same place and at the same time. These compound risks would lead to new hazards and exacerbate current ones.¹² A compound event was seen in Tasmania in January 2016, with part of the State experiencing bushfires, at the same time as heavy rainfall caused flooding in other areas.¹³ This is a particular challenge for emergency responders.

If emissions continue to grow at the rate of recent decades and don't peak until 2100, scientists estimate that the world is likely to be 4°C warmer than pre-industrial times by the end of the century, and continue to warm thereafter.¹⁴ The IPCC projects that such a 4°C world would see a high risk of extensive species extinction and ecosystem collapse, both on land and in marine environments; reduced crop yields and large risks to food security; displacement of people due to extreme events; and an increased risk of illness and death from heatwaves.¹⁵ A recent national assessment conducted for the United States found that continuing climate change could cost the United States economy billions of dollars per year by the end of the century.¹⁶ The biggest financial losses are expected to be felt due to declining labour productivity in a hotter climate, heat-related mortality and damage to coastal property.

A 4°C world would also lead to a substantially greater risk of breaching "tipping points" or thresholds of change that trigger abrupt and irreversible changes in human and natural systems, such as melting of ice sheets.¹⁷ Defence experts have described climate change as an 'existential threat' to society.¹⁸

In their responses to the Panel's issues paper, most individual submissions and many stakeholder submissions (e.g. from Beyond Zero Emissions, Climate Council, Environment Victoria and a range of local councils) expressed their sense of urgency about the task of significantly reducing emissions by 2030 to help avoid the worst impacts of climate change.

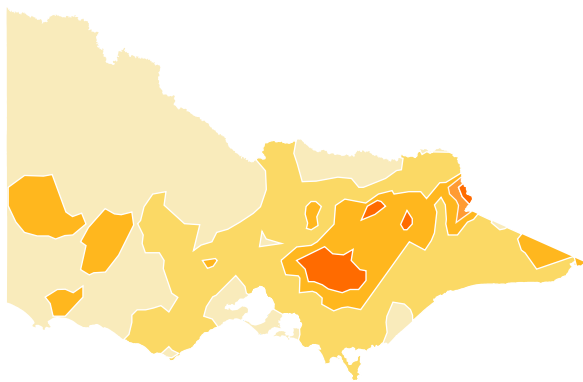
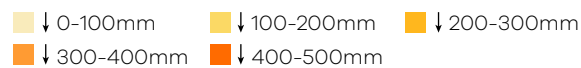
Victoria has already become warmer and drier - a climate trend likely to continue

Locally, climate change is already affecting Victoria's communities, economy and environment.

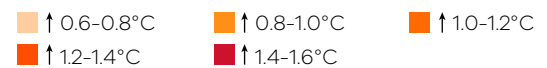
Victoria has already seen a rise in temperature since 1910 and a change in rainfall patterns in recent decades, with a notable decline in autumn and winter rainfall since the 1990s (**Figure 2.1**).

Figure 2.1 Temperature and rainfall change in Victoria since 1950

Total rainfall change since 1950



Total temperature change since 1950



Source: Department of Environment, Land, Water and Planning (2015) *Climate-ready Victoria*.

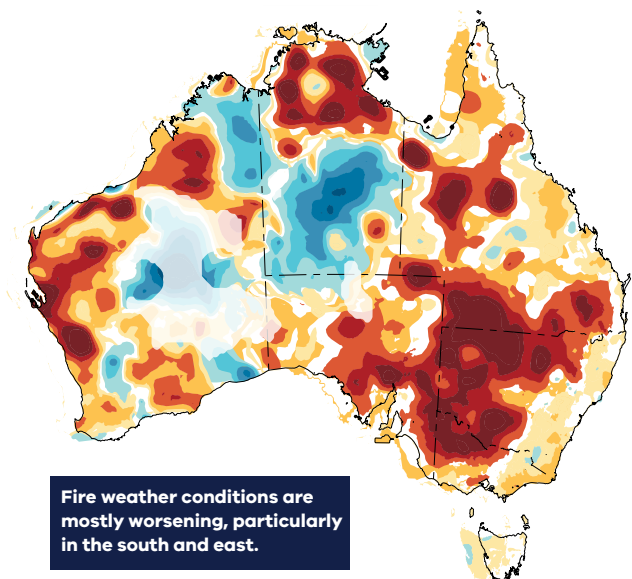
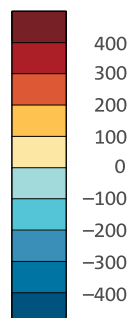
There has been an increase in extreme fire weather, and a longer fire season, across large parts of Australia since the 1970s (**Figure 2.2**).¹⁹

The sea level around the coast of Australia has risen by an average of 2.1mm per year since the 1960s.²⁰

Figure 2.2 Changing fires weather conditions in Australia

Trends from 1978 to 2017 in the annual (July to June) sum of the daily Forest Fire Danger Index - an indicator of the severity of fire weather conditions. Positive trends, shown in the yellow to red colours, are indicative of an increasing length and intensity of the fire weather season.

Forest Fire
Danger Index
points/decade



Fire weather conditions are mostly worsening, particularly in the south and east.

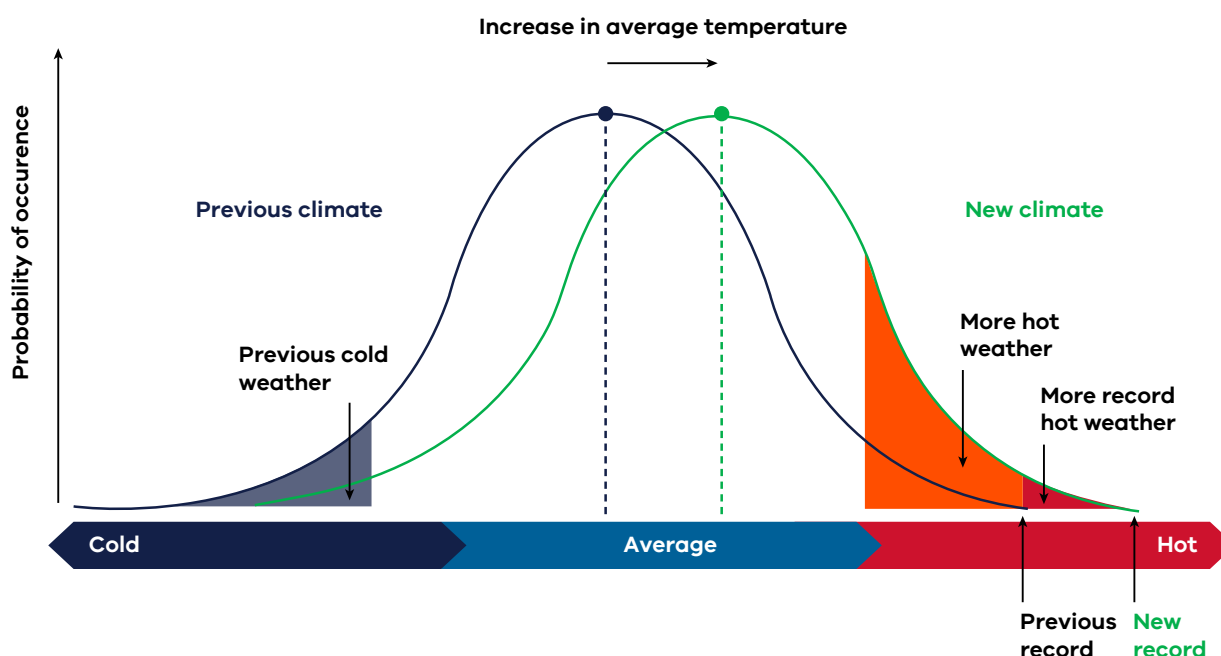
Source: Bureau of Meteorology

Source: BOM 2018 *State of the Climate*

Due to the warmer atmosphere and ocean, extreme hot weather (such as very hot days or warm nights, and heatwaves) is more likely to occur than in the past (**Figure 2.3**). Other extreme weather events, such as extreme fire weather, severe droughts and intense heavy rainfall, are also more likely. This is consistent with observed trends in extreme weather in Victoria in recent years: for example, the January-February 2009 heatwave which saw Victoria's highest temperature recorded (48.8°C in Hopetoun in the state's northwest);²¹ the Black Saturday bushfires (Australia's deadliest ever, killing 173 people) and 374 additional heat-

related deaths; large areas of the state receiving an entire summer's worth of rain in six days in January 2011, leading to severe flooding²²; and an extensive heatwave in northern Victoria in April 2018 characterised as more typical of mid-summer than mid-autumn.²³ In Victoria, there is a trend toward more severe heatwaves. For example, in Melbourne heatwaves have been on average 17 days earlier and are 1.5°C hotter than between 1950 and 1980.²⁴ A continuation of this trend would have significant impacts for the Victorian economy (**Box 2.1**) and community (**Box 2.2**).

Figure 2.3 The relationship between climate averages and extremes



Source: Climate Change Authority (2014) *Reducing Australia's Greenhouse Gas Emissions: Targets and Progress Review*.

Box 2.1 The economic impact of heatwaves on Victoria

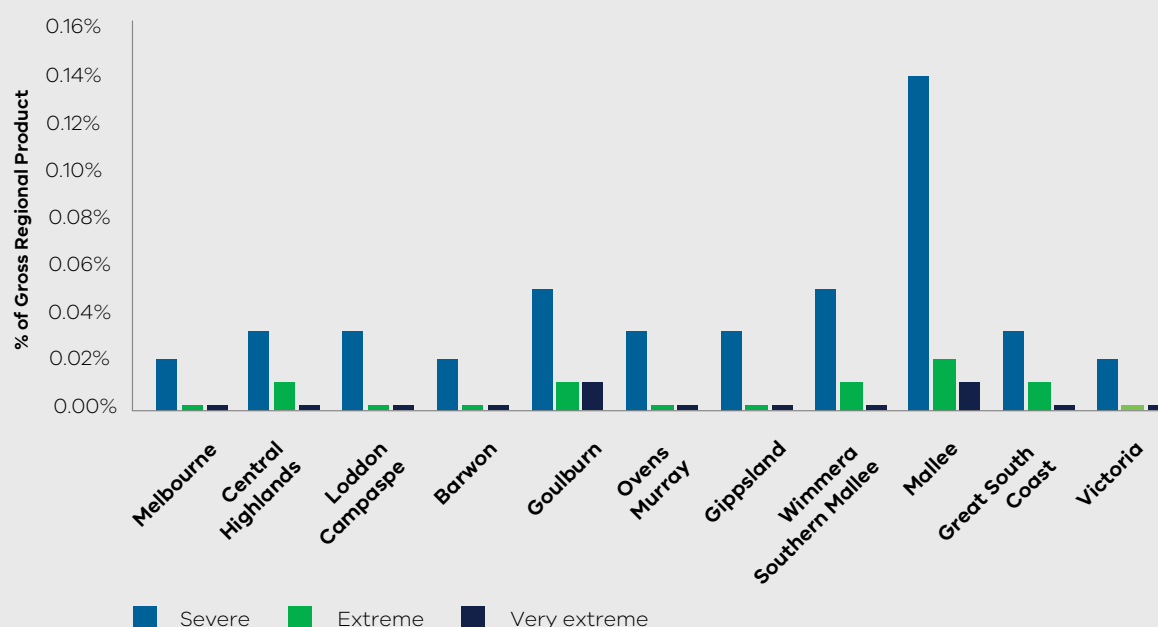
Heatwaves already have a significant impact on the Victorian economy, and this could worsen over time if no action is taken. If climate change continues and Victoria does not take steps to adapt, Victoria's economic vulnerability will substantially increase. For example, without global action, Victoria can expect to experience a severe heatwave every year by 2030 – doubling the current event frequency and the costs to the economy.

Severe heatwaves currently impact the state every two years at an estimated cost of \$131 million. Extreme heatwaves, such as those experienced by Victoria in 2009 and 2014, typically occur every 25 years and cost the state an estimated \$291 million. A "very extreme" heatwave (an unprecedented, one in 110-year event, with an intensity 10% higher than that experienced in January 2014) would strip \$1 billion from the Victorian economy. Averaged over time,

these three types of heatwave events cost Victoria 0.025% of Gross State Product (around \$87 million) every year. These are very conservative estimates, which do not account for the cost of cross-sectoral impacts or the value of the environment to the Victorian economy. Under a "very extreme" heatwave event, it is likely that many environmental services would be irreparably impacted.

The aggregate economic impacts of heatwaves are not evenly distributed across Victoria. **Figure 2.4** shows the distribution of impacts as a percentage of Gross Regional Product (GRP). Whilst Melbourne faces the highest value economic impact, these results show that regional economies with a high dependency on the agriculture sector are most vulnerable to heatwaves. For severe level heatwave events, almost half of the total economic impacts are incurred by the agriculture sector.

Figure 2.4 Annual expected impacts of heatwaves as a % of Gross Regional Product (GRP)



Source: Natural Capital Economics (2018). *Heatwaves in Victoria: a vulnerability assessment*. Report prepared for the Department of Environment, Land, Water and Planning, Vic.

Victoria in a 4°C world

A global climate 4°C warmer than pre-industrial times would have wide-ranging and significant impacts for Australia and Victoria. The potential impacts on some important parts of society are outlined in **Box 2.2**.

Box 2.2 Potential impacts of climate change on Victoria in a 4°C world

HEALTH

In a world that is 4°C warmer, Melbourne is projected to experience at least 24 days per year over 35°C, more than double the current number. Heatwaves would become more frequent and longer, with their effects amplified in cities due to the heat built up and stored in urban areas (known as the “urban heat island effect”).²⁵

Heatwaves cause more deaths than any other natural disaster in Victoria.²⁶ One study found that if the State doesn’t adapt, there will be an average of 400 extra deaths per year in Melbourne by 2050 from heatwaves caused by climate change. These deaths are on top of the current estimate of 330 deaths per year and beyond what would normally be expected with population growth.²⁷

Climate change may result in health impacts through poorer air quality, as international studies indicate a hotter climate, with more heatwaves, could result in greater ozone production and a hotter climate with less rain is associated with higher levels of particulate matter. Climate change may also contribute indirectly to poorer air quality through an increase the occurrence of fire weather and dust storms, as well as affecting the production and dispersion of allergens such as pollens²⁸.

In addition, a 4°C world is projected to see risks to health from the increased frequency of extreme weather events, associated mental health impacts, and changes to the distribution of vector-borne diseases such as Ross River fever.²⁹

In their submission to the Panel’s issues paper, Doctors for the Environment expressed their concern about multiple adverse health effects for Victorians because of unmitigated climate change, including effects from extreme weather events, access to adequate food and water, and air quality.

INFRASTRUCTURE

Both public and private infrastructure would be severely impacted in a 4°C world by the increasing frequency and intensity of extreme weather events such as flooding, fire, heatwaves and storm-surge inundation. This could put critical water, transport, energy and telecommunications infrastructure under strain and leave Victorians at increased risk of outages of vital services.

For example, the heatwave in early 2009 in Victoria had significant impacts. Record demand for electricity as people kept cool with air conditioners led to the failure of parts of the electricity network, with 500,000 people in Melbourne losing power on one day. The train network also struggled, with buckled tracks, loss of power and air conditioning failures leading to more than one-third of train services being cancelled.³⁰

As well as the potential for damage by extreme weather events and increased maintenance costs, buildings will become less comfortable for occupants as temperatures increase.

ALPINE AREAS

The alpine environment is one of the most vulnerable ecosystems in the country.³¹ In a 4°C world, a recent study estimates that the Victorian alpine resorts could receive about 60-80% less snow compared with recent decades.³² While variation between years would continue, the ski season would likely be 65-90% shorter than at the start of this century,³³ negatively affecting the alpine communities that rely on winter tourism for their income. The fragile alpine environments that rely on snow cover would disappear.

WATER

Victorians are projected to face increasing risk of water shortages in a 4°C world. Reduced rainfall in the cool season (April–October) has already been seen in recent decades in Victoria.³⁴ The changes in cool-season rainfall observed during the Millennium Drought were equivalent to drier projections of average rainfall at 2060.³⁵ While the extent of projected changes in rainfall is less certain than for temperature, rainfall and consequently runoff in Victoria are projected to decline. This would lead to less water being available for Victoria's communities, industries and environment.

For example, Bendigo is projected to have a water supply shortfall as population growth increases demand and climate change reduces supply. This is projected to continue over the long term, with the supply shortfall in 2065 projected to be as high as 28,000ML – an amount which is double Bendigo's current water use of 15,000ML.³⁶

While the average annual rainfall is projected to decline, the rain that does fall is expected to fall in more intense downpours, leading to an increased risk of flooding of rivers and creeks and the resulting risks to safety and damage to infrastructure.

PRIMARY PRODUCTION

The agriculture industry is highly sensitive to changes in climate. Nationally, there has been a 27% decrease in wheat productivity in the last 30 years, relative to expectations, due to reductions in growing season rainfall.³⁷ In Victoria, climate change is already affecting the spatial distribution of crops.

Rising temperatures and reduced water availability from climate change will adversely affect many crop yields and change the locations where certain crops are viable. In a warmer world, livestock would need increased shelter from high temperatures. If the future climate is at

the drier end of projections, it is expected that a significant decrease in agricultural productivity would occur in the Murray–Darling Basin.³⁸ The Garnaut Review (2008) estimated that under a scenario of no climate change mitigation, irrigated production in the Murray–Darling Basin would fall very significantly by 2100, affecting dairy, fruit, vegetables and grains.³⁹

While many lessons about coping with drought were learned from the extended Millennium Drought from 1996 to 2009, the projected increase in frequency and duration of extreme droughts, when combined with the other pressures facing rural areas, would further test the resilience of the agriculture industry and its contribution to the economy, and risk rising levels of farmer debt and mental health problems.⁴⁰ One individual submission to the Panel's issues paper stated that "as a farmer, climate change will define my career challenges and livelihood security".

ABORIGINAL CULTURAL HERITAGE

Victoria is home to many sites of cultural and spiritual importance to Aboriginal people, who have been the custodians of the land and water now known as Victoria for at least 40,000 years. The Victorian Aboriginal Heritage Council has expressed concern that many of these places of significance are already impacted by a changing climate and would be further threatened by increased climate change. For example, a hotter and drier climate has the potential to significantly impact Australia's earliest aquaculture system, the Budj Bim National Heritage Landscape – Tyrendarra Area in south-west Victoria. Severe coastal erosion and sea level rise are threatening cultural heritage sites at Point Ritchie–Moyjil, at the mouth of the Hopkins River, Warrnambool. In north-west Victoria, heat, erosion and extreme winds are already exposing traditional Aboriginal burial places.



BIODIVERSITY

Victoria's diverse and precious natural environment would face irreversible changes in a 4°C world. While some species have a capacity to adapt and cope with variation in climate, the extent of changes in temperature, moisture availability and fire regimes would likely lead to irreversible damage to and disappearance of many ecosystems. While climate change itself will have impacts on biodiversity, adaptation measures including changes to agriculture systems, hazard reduction policies or water allocations may also increase pressure on ecosystems.⁴¹

The impact of more frequent fires is already evident in the Victorian alpine region. For example, repeated fires from 2003 to 2013 killed mature alpine ash trees and prevented regrowth from reaching maturity and producing seed. The forest has only been retained through an active reseedling program.⁴²

As another example, the impact of temperature alone is expected to have a big impact on mountain ash forests in the Central Highlands of Victoria. A study found that a temperature increase of 3°C could lead to reduced tree density of 15%, with trees no longer being able to grow from seed across much of their current range⁴³.

For marine biodiversity, warmer oceans would likely see species from warmer northern waters continue to move further

southwards to Victoria, changing fisheries and potentially bringing new pest species. This, combined with increased ocean acidification that hinders the ability of marine organisms to form shells and skeletons, would drastically alter food webs and ecosystems.⁴⁴

COASTS

Coastal areas in Victoria have already been impacted by climate change, with the risks posed to life, coastal infrastructure and biodiversity set to increase in a 4°C world.

The 0.4 to 0.9m of sea level rise projected for the Victorian coast by 2100 in a 4°C world⁴⁵ is projected to lead to increased flooding of low-lying coastal areas, dune erosion, loss of beaches and coastal ecosystems, damage to coastal infrastructure and reduced public access to coastal environments. If the West Antarctic ice destabilises this century, the global average sea level could rise by an additional tens of centimetres this century.⁴⁶ In the much longer term, irreversible melting of ice sheets could lead to many metres of sea level rise.⁴⁷

Taking into account the projected sea level rise of 0.4 to 0.9m mentioned above, as well as storm surges, coastal assets would need to be built 0.8m higher than their current levels to maintain their current frequency of breaches from the ocean to 2100.⁴⁸

Climate comparisons

Climate analogues illustrate the future climate of specific cities and towns by matching their projected climate to locations that currently have a similar rainfall and temperature.⁴⁹ The comparisons in **Figure 2.5** show that, in a 4°C

world, Victorian towns are projected to become more like hotter and drier locations to the north. For example, in 2090, Melbourne's climate will be like Dubbo's climate is today.

Figure 2.5 Victoria in a 4°C world



Source: *Climate Change in Australia*, Climate analogues website: www.climatechangeinaustralia.gov.au/en/climate-projections/climate-analogues/about-analogues/.

Avoiding the worst impacts

The international community has already committed to take action to limit the global temperature increase to well below 2°C and to pursue efforts to limit the increase to 1.5°C. The IPCC Special Report on the impacts of global warming of 1.5°C articulates the significant benefits to human and natural systems of limiting warming as much as possible, and that the difference in impacts is significant even between these two temperature goals.

If the world is successful in limiting the global temperature increase to 1.5°C, many of the

worst projected impacts of climate change in Victoria could be avoided. The impacts of climate change would still be felt in a 1.5°C world but would be less severe than the 4°C world described earlier, and less severe even than a 2°C world. **Table 2.1** gives a comparison of the future climate in a 1.5°C world and 4°C world.⁵⁰

The reduced extent of the changes would mean that Victoria's communities, environment and economy would be better able to cope with the impacts. The ability to adapt reduces the risk to many sectors to low or very low levels,⁵¹ improving the prospects of Victoria remaining a prosperous and liveable state.

Table 2.1 Projected changes for key climate variables in a 1.5°C and a 4°C world in 2090 relative to 1995

Variable	1.5°C world south of Great Dividing Range	4°C world south of Great Dividing Range	1.5°C world north of Great Dividing Range	4°C world north of Great Dividing Range
Average annual temperature change relative to 1995 (°C)	0.4 to 1.3	2.5 to 4.0	0.6 to 1.5	2.7 to 4.5
Average annual rainfall (% change)	-8 to +2	-19 to +5	-19 to +3	-27 to +9
Days above 35°C per year	12 to 17 (Melbourne)	19 to 32 (Melbourne)	39 to 50 (Mildura)	60 to 85 (Mildura)
Sea level rise (m) (Stony Point)	0.22 to 0.53	0.38 to 0.81	-	-

Source: Data taken from *Climate Change in Australia*, with 1.5°C world represented by RCP2.6 at 2090 and 4°C world by RCP8.5 at 2090. The ranges given correspond to the 10th and 90th percentiles of model simulations.

3. CONTEXT: CLIMATE POLICY AND OTHER DEVELOPMENTS

SUMMARY:

- The international community has committed to limiting the global average temperature increase from pre-industrial levels to well below 2°C and to pursue efforts to limit the increase to 1.5°C.
- 182 countries representing around 90% of global emissions have submitted their nationally determined contributions that outline national emissions reduction targets and adaptation plans under the Paris Agreement. While these national targets currently fall short of agreed temperature goals, the Agreement includes a process for countries to revisit and, where possible, increase their commitments starting from 2023.
- Alongside Victoria, many sub-national jurisdictions around the world, including most Australian states and territories, have also set targets for reducing emissions and are pursuing decarbonisation pathways. One study of the targets of 120 sub-national governments found that the average decarbonisation rate implied was close to that required for 2°C.
- While Australia's emissions are currently increasing, the Victorian Government has taken steps to reduce Victoria's emissions, for example through the Victorian Renewable Energy Target and the Victorian Energy Upgrades program.
- A wide range of businesses and investors in Australia and globally are also acting on climate change, driven by new markets, falling costs, shifting consumer preferences and an increased focus on the business risks of failing to act.


Climate policy

International

While climate change will continue to have an impact into the future, the worst impacts can be avoided with strong global action. In December 2015, the international community agreed, through the Paris Agreement,⁵² to limit the increase in the global average temperature to well below 2°C and to pursue efforts to limit the temperature increase to 1.5°C (the Paris goal). To achieve this goal, the Paris Agreement sets a new aim of balancing “anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century” – which Victoria's net zero emissions by 2050 target aligns with. The Paris Agreement builds upon the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and 1997 Kyoto Protocol.

Australia is a Party to the Paris Agreement. The Agreement requires all Parties to set post-2020 emissions reduction targets, called Nationally Determined Contributions (NDCs). Of the 197 Parties to the Agreement, 185 have ratified it (binding them under international law), and 182 have submitted an NDC – covering around 90% of global emissions. This includes China, India and the members of the European Union. China, the world's largest emitter, has launched a nationwide emissions-trading scheme⁵³, and committed to peaking its emissions by 2030⁵⁴.

The Paris Agreement includes a five-yearly cycle for the review NDCs once they are confirmed in 2020. The first “global stocktake” of progress will occur in 2023, with the intention that Parties revisit their commitments and increase these where possible⁵⁵. Parties are not permitted to reduce their level of ambition.



NDCs pledged by Parties to date are projected to result in about 3°C of warming by 2100. The UN Environment Programme estimates that current NDCs must be roughly tripled to limit global temperatures to 2°C. They must be increased fivefold to achieve a 1.5°C scenario. If NDCs are not increased before 2030, 1.5°C of warming will be unavoidable⁵⁶.

National

National climate and energy policy provides an important context for considering interim targets, as it has a significant effect on Victoria's emissions and strong interactions with Victoria's climate and energy policies.

Australia has committed to reduce its emissions by 26-28% below 2005 levels by 2030 in its NDC and to develop an emissions budget for the period 2021-2030⁵⁷. This follows earlier commitments to keep annual emissions to 108% of 1990 levels on average during the

Kyoto Protocol's first commitment period (2008-2012), to 99.5% of 1990 levels on average during the second commitment period (2013-2020), and to reduce emissions by 5% below 2000 levels by 2020.

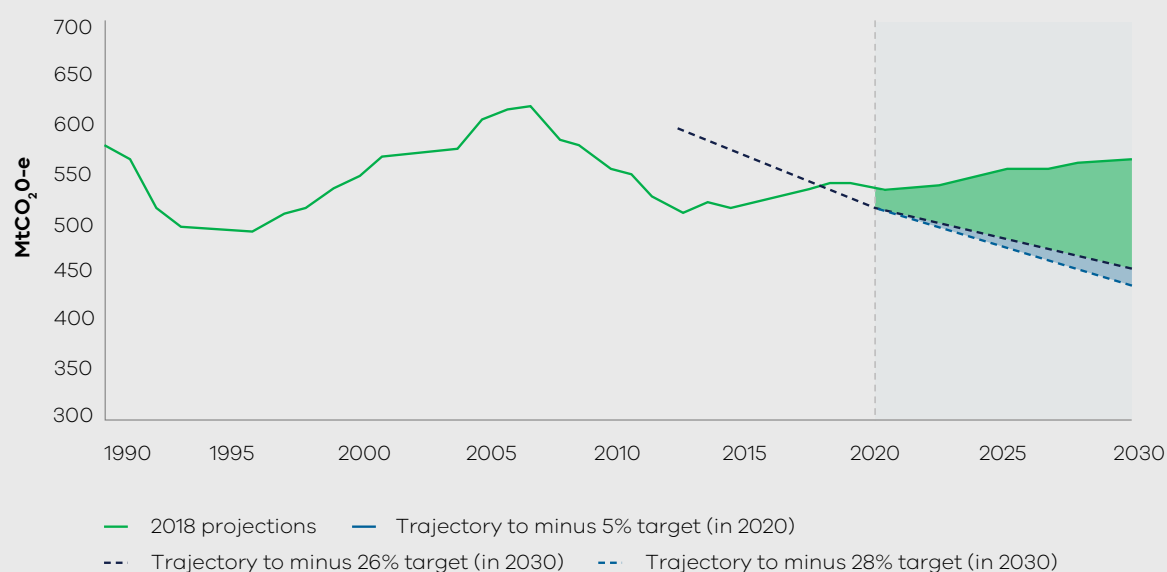
Australia's current key national climate change policies include the Renewable Energy Target⁵⁸, the Emissions Reduction Fund⁵⁹ and its Safeguard Mechanism,⁶⁰ and the National Energy Productivity Plan⁶¹. The latest projections from the Commonwealth Government Department of the Environment and Energy (DOEE) illustrate that under the policies in place in December 2018 Australia was not projected to meet its 2030 target (**Box 3.1**). In February 2019, the Commonwealth government announced further climate policies, including an additional \$2 billion funding for the Emissions Reduction Fund and additional focus on improving energy efficiency⁶².

Box 3.1 Australia's emissions trends and projections, 1990 – 2030

Australia's emissions are significant on a global scale. In 2014, Australia had the 13th-highest emissions of 192 countries.⁶³ Australia had the highest per capita emissions in the Organisation for Economic Co-operation and Development (OECD), with more than 22 tonnes of emissions per person in 2016.⁶⁴ This is due in part to the high emissions intensity of Australia's electricity generation.

Data from the DOEE shows that Australia's emissions are currently increasing⁶⁵ and latest projections show a continued steady increase in emissions⁶⁶ (Figure 3.1). In December 2018, DOEE projected Australia's emissions to be 8% below 2005 levels in 2030, whereas Australia's target under the Paris Agreement is to reduce emissions by 26–28% below 2005 levels by 2030.

Figure 3.1 Australia's emissions trends and projections, 1990 to 2030



Source: Modified from Australia's emission projections 2018, DOEE

Victoria

Climate policy in Victoria is grounded in Victoria's *Climate Change Act 2017*, which provides a legislative foundation to drive Victoria's transition to a net zero emissions, climate-resilient community and economy. The Act:

- legislates a long-term emissions reduction target of net zero emissions by 2050;
- requires the Premier and the Minister to set five-yearly interim targets from 2021, to keep Victoria on track to meet the long-term target;
- requires the Minister to develop a Climate Change Strategy every five years (with the first due by 1 August 2020), setting out how Victoria will meet its targets and adapt to the impacts of climate change;
- establishes a pledging model to reduce emissions from state and local governments' own operations as well as from key emitting sectors of the economy;
- introduces a new set of policy objectives and an updated set of guiding principles to embed climate change into government decision-making;
- requires Adaptation Action Plans be prepared every five years (from 2021) for key systems such as water, farming and health that are either vulnerable to the inevitable impacts of climate change, or are essential to ensure Victoria is prepared for the impacts; and
- establishes a system of regular reporting on Victoria's emissions and actions to provide transparency and accountability.

In 2016, the Victorian Government released Victoria's Climate Change Framework⁶⁷ (the Framework) which articulates the Government's long-term vision for 2050 and how the Government will drive the economic transition to a net zero emissions economy. The Framework also establishes two key emissions reduction targets for 2020:

- to reduce Victoria's emissions by 15-20% below 2005 levels,⁶⁸ and
- to reduce office-based emissions from government operations by 30% below 2015 levels.

Key policies

At present, Victoria's key policies to reduce emissions are:

- The Victorian Renewable Energy Targets⁶⁹ (VRET) of 25% of electricity generated in the state by 2020, 40% by 2025, and 50% by 2030.
- The Victorian Energy Upgrades program,⁷⁰ under which energy retailer companies must meet their share of an annual emissions reduction target by supporting the uptake of products and services that improve household and business energy efficiency.
- TAKE2,⁷¹ a voluntary pledge and review process focused on reducing emissions and building capacity and knowledge to identify and implement climate change actions. Pledges can be made by local governments, businesses, community groups, education organisations and individuals.
- New Energy Technologies Strategy,⁷² which focuses on investing in clean energy generation technology, strengthening sector skills, collaboration and innovation, encouraging the development of new consumer-driven markets, and building state-wide capabilities.

Victoria has a broader range of policies and measures that may contribute to reducing emissions. These are explored in further detail in **Chapter 6**.

Other sub-national jurisdictions


Within Australia

Other Australian states and territories are also advancing their climate policies (**Table 3.1**). Like Victoria, New South Wales, Queensland, South

Australia, and Tasmania have committed to net zero emissions by 2050, while the Australian Capital Territory (ACT) recently brought their net zero emissions deadline forward to 2045. Together these jurisdictions represent over 80% of Australia's emissions.

Table 3.1 Comparison of Australian state and territory emissions reduction targets

State or Territory	Long-term target	Interim emissions reduction target/s	Other key targets
ACT	<ul style="list-style-type: none"> Net zero emissions by 2045 (<i>legislated</i>) 	<ul style="list-style-type: none"> 40% below 1990 levels by 2020 50-60% below 1990 levels by 2025 65-75% below 1990 levels by 2030 90-95% below 1990 levels by 2040 <p>(all legislated)</p>	<ul style="list-style-type: none"> 100% renewable electricity by 2020
NSW	<ul style="list-style-type: none"> Net zero emissions by 2050 		
Queensland	<ul style="list-style-type: none"> Net zero emissions by 2050 	<ul style="list-style-type: none"> 30% below 2005 levels by 2030 	<ul style="list-style-type: none"> 50% renewable energy by 2030
South Australia	<ul style="list-style-type: none"> Net zero emissions by 2050 This supersedes the target in South Australia's <i>Climate Change and Greenhouse Emissions Reduction Act 2007</i> to reduce emissions by at least 60% below 1990 levels by 2050 (<i>legislated</i>) 		<ul style="list-style-type: none"> 75% of electricity from renewable sources by 2025



State or Territory	Long-term target	Interim emissions reduction target/s	Other key targets
Tasmania	<ul style="list-style-type: none"> Net zero emissions by 2050 This supersedes the target in Tasmania's <i>Climate Change (State Action) Act 2008</i> 60% below 1990 levels by 31 December 2050 (<i>legislated</i>) 		
Victoria	<ul style="list-style-type: none"> Net zero emissions by 2050 (<i>legislated</i>) 	<ul style="list-style-type: none"> 15-20% below 2005 levels by 2020 	<ul style="list-style-type: none"> 25% of electricity generated from renewable sources by 2020 and 40% by 2025 (<i>legislated</i>), 50% by 2030 (<i>policy commitment</i>) Victorian Energy Upgrades Program: emissions reduction target 6.5 MtCO₂e in 2020. (<i>obligation on energy retail companies, target represents deeming of emissions savings in future years</i>)

Around the world

Sub-national governments in other countries are also acting on climate change. For example, California (United States), British Columbia (Canada), Baden-Württemberg (Germany), Scotland and Wales (United Kingdom) have set ambitious 2050 targets and interim targets (in 2020 or 2030). A coordinated set of submissions to the Panel's issues paper from 267 individuals recommended that consideration be given to the targets set by the United Kingdom, Scotland and California.

A recent study of sub-national targets found that the planned average annual decarbonisation rate of the 120 sub-nationals studied (4% to 2030 and 9.5% from 2030-2050) is close to the rate required for 2°C and is more ambitious than that of the G20 NDCs. Those states and territories studied tended to have more ambitious 2030 targets than their national government⁷³.

Stated reasons for sub-national action include supporting regional and international commitments, such as the Paris Agreement, the absence of strong national policy, and a desire to provide leadership and demonstrate reforms that may be adopted at the national level. The protection of public health and welfare and the safeguarding of natural resources is also a strong driver of sub-national ambition.

In May 2015, the "Under2 Coalition" was formed, bringing together state, regional and local governments committed to supporting the Paris Agreement goal of keeping the rise in global temperature to well below 2°C. Members must sign the "Under2 MOU" (Subnational Global Climate Leadership Memorandum of Understanding), a commitment to limit emissions to two tonnes per capita by 2050 (by comparison, in 2015, Victorians emitted about 18 tonnes of emissions per capita). To date, 220 jurisdictions from 43 countries and six continents, including Victoria, have signed or endorsed the Under2 MOU. Together these represent 1.3 billion people and 43% of the global economy⁷⁴.

Private sector action

Businesses and investors are increasingly acting on climate change, not only due to climate policies but also because it makes economic sense, with new markets and opportunities, falling costs, growing consumer pressure and increased focus on the business risks from failing to act. Corporate governance requirements are also driving action in the sector.

Examples of the global business and investment community acknowledging and acting to manage the risks that climate change imply for their assets include:

- The International Monetary Fund's 2018 Annual Report highlights that, if unaddressed, climate change is likely to be one of the greatest economic shocks of the 21st century⁷⁵.
- The 2018 Global Investor Statement to Governments on Climate Change, signed by 415 investors representing more than US\$32 trillion in assets, calls for governments to: strengthen their strategies and policies to align with the Paris Agreement's goals; to accelerate private sector investment in the transition to a low-emissions economy through, for example, putting a meaningful price on carbon and phasing out thermal coal power by set deadlines; and to commit to improving climate-related financial reporting⁷⁶.
- The recommendations of the G20-instigated Taskforce on Climate-Related Financial Disclosures (TCFD), which have been influential in increasing voluntary reporting on risks companies face from climate change and the transition to a low-emissions economy and how these risks are being managed. TCFD supporters include major global emitters such as Shell, BHP and Rio Tinto⁷⁷.
- Black Rock, which oversees almost US\$6 trillion worth of assets, is asking companies they invest in to apply TCFD recommendations⁷⁸.

- Volvo has committed to having an electric option for all of its car models by 2019 and is planning for 50% of its global sales to be fully electric by 2025⁷⁹. Toyota and Volkswagen plan to have electric options for all of their models by 2025 and 2030 respectively.

Examples of Australian businesses, from across a range of economic sectors, that are integrating climate change into their strategies and decision making include:

- In 2017, Meat & Livestock Australia announced a target of a carbon-neutral Australian red meat industry by 2030, citing changing consumer demands and maintaining global competitiveness as key drivers for the decision⁸⁰.
- AGL Energy, Australia's largest emitter, has developed a Greenhouse Gas Policy, which includes commitments to not extend the life of any of its existing coal-fired power stations and to close them all by 2050 and to not build, finance or acquire new conventional coal-fired power stations in Australia⁸¹.
- Australia's largest infrastructure fund, the \$12 billion IFM Australian Infrastructure Fund, is working to reduce emissions at some of Australia's leading infrastructure assets including Melbourne Airport, Southern Cross Station and New South Wales electricity distributor Ausgrid⁸². The initiative is supported by a \$150 million investment from the Clean Energy Finance Corporation (CEFC) and is part of global fund IFM investors work to proactively manage its AU\$120 billion investments against the risks and opportunities from climate change⁸³.
- Victoria's largest industrial user of gas, Australian Paper, plans to construct a waste-to-energy plant that will reduce gas use at its Marysville plant by almost two-thirds and save 0.5 MtCO₂e emissions annually. Almost all of the electricity used at the plant is already sourced from renewables⁸⁴.
- GFG Alliance expects its investments in renewable energy will reduce the cost of electricity to its Whyalla and Laverton steelworks in South Australia and Victoria by about 40%⁸⁵. GFG will build 1GW of solar photovoltaics and 120MW of battery storage and has signed a 15-year power purchasing agreement with Numurkah solar farm.
- The Commonwealth Bank and Australian operations of Vodafone, Carlton & United Breweries⁸⁶, Mars⁸⁷, Telstra and Coca-Cola Amatil among others have committed to 100% renewable electricity as part of the global RE100 initiative⁸⁸. Many have already signed power purchase agreements with wind and solar farms⁸⁹.
- Nectar Farms will power and heat Australia's biggest greenhouse, once built in western Victoria, with 100% renewables.
- National Australia Bank has decided to stop all lending for new thermal coal projects. Westpac and Commonwealth Bank are undertaking climate change scenario analysis to assess the impact of different levels of warming and emissions reduction on their loan portfolios. In its 2017 annual report, the Commonwealth Bank acknowledged for the first time that climate change poses a significant risk to the bank's portfolio. ANZ has introduced a ban on financing new office buildings that lack a high environmental rating and has committed to working with 100 of its top-emitting customers to establish low-emissions transition plans for them by 2021.

In 2017, the Australian Prudential Regulation Authority stated that many climate-related financial risks were 'foreseeable, material and actionable now' and began asking Australian companies, banks, lenders and insurance companies to consider and disclose climate-related risks, as recommended by the TCFD⁹⁰. In September 2018, the Australian Securities and Investments Commission published a review of climate risk disclosure by listed companies, stating that "the law requires [annual reporting] to include a discussion of climate risk when it could affect the entity's achievement of its financial performance or disclosed outcomes".⁹¹

A range of Australian businesses are now seeking stronger, stable, long-term climate change policy. For example, 82% of executives surveyed by the Carbon Market Institute agreed that Australia should set an economy-wide net zero emissions by 2050 target, and two thirds agreed that increasing the ambition of Australia's 2030 target (e.g. to 45% below 2005) would not have significant negative impacts on economic growth.⁹² Large resource companies Woodside Petroleum, BHP and Rio Tinto have called for the implementation of a carbon price.⁹³ Business Council Australia and Ai Group have called for stable, integrated climate and energy policy.⁹⁴

4. DEVELOPING RECOMMENDATIONS FOR VICTORIA

SUMMARY:

- The Panel has built upon the robust body of existing work on developing targets, particularly by Australia's Climate Change Authority, adapting and supplementing this to suit Victoria's circumstances.
- The Panel developed a set of six target options for 2030 – 28%, 45%, 55%, 65%, 60% and 75% below 2005 levels – based on national reference points – and derived interim targets for 2025 by assuming constant or “straight line” emissions reduction between projected emissions in 2020 and the 2030 target.
- The Panel specifically assessed interim target options against:
 - Victorian emissions budgets to understand their climate effectiveness in relation to global temperature goals, trade-offs between earlier and later action and implied trajectories to 2050;
 - the availability of emissions reduction measures and technologies to achieve these targets; and
 - the potential economic, social and environmental opportunities and impacts of emissions reduction to meet the targets.
- Taken with the broader set of issues considered by the Panel, these align with legislative requirements under the *Climate Change Act 2017* and are consistent with what other jurisdictions have considered when setting their own interim targets.
- The Panel's assessment was significantly informed by consultation with and analysis from external experts, and by engagement with the public and a wide range of stakeholders.

Building on existing analysis

There is already a significant, robust body of work on developing emissions reduction targets and understanding their potential impacts (see, for example, [Box 4.1](#)). The Panel's approach has built upon this existing work and, where relevant, adapted and supplemented it to suit Victoria's circumstances.

In particular, the Climate Change Authority (CCA), an independent statutory agency established to provide expert advice to the Commonwealth Government on Australian climate change policy, has developed a significant body of analysis on emissions reduction and targets, including recommending targets for Australia of 45–65% below 2005 levels in 2030, and a pathway to reducing emissions to 2050.

In developing its advice on targets and emissions reduction pathways for Australia, the CCA considered the latest climate science, international action, Australia's progress in reducing emissions, international and inter-generational equity, the economic costs of different targets and opportunities for future emissions reduction⁹⁵.

The Panel commissioned external expert advice on whether the CCA's methodology and recommendations for emissions reduction targets for Australia could be reasonably applied to a Victorian context (Executive Summary at [Appendix E](#)).

Based on this advice, the Panel concluded that the CCA's work provided a useful starting point but that updated and Victoria-specific analysis should be undertaken. In particular, the Panel commissioned analysis of emissions budgets (**Chapter 5**) emissions reduction opportunities (**Chapter 6**) and economic impacts (**Chapter 7**); and further considered the design of a target range (**Chapter 8**) to help refine the application of national targets and recommendations to interim targets in Victoria.

The expert advice found that:

- a. **The CCA's methodology for determining a range for future emissions targets for Australia remains valid today**, and addressed similar requirements to those the Panel is required to consider under Victoria's *Climate Change Act 2017*. The CCA's work considered climate science, technology, economic impacts, and existing national and global climate change action.
- b. **National targets can be considered as broadly applicable to Victoria**, given that differences between Australia's and Victoria's emissions profile, emissions intensity of the economy and emissions per capita are minor on the whole. These are key indicators of the availability and cost of emissions reduction and form a basis for equitable sharing of emissions reduction "effort" across Australia (see **Chapter 5**).
- c. **The target levels recommended by the CCA remain valid today**. Developments since the CCA made its recommendations in 2014 - including strengthened international commitment to a below 2°C goal, sustained action at the national and sub-national level across the globe, growth in Australia's emissions (but flat global emissions) and reductions in the cost of low-emissions technologies - taken together leave findings broadly unchanged.

Box 4.1 Approaches of other sub-national jurisdictions to setting interim targets

Many sub-national jurisdictions – including Scotland, Wales, California, and the Australian Capital Territory (ACT) – already have significant experience in setting interim targets. This box presents the key lessons from reviewing the approach taken by a selection of sub-national governments with broad comparability to Victoria.

TARGET DESIGN

Most jurisdictions reviewed use a single year target, expressed as a percentage reduction on a base year. ACT set their target as a range while all others set a numeral target. Scotland and Wales also set a target for cumulative emissions within a five-year period, following the model used by the UK as a whole.^{96 97 98}

In Scotland, combining a percentage reduction target with an absolute reduction (MtCO₂e), was found to be problematic, as emissions inventory methodological updates changed the base year emissions estimate.⁹⁹

Offsets are used in many jurisdictions, particularly in conjunction with trading schemes.¹⁰⁰

TARGET-SETTING PROCESS

Sub-national governments commonly inform target design and implementation by drawing on analysis and advice from independent experts and commissioned research. Both the Scottish and Welsh governments, for example, have drawn on the advice of the independent UK

Committee on Climate Change^{101 102}. The ACT has set interim targets based on advice from the ACT Climate Change Council¹⁰³.

All target-setting processes reviewed included in-depth economic and policy modelling, as well as consideration of broader health and environmental benefits. All included consideration of “business-as-usual” emissions.

Emissions budgets, linked to global temperature goals, are used to inform target setting in Scotland, Wales and the ACT¹⁰⁴.

Consultation has been critical in the setting sub-national targets, with many jurisdictions undertaking a multi-stage process that incorporated several rounds of consultation.

LESSONS FROM TARGET IMPLEMENTATION

Political focus and cross government coordination was found to be crucial in successfully delivering emissions reduction to meet targets. In most jurisdictions energy de-carbonisation has been identified as an early priority. However, a repeated finding (ACT, California to some extent, British Columbia, Scotland and Wales) is that progress in non-energy sectors can stall if masked by headline ‘progress’¹⁰⁵.

Outside Australia, emissions trading or carbon taxes were in place in all jurisdictions reviewed. Many of these were national or regional (rather than state-based).

Developing target options for analysis

The Panel developed 2030 target options for Victoria to guide its assessment and analysis. These were based on the following national reference points, against a 2005 baseline (**Box 4.2**), which were directly applied pro-rata to Victoria:

- **26-28% below 2005 levels by 2030**, which is the Commonwealth Government's international commitment for Australia expressed in its Nationally Determined Contribution (NDC) (see **Chapter 3**);
- **55% below 2005 levels by 2030**, which is the target consistent with straight-line emissions reduction to meet the national emissions budget recommended by the CCA; and
- **45-65% below 2005 levels by 2030**, which is the recommended range around the 55% target developed by the CCA. The CCA's recommendations have not been endorsed by the Commonwealth Government.

The Panel also considered a target option of **75% below 2005 levels by 2030** to test the potential for and implications of deeper emissions cuts, aligned with the potential for greater overall international emissions reduction.

Later in the process, based on consideration of evidence on emissions budgets and emissions reduction opportunities, the Panel added a sixth target option of 60% below 2005 levels by 2030.

These 2030 target options provided a broad spread across which to understand the potential implications of different target levels.

In developing recommended interim targets, the Panel's focus has been on the transition needed in the Victorian economy over the next decade to put the state on a pathway to achieving net zero emissions by 2050. As such the Panel has derived interim targets for 2025 by assuming constant or "straight-line" emissions reduction between projected emissions in 2020 and its 2030 target options.

Box 4.2 Understanding the 2005 baseline

Emissions reduction targets are generally measured against a historical emissions reference point, or “baseline”.

Section 11 of the *Climate Change Act 2017* requires interim targets to be expressed as the amount by which Victoria’s emissions must be reduced in relation to Victoria’s emissions in 2005. This means that Victoria’s emissions in 2005 act as the reference point against which all of its emissions reduction are measured. For example:

- Victoria’s emissions in 2005 were 128 MtCO₂e. This is the emissions baseline.
- Victoria’s emissions in 2016 were 114 MtCO₂e. This represents an 11% reduction in emissions below 2005 levels.

- Emissions baselines for target setting are not consistent across countries and jurisdictions. For example, interim targets in California and in Scotland are set against a 1990 emissions baseline. To compare the targets of different countries and jurisdictions requires consideration of the effort implied by those targets (compared to emissions over time – since comparison to a single year can bias results) alongside other factors such as the make-up of the economy (and with developing countries, their capacity to act and responsibility for past emissions)¹⁰⁶.

The Commonwealth’s 2030 emissions reduction target is also set against a 2005 baseline.

Assessing target options

The Panel assessed its target options by considering:

- **A Victorian emissions budget:** this tested the environmental effectiveness of its draft target options, their consistency with global ambition under the Paris Agreement and provided a basis for developing emissions trajectories to 2050 ([Chapter 5](#));
- **Emissions reduction opportunities:** testing the achievability of the draft target options by gathering information on ways that emissions could be reduced across all sectors of the Victorian economy, based on known technologies and behaviours to reduce emissions and bearing in mind

their cost, and market factors such as deployment rates, asset turnover, return on investment, capacity etc ([Chapter 6](#)); and

- **Opportunities, impacts and co-benefits:** this built an understanding of economic opportunities and impacts and of potential social and environmental co-benefits of emissions reduction for the Victorian economy and for Victoria’s regions, industries and communities ([Chapter 7](#)).

Together with the Panel’s consideration of climate science ([Chapter 2](#)), the policy context ([Chapter 3](#)), progress in reducing Victoria’s emissions ([Chapter 6](#)) and public consultation, these pieces of work are in line with what the Panel is required to consider under the *Climate Change Act 2017*.

5. EMISSIONS BUDGETS FOR VICTORIA

SUMMARY:

- A global emissions budget is a science-based estimate of the amount of cumulative greenhouse gases that can be emitted worldwide, while providing a certain likelihood (e.g. 50%, 90%) of keeping the increase in global temperature from pre-industrial times within a specified limit (such as 2°C and 1.5°C). The Panel worked with globally recognised experts to develop Victorian emissions budgets for 2017-2050 that represent Victoria's fair share of a global emissions budget.
- Emissions budgets provide a tool to understand the implications of different temperature goals for targets, the trade-off between earlier and later emissions reduction, and the emissions reduction trajectories to 2050 implied by different target options in 2030.
- Multiple emissions trajectories, and therefore multiple 2030 targets, can be consistent with any given emissions budget and temperature goal. Different pathways distribute costs and benefits differently over time.

KEY FINDINGS:

- The world cannot continue to emit at current levels if the Paris goal is to be achieved – and neither can Victoria. At 2016 emissions levels, the Panel's 2°C-consistent emissions budget for Victoria will be exhausted in 2032, and the 1.5°C-consistent budget will be exhausted in 2026 – well before 2050. The global 2°C emissions budget will be exhausted in 2034 at current emissions levels.
- A target of 28% would imply unreasonably steep emissions reduction in the period after 2030 to remain within a 2°C-consistent emissions budget, while a target of 75% would imply unreasonably steep emissions reduction in the period before 2030.
- The Panel's recommended 2030 target range of 45-60% below 2005 levels is consistent with the Paris goal:
 - From the 45% end of the target range, emissions reduction would need to accelerate slightly to reach net zero in 2050 to be consistent with 2°C, and more rapidly to be consistent with well below 2°C.
 - From the 60% end of the target range, relatively steady emissions reduction to net zero in 2050 would be consistent with well below 2°C. Rapid emissions reduction after 2030 could bring consistency with 1.5°C within reach.
- Reaching 60% in 2030 would also provide the flexibility to reduce emissions more gradually after 2030, which may help manage the risk that emissions have become harder to reduce while still maintaining consistency with well below 2°C.
- Emissions budgets have played an important part in developing the Panel's target recommendations. Determination of interim targets post-2030 should take into consideration the emissions budgets for Victoria developed by the Panel, updated to reflect the latest climate science.

Introduction to emissions budgets

The Panel has used emissions budgets to help evaluate the environmental effectiveness of its target options and to consider trajectories to reach net zero emissions by 2050 in a way that is consistent with the Paris Agreement. Emissions budgets highlight the trade-off between earlier and later emissions reduction, providing a useful tool to evaluate target options and trajectories.

The use of emissions budgets in the interim target-setting process was widely supported by stakeholders and individuals who responded to the Panel's public consultation process. For example, the Australian Energy Council wrote "As a general principle, the concept of applying a long-term emissions budget and then subdividing into interim targets is a sound one".

Box 5.1 provides an overview of the key concepts relating to emissions budgets and trajectories.

Box 5.1 Understanding emissions budgets, targets and trajectories

A global emissions budget is an estimate of the total cumulative amount of greenhouse gases that could be emitted consistent with a certain likelihood (e.g. 50%, 67%, 90%) of keeping global temperature rise within a set limit above pre-industrial levels (e.g. 1.5°C, 2°C) by 2100. That is, a global emissions budget tells us the finite quantity of greenhouse gases that can be emitted if the world is to have a certain likelihood of keeping average temperature increase below certain thresholds.

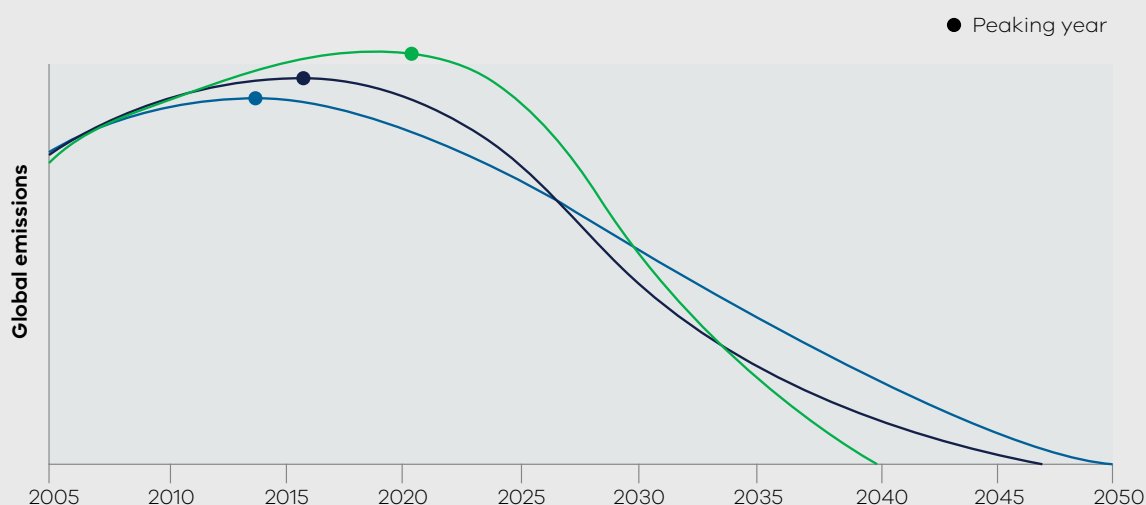
A single global emissions budget will provide different likelihoods of keeping temperatures below different thresholds: for example, a budget that provides a high likelihood of keeping average temperatures below 2°C would provide a low to medium likelihood of keeping average temperatures below 1.5°C and a very high likelihood of keeping temperatures below 3°C.

Given that developing a global emissions budget relies on a series of assumptions, methodological choices, and climate science with significant levels of complexity and uncertainty, estimated budgets are neither precise nor definitive. Despite this, it is certain that the majority of a global

2°C-consistent emissions budget starting in pre-industrial times has already been consumed.

Emissions budgets for nations or sub-national jurisdictions can be calculated as a share of a global emissions budget. There are multiple methodologies for sharing a global emissions budget.¹⁰⁷

An emissions budget does not prescribe when emissions should peak and at what rate they should fall. As such, there are many emissions trajectories and targets along these trajectories consistent with a single emissions budget and therefore with a single temperature goal (**Figure 5.1**). This means there are choices – and trade-offs — regarding how to “spend” an emissions budget over time. Delays in reducing emissions in the short term mean that emissions must be reduced more rapidly in future years, and vice versa. Therefore, different emissions trajectories and associated targets may appear more or less preferable when considering the cost and availability of different emissions reduction opportunities and the distribution of benefits and impacts over time.

Figure 5.1 Illustrative alternative emissions trajectories for a given emissions budget

Note: The emissions budget is the area under the curve.

Source: Climate Change Authority (2014), *Reducing Australia's Greenhouse Gas Emissions - Targets and Progress Review Final Report*.

A lot of literature focuses on carbon budgets – which consider carbon dioxide emissions only – rather than emissions budgets, which cover all greenhouse gases. This is because carbon dioxide makes up the large majority of greenhouse gas emissions, and it is more robust to assume a linear relationship between carbon dioxide emissions and warming than it is for

all greenhouse gases. However, the Panel has chosen to use emissions budgets as Victoria's targets cover all emissions, and expert advice has confirmed that this is a robust approach for the time period under consideration ([Appendix F](#)).

Developing emissions budgets for Victoria

The Paris Agreement includes a commitment to “limiting the global average temperature increase to well below 2°C” and “pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels”. Although this provides a firm commitment to well below 2°C and a more aspirational goal of 1.5°C, many submissions from individuals and environment groups expressed a preference for using an emissions budget consistent with 1.5°C of warming rather than 2°C. The IPCC special report on global warming of 1.5°C found that there are significant differences in the impacts between these two levels of warming ([Chapter 2](#)); for example, the IPCC estimates that double the number of people would suffer from water scarcity with 2°C of warming compared with 1.5°C of warming.

The meaning of “well below” has not been defined by the international community. Therefore, to guide consideration of interim targets that would be consistent with the Paris Agreement, the Panel has developed a 2°C-consistent emissions budget and a 1.5°C-consistent emissions budget for Victoria. These budgets draw on global and national analysis.

The Panel took the emissions budget developed by the Climate Change Authority (CCA) for Australia as a starting point to develop a 2°C emissions budget for Victoria, and drew on estimates for a global budget presented in the IPCC’s 2018 special report on the impacts of global warming of 1.5°C as the basis to develop 1.5°C emissions budget for Victoria.

The Panel sought expert advice on:

- Whether the CCA 2°C emissions budget for Australia remains valid;

- Estimating Victoria’s share of an Australian emissions budget; and
- Estimating an emissions budget consistent with limiting warming to 1.5°C.
- The executive summary of this advice can be found at [Appendix F](#).

A Victorian emissions budget consistent with 2°C of warming

Reviewing the CCA 2°C emissions budget for Australia

In 2014, the CCA recommended a 2°C-consistent emissions budget for Australia of 10.1 Gt CO₂-e for the period 2013-2050. The CCA considered this an equitable share for Australia (0.97%) of the remaining global emissions budget consistent with a likely (67-90%) chance of staying below 2°C of warming. The budget assumes that all countries converge towards the same level of per capita emissions in the longer term while allowing for growth by developing countries in the short term.

After applying updates in climate science and methodological developments since 2014, the expert review found that the CCA’s emissions budget methodology remains valid and the estimated budget remains consistent with a likely chance of keeping global average warming below 2°C.

The Panel has therefore adopted the CCA emissions budget for Australia as its starting point for estimating a Victorian emissions budget consistent with staying below 2°C. The national budget was updated to reflect recent Global Warming Potentials (from the IPCC Fourth Assessment Report), and the passing of time (by subtracting actual national emissions for 2013-2016). This resulted in an Australian emissions budget of 8.09 GtCO₂-e for the period 2017-2050.

Estimating Victoria's share of an Australian budget

Estimating an emissions budget for Victoria requires determining its "fair share" of an Australian budget. The Panel does not presume what other states and territories will do to limit their emissions but has considered equity across states in forming its views about appropriate Victorian action.

There are many ways to share emissions budgets. The expert review explored four approaches:¹⁰⁸

- Convergence to equal emissions per person, also known as contraction and convergence (based on the principle of equality – or

recognising the equal "right" of each person to emit). Two emissions convergence dates were tested: 2030 and 2050;

- Equal cumulative emissions per person (based on the principle of responsibility for historical emissions);
- Gross State Product (GSP) per capita – emissions allocations are inversely related to GSP per person (based on the principle of capability – interpreted as the ability to afford to reduce emissions); and
- Current emissions shares are maintained ("status quo", or "grandfathering").

The resulting shares of an Australian emissions budget for Victoria are presented in **Table 5.1**.


Table 5.1 Victorian shares of an Australian emissions budget under different equity approaches

Approach	Victoria's share of an Australian budget
Contraction and convergence (convergence by 2030)	23.7%
Contraction and convergence (convergence by 2050)	22.7%
Equal cumulative emissions per person	31.1%
GSP per capita	23.4%
Grandfathering	21.7%

The Panel has concluded that a reasonable share for Victoria of an Australian budget is approximately 23%. This is based on an average of the results for the three approaches yielding similar results: contraction and convergence, GSP per capita and grandfathering. The Panel excluded the equal cumulative emissions per

capita approach, as its results were outliers (both for Victoria and other states).

The Panel is satisfied that a share of 23% for Victoria is not inequitable and does not rely on unreasonable emissions reduction in other states and territories.



Resulting 2°C emissions budget for Victoria

Applying the 23% share to the updated Australian 2°C emissions budget, the Panel estimates a Victorian 2°C-consistent emissions budget of 1.85 GtCO₂-e over the period 2017 to 2050.

A Victorian emissions budget consistent with 1.5°C of warming

There is no established estimate of an emissions budget for Australia consistent with 1.5°C of warming. However, the IPCC special report on global warming of 1.5°C includes estimates of the remaining global carbon budget consistent with limiting global temperature rise to 1.5°C. The Panel sought expert advice to develop a 1.5°C-consistent emissions budget for Victoria based on these IPCC estimates.

The Panel's 1.5°C emissions budget for Victoria was developed from a global 1.5°C carbon budget that provides a 50% chance¹⁰⁹ of limiting warming to 1.5°C, in line with the central estimate presented in the IPCC report (580 GtCO₂ for 2018 - 2100). This was adjusted to cover the period 2013-2050 and, for policy relevance, to cover all greenhouse gases (instead of just CO₂) and to use pre-industrial temperatures as a baseline. This gave a global emissions budget of 800 GtCO₂-e for the period 2013-2050 (**Appendix G**).

To move from a global to a Victorian 1.5°C emissions budget, the Panel used the same methodology used for its 2°C budget: first applying the same share for Australia of a global emissions budget as was used by the CCA (0.97%)¹¹⁰, and then using the same share for Victoria of an Australian emissions budget (23%). This produces a Victorian 1.5°C-consistent emissions budget of 1.25 GtCO₂-e over the period 2017 to 2050 (**Appendix G**).

Developing a 1.5°C emissions budget involves consideration of global emissions pathways to achieving 1.5°C and judgments on the future role of negative emissions technologies. There is a considerable range of uncertainty around these budgets – including the Panel's 1.5°C emissions budget for Victoria. These concepts are discussed further in **Box 5.2**.

Box 5.2 Different pathways to achieving 1.5°C and the role of negative emissions

A key question in developing a 1.5°C budget to 2050 is the global emissions pathway assumed to meet this temperature goal (given that the emissions budget is cumulative emissions over time, or the “area under the curve” – see [Box 5.1](#)).

For the IPCC special report, 90 different 1.5°C-consistent scenarios and associated emissions pathways to 2100 were developed. Each of these vary depending on assumptions about:

- How quickly emissions can be reduced in the near term (e.g. socio-economic drivers and developments and strength of climate policies);
- The extent of use of carbon dioxide removal technologies (e.g. to achieve “net negative emissions”, where more emissions are removed from the atmosphere than are emitted); and
- The likelihood of temperatures remaining below 1.5°C, or of “overshooting” 1.5°C and returning to this level by 2100.


The IPCC report demonstrates that there is a trade-off between the speed of emissions reduction required in the coming decades and the amount of global net negative emissions required later in the century. If sharp emissions reduction in the near term are infeasible, then a greater amount of negative emissions would be needed to pursue a 1.5°C goal, and there is a greater likelihood of “overshooting” 1.5°C and returning to this temperature by 2100. If there is limited confidence in the technologies and processes required to remove carbon dioxide from the atmosphere at scale, this indicates the need to reduce emissions even more rapidly in the short term, driving pathways that are more likely to result in no or limited overshoot of 1.5°C.

The Panel’s 1.5°C budget for Victoria is based on the latter approach. Scenarios

explored in the IPCC report that place limited reliance on technologies for carbon dioxide removal instead require social, business and technological innovations (including enhanced energy efficiency) resulting in lower energy demand, rapid decarbonisation of energy supply through strong growth in renewables, and fast electrification of energy use (e.g. in buildings and transport). The IPCC special report notes that 1.5°C pathways of this nature would require emissions reduction of an unprecedented speed and scale across all sectors of the global economy.

Other pathways explored in the IPCC special report that place greater confidence in technologies and processes to remove carbon dioxide from the atmosphere are associated with larger carbon budgets in the first half of the century, which are then compensated for by heavy reliance on these technologies and processes in the second half of the century. As an illustration, using the same approach set out above but assuming 100 GtCO₂-e of global net negative emissions post-2050 provides a Victorian emissions budget of approximately 1.53 GtCO₂-e. However, this approach increases the chances of the world “overshooting” 1.5°C before returning to 1.5°C by the end of the century (rather than global temperature rise remaining below 1.5°C). The climate impacts experienced in a world that exceeds 1.5°C are likely to be significantly greater, with increased risks of irreversible changes in the climate, than keeping temperature rise to 1.5°C ([Chapter 2](#)).

Options for removing carbon dioxide from the atmosphere include large-scale afforestation and reforestation, bioenergy with carbon capture and storage, enhancing natural weathering of silicates or carbonates, and direct air capture machines. Most are at very early stages of



development, and many are not currently considered to be economically viable. Some options also raise questions about environmental and social impacts, arising from potential conflicts with food security, biodiversity and other competing land uses. The IPCC special report notes that carbon dioxide removal technologies deployed at scale are unproven, and that relying on these to achieve 1.5°C is a major risk.

The Panel believes that the IPCC special report on 1.5°C of warming points both to the need to start reducing emissions as

quickly as possible, and to the importance of investigating options to remove carbon dioxide from the atmosphere. This could involve supporting research and development for carbon dioxide removal technologies and, more immediately, developing policies to support increased emissions sequestration through reforestation and forest management, where appropriate, alongside other policy priorities such as biodiversity protection, water, food production and regional jobs and economic development.

Assessment: consistency of target options with the Paris Agreement

Introduction

The world cannot continue to emit at current levels if the Paris goal is to be achieved – and neither can Victoria. At 2016 emissions levels, the Panel's 2°C-consistent emissions budget for Victoria will be exhausted in 2032, and the 1.5°C-consistent budget will be exhausted in 2026 – well before 2050. The global 2°C emissions budget will be exhausted in 2034 at current emissions levels.

As mentioned earlier in this chapter, the meaning of “well below” 2°C has not been defined by the international community. The Panel's 2°C and 1.5°C-consistent emissions budgets for Victoria therefore provide indicative boundaries for Victoria's cumulative emissions. Victoria's emissions over the period 2017-2050 will need to remain well below the 2°C budget to be consistent with the Paris Agreement and avoid dangerous climate change.

Summary of evidence

The consistency of Victorian action with the Paris Agreement is dependent not only on the level of emissions reduction achieved in 2030, but also on Victoria's emissions reduction trajectory before and after 2030 – or, put another way, on Victoria's cumulative emissions to 2050.

Straight-line trajectories

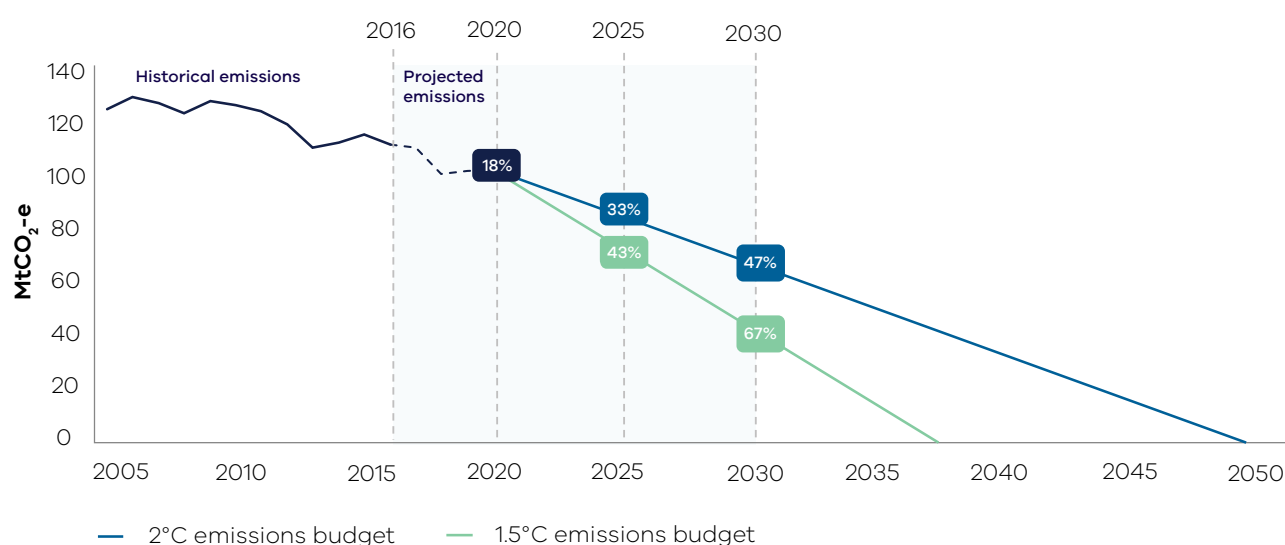
Straight-line trajectories are a simplified way of linking targets with temperature goals via emissions budgets. They provide guidance on the range within which targets would fall if emissions were to reduce steadily, spreading economic adjustment costs and other impacts evenly over time.

If Victorian emissions were to reduce steadily from 18% below 2005 levels in 2020 to when the budget is exhausted, this would imply a target in 2030 of about:

- 47% below 2005 levels under the Panel's 2°C-consistent budget, and
- 67% below 2005 levels under the Panel's 1.5°C-consistent budget (**Figure 5.2**)

If good progress is made with carbon dioxide removal technologies and the world is able to sustain net negative emissions post-2050 (**Box 5.2**) – that is, remove more emissions from the atmosphere than are emitted – this could provide greater confidence that Victoria's cumulative emissions to 2050 could be kept within limits consistent with 1.5°C.

Figure 5.2 Straight lines from Victoria's projected emissions in 2020 until Victoria's 2°C and 1.5°C-consistent emissions budgets are exhausted

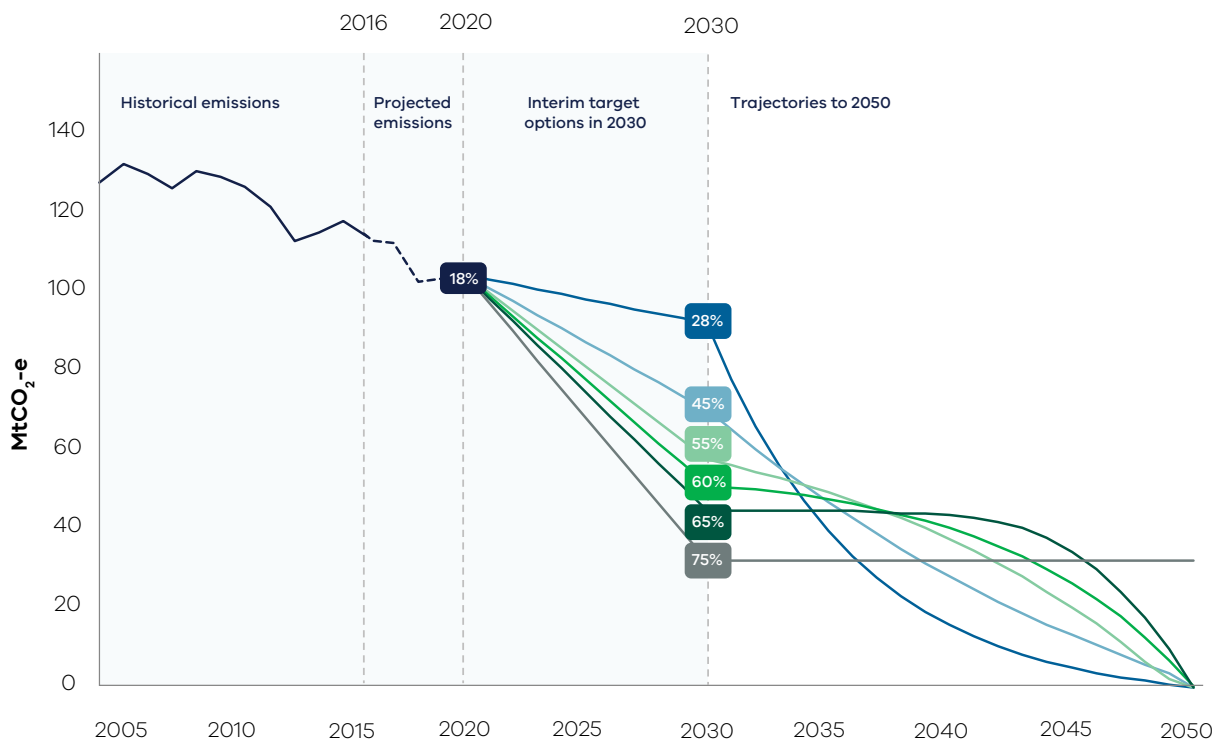


Trajectories implied by the Panel's target options

To understand emissions trajectories to 2050 implied by each of the Panel's six target options, the Panel applied these target options to its 2°C-consistent Victorian emissions budget (**Figure 5.3**). A straight-line emissions reduction trajectory is assumed in the period 2021-2030, consistent with the Panel's methodology for

deriving a recommended 2025 target, and a curved trajectory is applied starting in 2031 to exhaust the Victorian emissions budget in 2050, the year by which Victoria must achieve net zero emissions under the *Climate Change Act 2017*. To be consistent with the Paris goal of well below 2°C, each of the trajectories would need to decline more rapidly beyond 2030 than shown here.

Figure 5.3 The Panel's six draft 2030 target options and resulting trajectories when applied to a 2°C-consistent budget for Victoria



Note: Assumes that emissions in 2020 are 18% below 2005 levels as estimated in the Victorian Greenhouse Gas Report 2018.

Actual emissions may vary from these targets and trajectories if offsets from outside Victoria are used. The *Climate Change Act 2017* provides for the use of offsets to achieve net zero emissions in 2050 and to meet interim targets. Offsets are discussed in [Chapter 6](#).

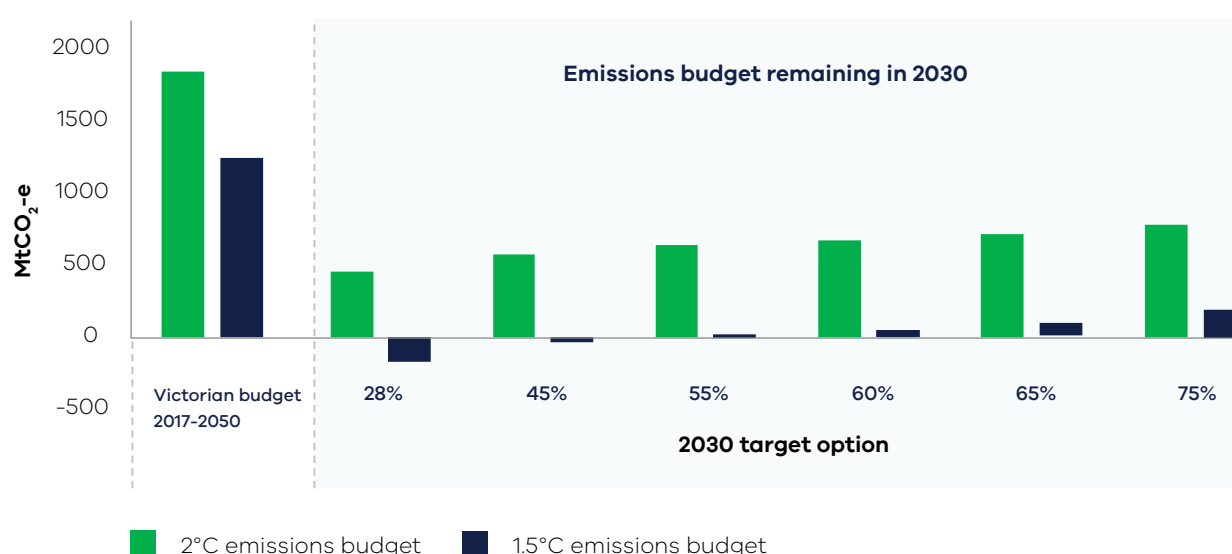
Under the 75% 2030 target option, the 2°C-consistent Victorian emissions budget is not used up by 2050.

Remaining 2°C and 1.5°C emissions budgets under the Panel's target options

Another way of assessing interim target options is to consider how much of the emission budget is "spent" in the 10 years to 2030 and how much remains for the 20-year period to 2050.

Under all six target options considered by the Panel, the majority of the Panel's 2°C-consistent emissions budget for Victoria would be used up by 2030, and the Panel's 1.5°C-consistent emissions budget would be exceeded before 2030 for the 28% and 45% target options ([Figure 5.4](#)).

Figure 5.4 Victorian 2°C- and 1.5°C-compatible emissions budget remaining post-2030 under different 2030 target options



Implications for the target options

Consideration of emission budgets for Victoria shows that a 2030 target of 28% below 2005 levels would require very rapid emissions reduction after 2030 to remain consistent with 2°C (Figure 5.3), and even faster reductions to remain consistent with well below 2°C. This would shift a significant burden to Victorians in the future, and concentrate economic adjustment costs in the period after 2030. The evidence also suggests that a 28% target in 2030 is incompatible with Victoria making a fair contribution to pursuing 1.5°C, as the Panel's 1.5°C budget would be significantly exceeded by 2030 (Figure 5.4).

Conversely, a 2030 target of 75% below 2005 levels would imply very rapid emissions reduction in the period 2021 to 2030, which would concentrate economic adjustment costs in the period before 2030 and therefore place a substantial burden on current Victorians. A

target of 75% is also higher than what would be required, on a straight-line basis, to be consistent with 1.5°C (Figure 5.2).

In light of this information, the Panel concluded that both the 28% and 75% target options should be excluded from further consideration because of the unfair distribution of effort they imply. The 28% target is also incompatible with the Panel's principle of environmental effectiveness as it is not credibly consistent with the Paris goal.

Figure 5.3 suggests that the target options of 55%, 60%, and 65% could be consistent with well below 2°C with relatively steady emissions reduction over time to reach net zero in 2050, and that 45% could be consistent with well below 2°C with an acceleration of emissions reduction after 2030.

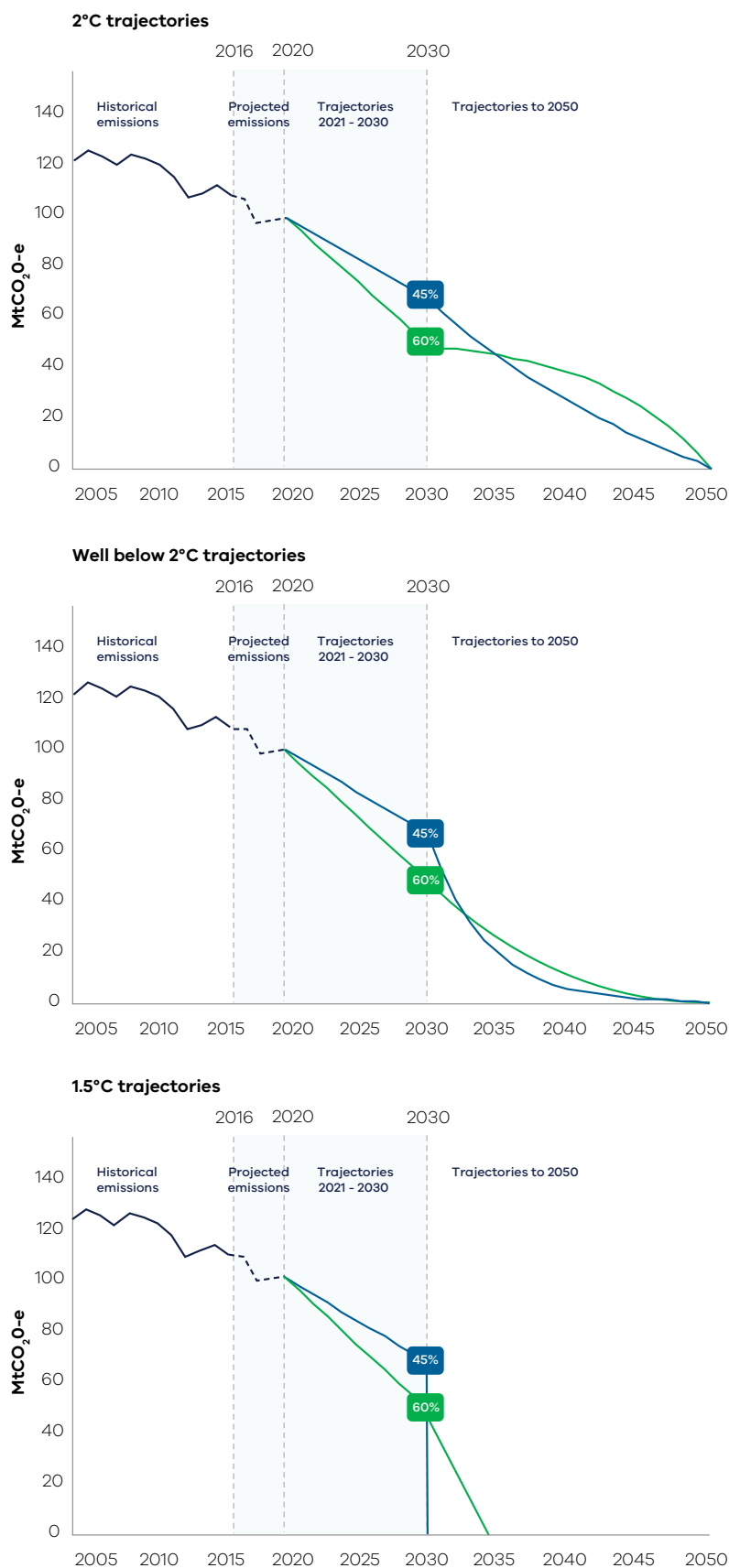



Chosen target options and associated trajectories

Following consideration of all factors affecting target choice – including emissions reduction opportunities ([Chapter 6](#)) and impacts ([Chapter 7](#)) — **the Panel has decided to recommend a target range of 45-60% below 2005 levels in 2030**. This section contemplates the trajectories to 2050 associated with this target range.

[Figure 5.5](#) presents the Victorian emissions trajectories implied by the Panel's chosen target range when the Panel's 2°C and 1.5°C emissions budgets are applied. It also presents indicative well below 2°C trajectories, which are developed using an emissions budget approximately half way between the Panel's 1.5°C and 2°C budgets.

Figure 5.5 2°C, illustrative well below 2°C and 1.5°C trajectories associated with emissions reduction of 45% and 60% in 2030





These graphs show that:

- The Panel's chosen target range is entirely consistent with a 2°C temperature goal, with a slight acceleration in emissions reduction to 2050 from 45% in 2030, and a significant deceleration to 2050 from 60% in 2030.
- The Panel's chosen target range is consistent with a well below 2°C temperature goal, with relatively steady emissions reduction to 2050 from 60% in 2030 and a more rapid acceleration of emissions reduction to 2050 from 45% in 2030.
- The Panel's chosen target range could be consistent with a 1.5°C temperature goal. From 60% in 2030 this would require rapid emissions reduction to reach net zero emissions in 2034.

6. VICTORIA'S EMISSIONS REDUCTION OPPORTUNITIES

SUMMARY:

- Victoria's emissions are projected to reach about 18% below 2005 levels in 2020, and will continue to fall over the following decade under existing policy settings.
- In this chapter, the Panel sets out significant opportunities for emissions reduction across the Victorian economy that would allow the recommended target range of 45-60% below 2005 levels in 2030 to be met.
- In some cases, there are significant information, regulatory and cost barriers to realising these opportunities that would require substantial policy action to overcome.

KEY FINDINGS:

- Emissions reduction of 45% below 2005 levels in 2030 or greater could be achieved with strong action by the Victorian Government and community, using available measures, while the economy continues to grow. Reductions of 60% could be achieved with state and Commonwealth action. Continued rapid technology development may also allow emissions to be reduced more easily and cheaply than analysis suggests today.
- Transition of the electricity generation sector will be critical to achieving the interim targets recommended in this report. This is both a significant opportunity and a challenge for Victoria.
- The next largest opportunity is Victoria's land sector, with significant potential to increase the carbon sink from forest management on public land, plantations and on-farm planting. However, there are substantial challenges to realising this potential as it requires significant changes in land management practices.
- Strong policies and investment will be needed in Victoria's transport sector – the State's second-largest emissions source – to counter upward pressure on the sector's emissions from Victoria's growing population. Support for low-emissions vehicles and public transport can reduce emissions by 2030, will be critical to achieving interim targets after 2030, and can provide substantial health benefits.
- There are also significant opportunities to reduce emissions from the agriculture sector while improving productivity, and to reduce Victorian industry and buildings emissions through energy efficiency and switching from gas to electricity.
- Offsets can provide additional flexibility to meet interim targets. However, the Panel recommends prioritising the transition of the Victorian economy.

Introduction

The consideration of specific emissions reduction policies remains outside the scope of the Panel's work. The Panel has, however, been charged with identifying potential opportunities across the Victorian economy to reduce emissions in the most efficient and cost-effective manner in each interim target period. It has sought to do so by assessing emissions trends, drivers and existing analysis on the potential scale, nature, timing and likely costs of emissions reduction.

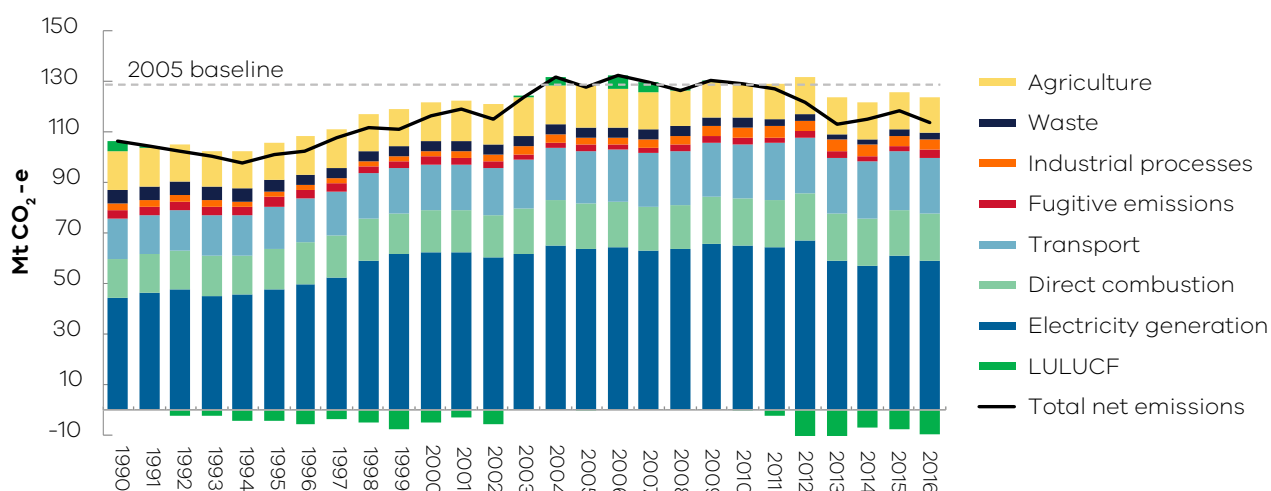
Whether emissions reduction opportunities are realised, and the resulting scale of emissions reduction in Victoria, will depend on policy choices made by the Victorian and Commonwealth governments alongside a range of other factors including the future evolution of technology and its costs; the growth of Victoria's population and economy; action by business and the community; trade impacts; and changing social attitudes and preferences.

Understanding Victoria's emissions

Knowing the sources of Victoria's emissions, and emissions trends across key sectors of the Victorian economy, is essential to understanding emissions reduction opportunities.

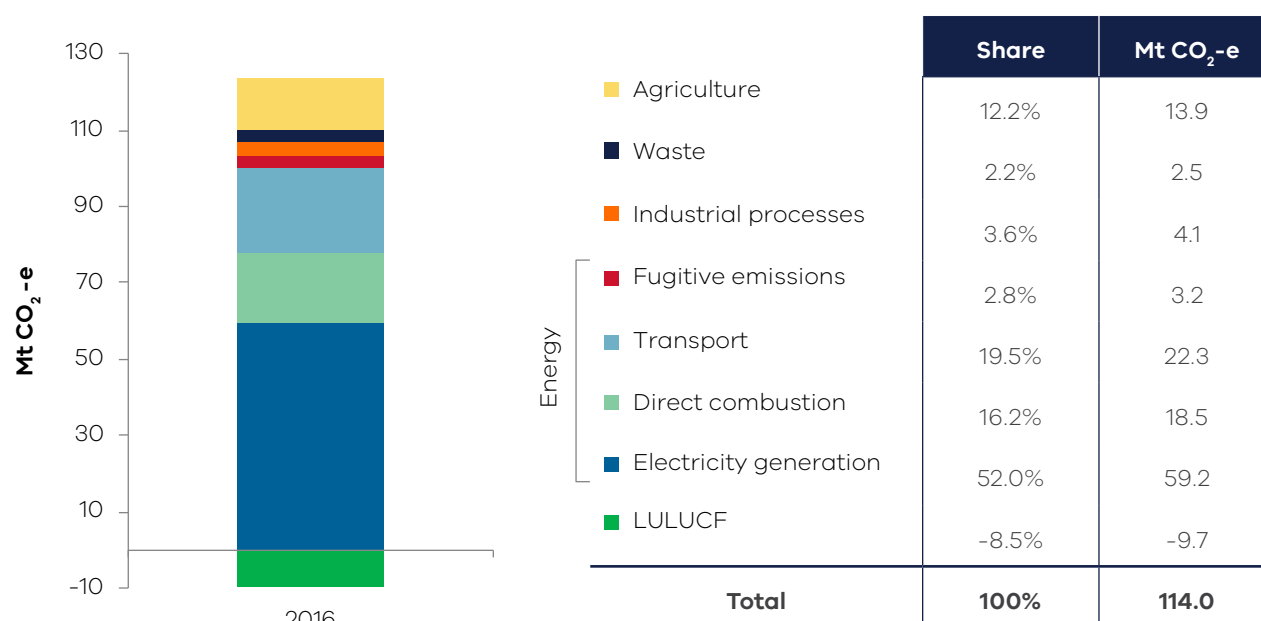
Victoria's net emissions generally rose from 1995, peaked during the 2000s and have declined since then (**Figure 6.1**). The general downward trend in Victoria's emissions since 2009 is due to a combination of factors. These include a decline in electricity demand across the National Electricity Market (driven by continuing improvements in energy efficiency, higher electricity prices, some decline in manufacturing activity and growth in rooftop solar photovoltaics) and some increased land sector sequestration. The presence of a national carbon price for some of this period may also have had an impact.

Figure 6.1 Victoria's emissions from 1990 to 2016, by sector



Note: At the time of the finalisation of this report, 2016 is the most recent year for which economy-wide greenhouse gas emissions data is available.

Source: Victorian Greenhouse Gas Emissions Report 2018.

Figure 6.2 Victoria's emissions by sector in 2016

Note: At the time of the finalisation of this report, 2016 is the most recent year for which economy-wide emissions data is available.

Source: Victorian Greenhouse Gas Emissions Report 2018

Electricity generation is the largest source of Victoria's emissions, with most electricity produced in Victoria coming from emissions-intensive brown coal generation. In 2016, the sector produced 52% of Victoria's emissions (Figure 6.2). By 2020, after accounting for the closure of the Hazelwood power station in 2017, it is projected that electricity generation will contribute about 42% of Victoria's total emissions¹¹¹. The largest end-users of electricity in 2016 were commercial services (including buildings) (34%), followed by manufacturing (23%), residential users (22%) and electricity, gas and water supply (17%).

Transport was the second-largest contributor to Victoria's emissions in 2016 (20%). Transport is also the sector with the highest growth in emissions in Victoria since 1990, driven by

population growth and a reliance on road transport for both passengers and freight. Direct combustion emissions¹¹² (16%) are primarily from gas use - approximately half from industry and half from commercial buildings and homes. The other sectors of the economy producing emissions are agriculture¹¹³ (12%), industrial processes (4%), fugitive emissions from gases leaking into the atmosphere during fossil fuel production, storage and distribution (3%) and waste (2%).

While net emissions from Victoria's land use, land use change and forestry (LULUCF) sector have fluctuated considerably between 1990 and 2016 (from an estimated -10 Mt CO₂-e to +5 Mt CO₂-e), the sector has acted as a "net sink", absorbing approximately 80 Mt CO₂-e more than it has released over the period.

Victoria's projected emissions to 2020

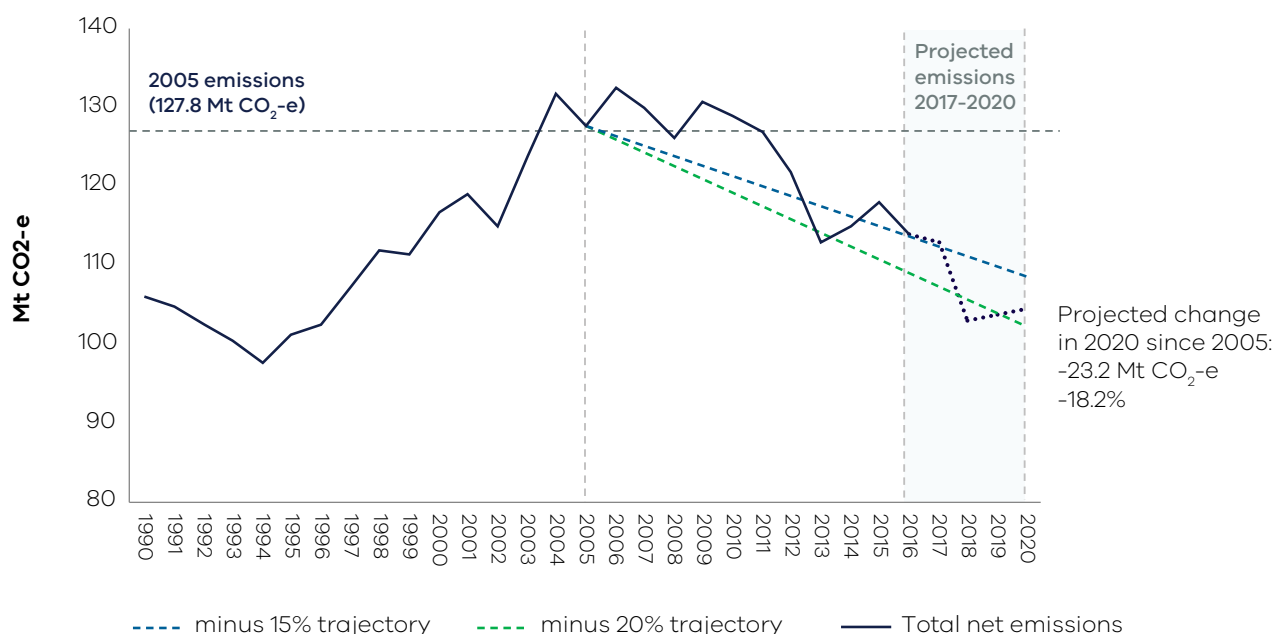
Victorian emissions are projected to be 104.5 Mt CO₂-e in 2020, a reduction of 23.2 Mt CO₂-e (18.2%) from 2005 emissions¹¹⁴. This indicates Victoria is on track to achieve its 2020 emissions reduction target of 15-20% below 2005 levels (**Figure 6.3**).

Total emissions fell in 2017 and 2018, primarily due to the closure of the Hazelwood Power

Station in March 2017 and the impacts of emissions reduction policies. Emissions from electricity generation are projected to remain flat in 2019 and 2020. However, total emissions in these years are projected to increase slightly due to a decline in sequestration from LULUCF and growth in emissions from other sectors of the economy, particularly transport and agriculture.

Key drivers of emissions within sectors are explored in more detail below.

Figure 6.3 Victoria's historical and projected emissions



Note: Emissions in the inventory are reported across financial years (1 July – 30 June) rather than calendar years (1 January – 31 December). Therefore, the closure of Hazelwood Power Station in April 2017 means that 2017 emissions (for the period July 2016 to June 2017) are projected to fall slightly – as the closure impacts only the last three months of the financial year (from April to June 2017). The drop for 2018 emissions (for the period July 2016 to June 2017) is much larger because this is the first full 12 months that reflect the closure of Hazelwood Power Station.

Source: Victorian Greenhouse Gas Emissions Report 2018

The anticipated reduction in Victoria's total emissions in the period from 2016 to 2020 is primarily due to a projected fall in electricity generation emissions of 14.9 Mt CO₂-e, to which the closure of Hazelwood Power Station contributes a net reduction of 11.8 Mt CO₂-e.

Small reductions are also projected for fugitive emissions from fuels (0.5 Mt CO₂-e), direct combustion (0.2 Mt CO₂-e) and waste (0.1 Mt CO₂-e). The main drivers include:

- An anticipated slight decline in natural gas consumption to 2020 due to ongoing reductions in industrial load, inner-city residential users switching from gas to electrical appliances, and improvements in energy efficiency.
- Reduced losses of natural gas from distribution activities associated with the decrease in natural gas consumption.
- The diversion of organic waste from landfills in line with the 30-year roadmap set out in the Statewide Waste and Resource Recovery Infrastructure Plan (2018) and wastewater emissions reduction required by the Water Sector Statement of Obligations.

Increased emissions are projected for LULUCF (2.5 Mt CO₂-e), transport (2.3 Mt CO₂-e), agriculture (1.4 Mt CO₂-e) and industrial processes (0.1 Mt CO₂-e). The main drivers include:

- An anticipated increase in harvesting of commercial plantations and a return to average levels of net sequestration from forest land. Nonetheless, LULUCF is projected to continue to be a net sink.
- Population and economic growth linked with a reliance on road transport for both passengers and freight. Cars and light commercial vehicles are projected to continue as the largest source of transport emissions.

- Rising food demand with beef cattle being the biggest contributor of agriculture emissions, followed by sheep and pigs.
- Increasing usage of hydrofluorocarbons (HFCs) due to population and economic growth. Emissions reduction from the national legislative phase-down of HFCs are not expected to occur until after 2020.

Overview of emissions reduction opportunities

The Panel is required to provide advice on potential opportunities across the Victorian economy to reduce emissions in the most efficient and cost-effective manner in each target period. Information on the scale of opportunities to reduce emissions during 2021-25 and 2026-30 is also important for the Panel's recommendations for interim targets in those periods.

A range of existing reports and studies have identified cost-effective emissions reduction opportunities across the economy. The Panel has also considered advice from Victorian Government departments and from a range of sector experts in understanding the opportunities to reduce Victoria's emissions.

The range of measures that have potential to reduce Victoria's emissions to zero are relatively well established and are presented in **Table 6.1**. It is likely, however, that before 2050, and potentially before 2030, technology advancement will provide new opportunities, and lower costs, in reducing Victoria's emissions. Examples could include a vaccine to address methane emissions from livestock rather than use of feed additives, or technologies for zero emissions industrial processes rather than use of carbon capture and storage.

Table 6.1 Overview of potential emissions reduction actions across the Victorian economy

Sector	Actions
Electricity Supply	<ul style="list-style-type: none"> • Shifting electricity generation from coal / gas to renewables (e.g. solar, wind, hydro, biomass) • Reduction in line losses
Transport	<ul style="list-style-type: none"> • Improving motor vehicle efficiency and energy efficiency • Shifting to electric and other low/zero emissions (e.g. hydrogen, biofuels) vehicles from conventional petrol/diesel/gas vehicles • Mode shift including from cars & trucks to rail and from motorised transport to walking/cycling • Behavioural change (e.g. car sharing; telecommuting, intelligent freight systems etc) • Shifting to biofuels in air transport
Built Environment	<ul style="list-style-type: none"> • Improving the energy efficiency of existing buildings and of new appliances • Fuel switching (e.g. from gas to zero emissions electricity) • Zero carbon new buildings
Industry	<ul style="list-style-type: none"> • Improving energy efficiency and process efficiency including through artificial intelligence and robotics • Fuel switching (e.g. from gas to zero emissions electricity; from gas to hydrogen) • Phase-down of hydrofluorocarbon use • Improving the efficiency of industrial processes • Reduction in fugitive emissions through reduced gas production and economy wide use • Carbon capture and storage (CCS) of process emissions (e.g. from cement, steel or hydrogen production from coal)
Land sector	<p><u>Agriculture</u></p> <ul style="list-style-type: none"> • Improving animal management (breeding low-emissions animals, feed additives, methane inhibitors, manure management) • Improving fertiliser management and technology <p><u>Forestry and Land Use Change</u></p> <ul style="list-style-type: none"> • Reforestation • Improving forest management practices • Avoiding deforestation

The scale of emissions reduction from each of these opportunities varies significantly as does the potential across different sectors. Some of these opportunities will be more important in the period to 2030, while others are likely to provide greater reductions in the period from 2030 to 2050.

In considering the available evidence on emissions reduction opportunities to 2030, the Panel recognises that:

- The scale of emissions reduction opportunities identified will vary depending on the assumptions made about a wide range of factors including the availability and cost of technologies and the level and mix of future economic activity;
- Analyses of emissions reduction opportunities may underestimate the potential for cost-effective emissions reduction – this has been the case for past analysis (see **Appendix H**) which has not, for example, adequately accounted for rapid uptake, improvements in technology and reductions in costs (see **Box 6.1**);
- On the other hand, broad scale analyses often do not take into account all of the practical issues and barriers that must be overcome to realise emissions reduction opportunities. These issues can only be fully explored through detailed policy development processes, which are the responsibility of the Victorian Government;
- The scale, pace and cost of emissions reduction will be significantly influenced by government policy. However, it is not the Panel's task to consider specific policy mechanisms but rather to focus on broader potential for emissions reduction. It is a matter for the Victorian Government to determine the policies it will implement (and/or advocate for nationally) to help drive emissions reduction. It is important to note, however, that market based mechanisms often achieve the most cost-effective emissions reduction and also allow policy to remain technology neutral; and
- Businesses and the community are already acting, so efforts to reduce emissions can build on this existing momentum.

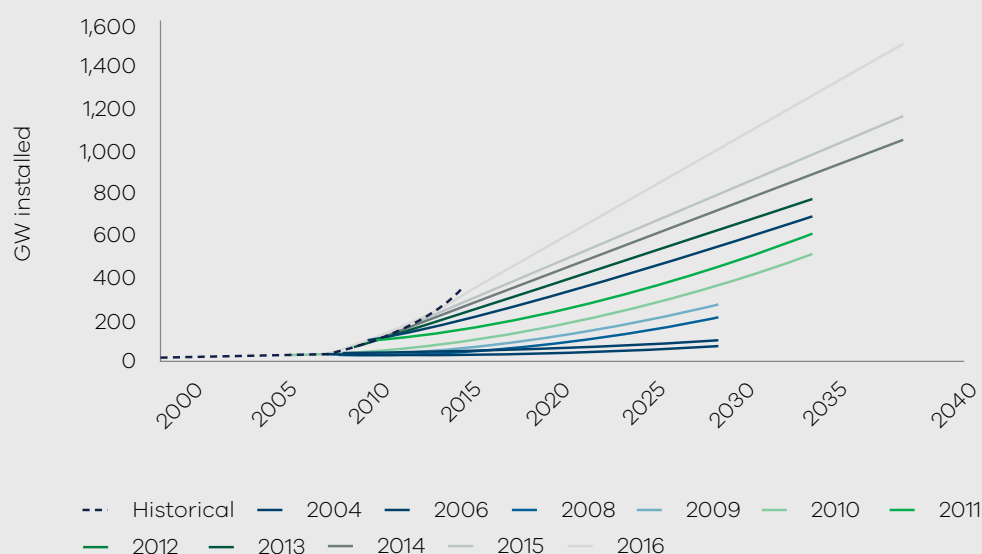
Box 6.1 Projections underestimate rapid cost reductions and uptake

Consideration of the potential for emissions reduction takes place in an evolving and dynamic context. For example, the past decade has seen substantial reductions in the cost of renewable energy technologies such as solar and wind generation, which has made these technologies increasingly competitive with fossil fuel-based electricity¹¹⁵. These price reductions, coupled with supportive policies, have led to a surge in investment in renewables. Nationally, the rate at which solar and wind is being installed has accelerated significantly over recent years. The 83 large-scale renewable energy projects underway in 2019 are expected to deliver over 14,000 MW of new renewable energy capacity¹¹⁶. Australia has 5.6GW of rooftop solar across 1.7 million households – a global record in per capita terms.¹¹⁷ If the current rates of construction and installation of renewables were maintained, Australia would reach 50% renewable electricity in 2025 and 100% in the early 2030s¹¹⁸.

Projections consistently underestimate the scale of growth of new technologies, at the same time as underestimating the reductions in costs that would be achieved over time. For example, modelling for the Commonwealth in 2008 (Australia's Low Pollution Future) projected that renewables would remain significantly more expensive than coal and gas out to 2050¹¹⁹, rather than becoming the cheapest form of new generation before 2020.

The uptake of renewables across the globe has consistently outperformed projections over the past 20 years. The International Energy Agency (IEA) has increased its projections for solar uptake in each annual update, but exponential growth since about 2010 has continued to outstrip these projections (**Figure 6.4**).

Figure 6.4 IEA World Energy Outlook solar photovoltaic projections v actual additions to capacity, 2004-2016



Source: Bloomberg New Energy Finance, 2017²⁰

This pattern of rapid technology development and cost reductions is being repeated with battery technology, which is critical for electric vehicles (EVs) and for storage of renewable energy. Globally, battery costs fell by 73% between 2010 and 2016 ¹²¹. CSIRO projects battery costs will continue to fall significantly to 2030 to about one sixth of current levels ¹²².

Technological developments also create opportunities for business innovation that will alter the context in which emissions reduction take place. The rise of rooftop solar and batteries indicates a future where generation is more decentralised, while the introduction of "smart" technology may see the rise of more integrated, customised home energy management services. In the transport sector, autonomous vehicles and ride-sharing schemes may have major impacts on transport behaviour and emissions.

The lesson of recent years is that actions that may appear unlikely or uneconomic today can become part of "business as usual" more quickly than anticipated.

Lessons from economy-wide assessments

While there are numerous studies on emissions reduction opportunities in individual sectors – as referenced in this chapter – economy-wide studies provide the advantage of taking an integrated approach and of considering potential interactions between different sectors.

Most published studies are at the national level. These can provide important insights given that the differences between Australia's and Victoria's emissions profile, emissions intensity of the economy and emissions per capita are minor on the whole (**Appendix E**). The key national level studies considered by the Panel are ClimateWorks et al (2014) Pathways to Deep Decarbonisation in 2050 (DDPP)¹²³; CSIRO (2015) Australian National Outlook (ANO)¹²⁴; and Climate Change Authority (CCA) (2014) Targets and Progress Review¹²⁵. The key messages emerging from these reports are:

- Emissions can be reduced across all sectors of the economy;

- The largest volume of abatement opportunity lies in decarbonising electricity generation by moving to renewable energy sources, while land-based sequestration is an essential “sink”, or offset, to achieve net zero emissions by 2050;
- Pursuing energy efficiency measures in the buildings, transport and industry sectors is important to achieve economy-wide emissions reduction; and
- Strong policy action will be needed to achieve emissions reduction.

The Panel has also considered a forthcoming study by ClimateWorks, titled “Decarbonisation Futures”, which provides up-to-date scenarios for emissions reduction in Victoria to 2030 and to 2050. These findings for Victoria are briefly summarised below, in the context of the Australia-wide studies. ClimateWorks' approach is summarised in **Box 6.2**.


Box 6.2 ClimateWorks' approach

ClimateWorks has developed a range of scenarios that find least-cost pathways for Australia to achieve emissions reduction based on different assumptions about:

- the amount and timing of assumed policy effort (consistent with temperature outcomes of between 3°C and 1.5°C depending on scenario);
- the speed of technology development; and
- the strength of demand for low-emissions goods and services.

Victoria-level emissions reduction results are drawn from this Australia-wide modelling – and therefore form part of an emissions reduction pathway optimised at the national level, rather than an emissions reduction pathway optimised for Victoria.

Across all scenarios, the modelling assumes continued economic growth and is limited by known technologies, systems and behaviours, and takes into consideration existing assets and their economic viability.



ClimateWorks estimates that with strong policy action (consistent with a 2°C to 1.5°C temperature goal), Victoria's emissions could be reduced by between 56% and 65% below 2005 levels by 2030 (30-36% by 2025). Without strong policy action, Victoria's emissions are projected to decline slowly but remain far above net zero by 2050.

This finding is similar to that in ClimateWorks' 2014 national level DDPP study, which found that on a 2°C-consistent pathway to net zero emissions by 2050, Australia's emissions would reach 50% below 2000 levels (equivalent to 46% below 2005 levels) in 2030.

More detailed Victoria-level results from ClimateWorks' Decarbonisation Futures report estimate the following reductions from current emission levels by 2030, under strong policy action:

- Electricity sector emissions are reduced to almost zero through uptake of renewables;
- Energy efficiency and electrification are key opportunities, particularly in buildings and industry. Industrial emissions are cut by a third or more, with output growth in some industrial sectors;
- Agriculture emissions are halved while production increases, in scenarios where new technologies to address methane emissions from cows and sheep are applied;
- Transport emissions reduce modestly, despite strong growth in demand, with very significant reductions estimated after 2030 through growing uptake of EVs.

ClimateWorks also found declining carbon sequestration in Victoria's land sector, despite significant technical potential for carbon forestry, as sequestration in other Australian states was assumed to have a lower cost. However, ClimateWorks' analysis considers only the potential for conversion of agricultural land to permanent plantings and, due to modelling

limitations, does not include on-farm forestry, plantations or changes to management of public forests that offer significant opportunities in Victoria (see land sector section below).

Electricity supply

Reducing emissions from electricity generation will be critical if the interim targets recommended in this report are to be achieved. The electricity sector is by far the largest source of Victoria's emissions, with emissions produced by the combustion of fossil fuels – predominantly brown coal with a small contribution from gas.

Electricity generation also has the potential to provide a larger volume of lower-cost emissions reduction than other sectors of the economy – particularly given the declining costs of renewable energy.

In addition, low-emissions electricity is important for enabling emissions reduction opportunities in other sectors – including transport, buildings and industry. The electrification of these sectors will, however, increase demand for electricity and require changes in supply networks. This underlines the importance of effective policy in the electricity sector to deliver emissions reduction while maintaining secure and affordable electricity supply.

Based on expert advice and consideration of a wide range of analysis, there is potential to cut electricity sector emissions significantly (models indicate by as much as 16-52%) over the decade 2020 to 2030 with commercially available technologies, while ensuring that energy policy objectives regarding affordability, reliability and systems security continue to be met. Indeed, for the Panel's recommended targets to be met, a large proportion of the emissions reduction will need to occur in the electricity sector.

The Panel recognises that this finding will, understandably, amplify concerns over the potential closure of further coal-fired generation capacity in the Latrobe Valley in the coming decade. However, it is not within the Panel's role and responsibility to speculate about the likely responses of privately owned generation businesses to the Panel's recommendations, nor about government policy responses that have yet to be formulated.

The Panel does, however, strongly encourage the Victorian Government, the generation businesses, unions and the Latrobe Valley community to consult and collaborate in the formulation of policy responses and business decisions to achieve a planned and just transition. The Commonwealth Government and the National Electricity Market agencies clearly also have important roles to play in this regard.

Many submissions on the Panel's 2018 Issues Paper identified the importance of decarbonising electricity generation. The key role of the electricity sector in emissions reduction was also reflected in submissions by electricity industry participants to the Commonwealth Government on the proposed National Energy Guarantee –

Origin “believe[s] the electricity sector can be responsible for more than its proportionate share of any national carbon reduction measure¹²⁶.”

AGL considers “that the energy sector is in a unique position to act first and to unlock substantial emissions reduction in other sectors of the economy technological substitutes to fossil fuels are available and increasingly cost effective. Significant emissions are generated by a small number of individual assets. Moreover, electricity generation also has the potential to facilitate emissions reduction in other sectors, notably transport with electrification powered by renewable energy and manufacturing¹²⁷.”

Electricity sector transition

The potential for significant decarbonisation of the electricity sector is a common finding across a range of recent Australian and international studies ¹²⁸. A transition towards lower-emissions electricity generation is already underway in Victoria (see **Box 6.3**), other Australian states and overseas, due to:

- Rapidly falling costs of renewable energy (see **Box 6.1**) – according to CSIRO, solar and wind are already the cheapest forms of new energy generation, even when additional costs are included for energy storage ¹²⁹.
- Government policy – for example, the Victorian Government has set a Victorian Renewable Energy Target (VRET) of 25% renewable generation by 2020 and 40% by 2025, and has committed to achieving 50% renewable generation by 2030. This will require substantial investment in new large-scale renewable generation. The Commonwealth's national Renewable Energy Target is also supporting investment in renewable energy across Australia.

Action is also occurring overseas, as evidenced by Germany's commitment to phase out coal-fired power by 2038; and California's target of 60% renewables by 2030 and its goal that the state's electricity grid be powered entirely by clean energy by 2045.

- Ageing coal-fired power stations are experiencing increasing operational challenges and declining reliability due to old equipment, more hot days and increased market variability driven by renewables. A shift away from coal-fired electricity generation is already occurring as power stations reach the end of their operating lives. This is exemplified by the closure of Victoria's Hazelwood Power Station in 2017 and Anglesea Power Station in 2015; South Australia's Northern and Playford power stations in 2016; and the impending closure of the Liddell Power Station in New South Wales in 2022.

This transition will see Victoria shift from a system of centralised electricity generation based on fossil fuels towards renewable and more decentralised electricity generation accompanied by consumer and community

driven energy services in which electricity storage, electric vehicles, smart metering and enhanced demand management will play an increasingly important role.

Box 6.3 Renewable energy development in Victoria

Renewable energy generation is already growing strongly in Victoria (**Figure 6.5**). Victoria generated 9,884 GWh of renewable energy in 2018, and renewables' share of the State's total electricity generation has increased rapidly over the 2012-2018

period, rising from 9.7% to 20.5%¹³⁰ There has already been significant uptake of roof top solar and CSIRO predicts that the number of rooftop solar panels in Victoria will increase by 500% by 2030.¹³¹

Figure 6.5 Large-scale renewable energy – Victoria as at 1 March 2019

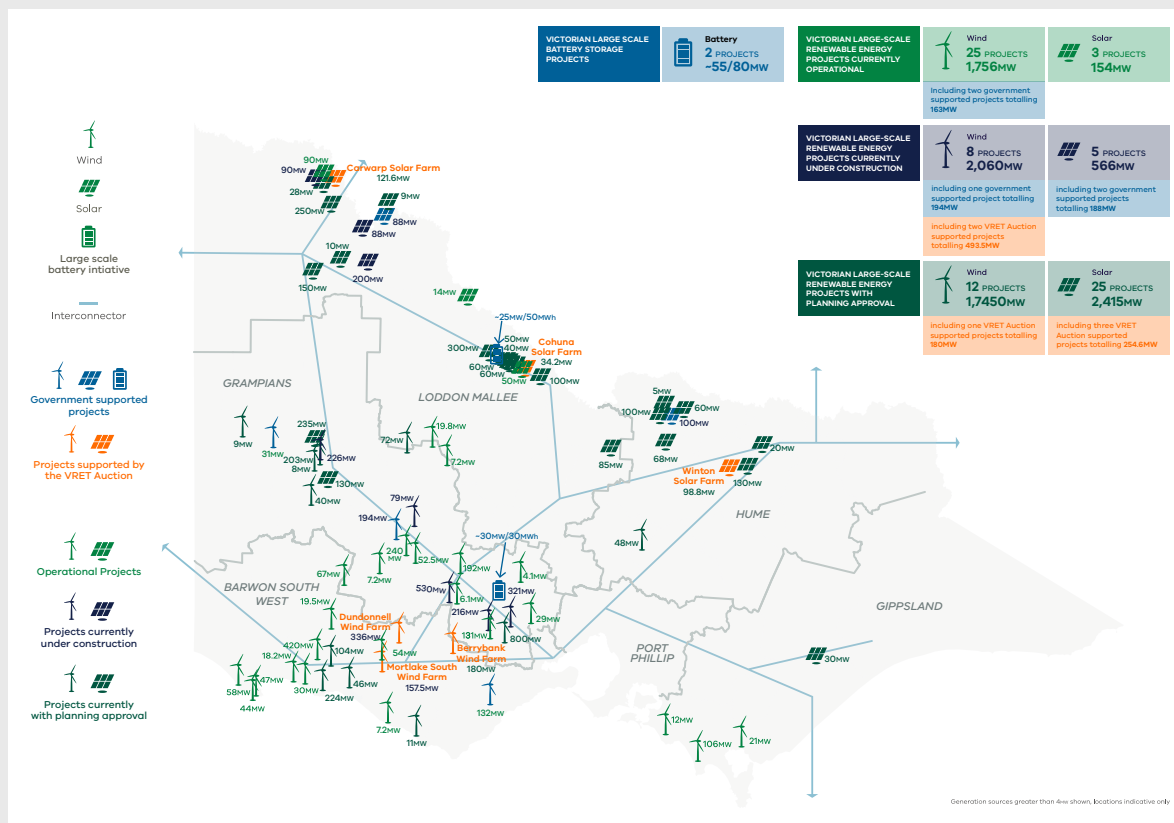
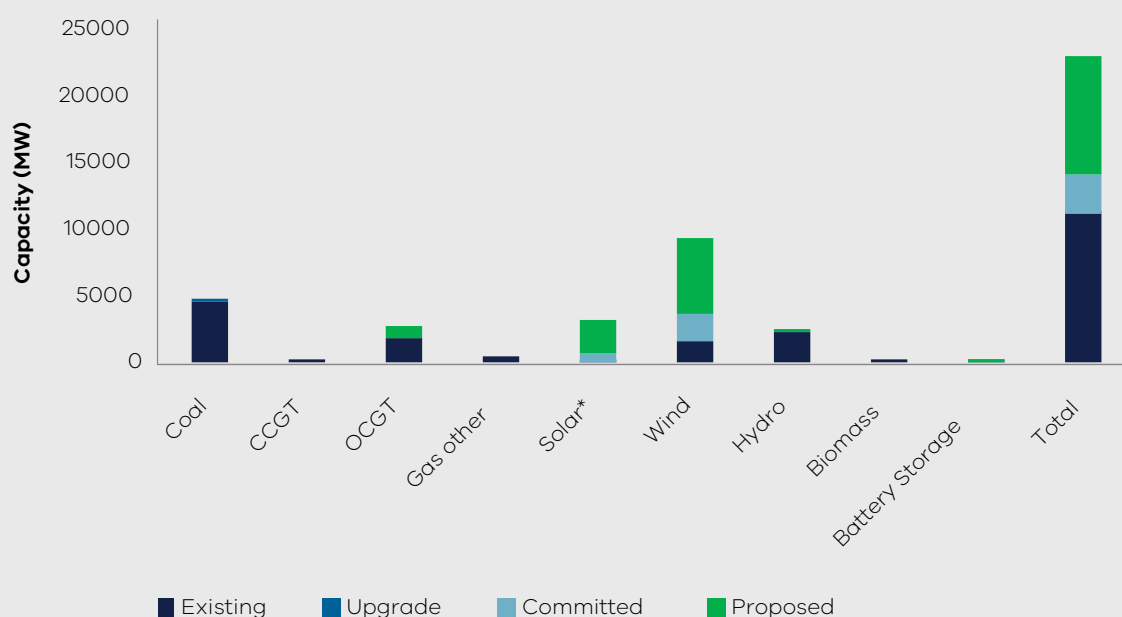


Figure 6.6 presents AEMO data on the scale of existing and potential (committed + proposed) renewable energy generation capacity in Victoria relative to existing fossil fuel-based coal and gas. Note that proposed capacity includes projects that

have planning approval as well as projects that have been announced but have not yet obtained planning approval. Committed projects include those under construction or with a firm commitment to commence construction.

Figure 6.6 Existing and potential new electricity generation capacity – Victoria



Note – CCGT = combined cycle gas turbine and OCGT – open cycle gas turbine


* Solar excludes rooftop PV

Source: based on AEMO data (current as of January 2019).

Managing the transition

Emissions reduction in the electricity sector commensurate with the interim targets recommended in this report are achievable, but will require careful management, sector planning and investment.

This is confirmed by electricity market modelling prepared for the Department of Environment, Land, Water and Planning (DELWP) to inform the Government's consideration of energy policy issues and options.



The modelling considered a scenario under which the electricity sector contributes the majority of emissions reduction required to achieve the economy-wide interim targets recommended in this report. This scenario involved emissions reduction in the electricity sector of 70% below 2005 levels by 2030. This is equivalent to around a 50% reduction from projected emissions in 2020 (which takes

into account the closure of Hazelwood Power Station in 2017). The modelling also considered conditions under which Commonwealth policy either remains unchanged or with additional action at the national level – the results from the modelling presented in **Box 6.4** reflect an assumption of no change in current Commonwealth policy.

Box 6.4 Results of electricity market modelling – Victoria

A reduction in electricity sector emissions of about 50% below projected 2020 levels by 2030 – assuming no change in current Commonwealth policy – is modelled to result in:

- A fall in electricity sector emissions to 20.1 Mt CO₂-e in 2030 – a reduction of around 21 Mt CO₂-e from projected levels in 2020.
- Renewables providing 67.6% of total electricity generation in 2030, with brown coal-fired generation providing 31.8%.
- Wholesale electricity prices in 2030 of \$79.4 compared with an average wholesale price ¹³² of \$90.5/MWh in 2018.
- Reliability of supply being maintained through the installation of significant additional battery and pumped hydro storage capacity and increased demand side participation.

The modelling also assessed the impacts of a scenario under which current policy settings are maintained. In this scenario,

Victoria's 2025 and 2030 renewable energy targets (of 40% and 50% respectively) are met and the Solar Homes program ¹³³ is fully implemented – but no new policy measures are introduced.

Under this scenario, modelling results for 2030 estimate electricity sector emissions of 35.2 Mt CO₂-e; wholesale prices of \$69.3; and the share of total electricity generation from renewables and brown coal of 50.1% and 49.6% respectively.

While wholesale prices under the scenario in which electricity sector emissions are about 50% below projected 2020 levels are higher than those modelled for current policy settings, they are, nonetheless, significantly lower than current prices (\$79.4 vs. \$90.5/MWh) and are accompanied by substantially greater emissions reduction than is forecast to be delivered by current policy.

While specific policy recommendations are beyond the scope of the Panel's work, it is clear that a supportive policy environment will be required to facilitate the scale and pace of electricity sector transition considered in this modelling and that would be needed in the sector to contribute to the economy-wide interim targets recommended in this report.

Action will be required to ensure sufficient new renewable energy capacity is installed in a timely manner, and also to ensure:

- reliability and security of supply are maintained through an appropriate combination of network augmentation (including interconnection), storage and demand-side participation,
- affordability of electricity – recognising that electricity market reforms and action to improve energy efficiency across the economy can place downward pressure on electricity prices and costs, and
- the electricity sector transition is just – particularly for regional communities.

The importance of these considerations is recognised by policymakers and, indeed, some steps are already being taken to change system infrastructure and rules. For example, AEMO stated in its "Integrated System Plan for the National Electricity Market" that given the level of transformative change the power industry is experiencing –

(the) Integrated System Plan helps identify the desirability of proactive policy, regulatory, and market reforms in the public interest. Collectively, these actions can simultaneously identify required and likely investments, provide pathways for orderly retirements and investments in new resources that can best meet established and new policy and economic objectives, and enable broad innovation through the removal of existing and emerging barriers

to entry and competition. As a result, the transition can occur in a much more orderly manner ... and help ensure the public interest in reliable, affordable energy is met, in the context of government energy policies, including emissions standards.¹³⁴


Reliability and security of electricity supply

Renewable generation is changing the way the electricity system works, requiring new or modified approaches to address network constraints, provide "firming" capacity and to manage supply and demand. Studies indicate that the required technical solutions are available to maintain secure and reliable supply even under scenarios in which electricity emissions reach zero by 2030.¹³⁵

Work is under way to prepare for increases in the share of electricity generation from renewables. In December 2018, COAG Energy Council agreed to implement a Retailer Reliability Obligation that will seek to ensure dispatchable generation is available to meet electricity needs in the National Electricity Market (NEM). A range of other actions are being taken, including supporting network upgrades, enhancement of demand-side management, pumped hydro and battery storage projects to help provide "firm" (on call) electricity.

As noted in **Box 6.4**, substantial increases in renewable energy will be needed to enable achievement of the interim targets recommended in this report; and significant storage capacity and demand-side participation will also be required. It will be important to review and – where necessary – strengthen the actions currently being taken to ensure they continue to support electricity supply reliability and security.

The electrification of transport, households, commerce and industry will increase demand for electricity. At the same time, these new technologies provide opportunities for



coordination which can help manage demand and respond to other technical challenges of increasing variable renewable generation such as voltage and frequency control. However, if not well managed, the additional load could exacerbate peak load challenges.

It is important to note that an unplanned exit of ageing coal-fired power stations also presents a challenge to reliability and security of supply. This underlines the importance of building sufficient new capacity to ensure energy security and affordability objectives can be met. It also indicates that taking a coordinated approach to achievement of emissions and energy policy objectives will be critical to addressing any challenges regarding reliability and security of supply.

Electricity affordability

The impact of electricity sector transition on electricity prices – and more broadly on electricity affordability – will be influenced by the specific policies put in place at the state and national level.

The modelling results presented in **Box 6.4** indicate that wholesale prices are estimated to be lower in 2030 relative to current levels, even with about a 50% reduction in electricity sector emissions from their projected level in 2020. These results are consistent with other recent analysis of the impacts of action to reduce electricity sector emissions on electricity prices. For example:

- Reputex¹³⁶ – in assessing the impact of the proposed National Energy Guarantee (NEG) on emissions and electricity prices – found that competitive pressure from higher volumes of solar and wind energy is modelled to push wholesale prices lower under a NEG emissions reduction target of 45% (relative to 2005 levels) compared with a 26% NEG target.

- Frontier Economics¹³⁷ – modelled the impacts on residential retail prices under a range of emissions reduction targets for the electricity sector (from 26% to 65% below 2005 levels by 2030). It found that residential retail prices (averaged across Victoria, NSW, SA and Queensland) would be 15% lower than current prices even under the 65% emissions reduction scenario. A key message from the analysis was “that, with the right settings, the National Energy Guarantee (or similar mechanism) could drive rapid emissions reduction in the electricity sector and put downward pressure on energy prices” and “higher emissions reduction targets for the energy sector provide more ‘bang for your buck’, producing significantly more emissions reduction than lower targets with similar savings to residential retail prices”.

It is also important to note that electricity affordability can be improved through action to drive greater energy efficiency and use of demand management. Such action can provide consumers with direct savings on their energy bills and can reduce system costs due to avoided investment. In the United States, for example, there is now more than 18GW of demand response capability, avoiding the need for substantial infrastructure investment¹³⁸.

A just transition

Governments must consider the social impacts of the transition of Victoria’s electricity sector from brown coal-based generation to renewables. The benefits and costs of the transition will be experienced differently across the State. As raised by stakeholders including the Victorian Trades Hall Council and the community of the Latrobe Valley, ensuring a just transition for affected workers and communities is essential (see also **Box 7.2**).

The transition also offers potential for economic benefits from the development of renewable energy in regional Victoria. It is important to ensure that such benefits can be captured by local communities, including by Traditional Owners (see [Box 9.2](#)).

Commonwealth policy

The outcome of the 2019 federal election could significantly influence Commonwealth Government policy in the electricity sector, including the level of emissions reduction being pursued in the sector nationally. It will be important to consider how national policy settings interplay with Victorian policy to achieve emissions reduction in the electricity sector – including opportunities to leverage any Commonwealth initiatives that drive or facilitate emissions reduction; contribute to placing downward pressure on electricity prices and costs; and assist in delivering a just transition.

Transport

Transport is currently the second-largest source of emissions in Victoria and the sector with the strongest emissions growth. It is therefore critical that the Victorian Government puts in place policies and investments to drive a transformation of the sector and reverse this trend. Reducing transport emissions will also provide substantial health benefits through reduced local air pollution (see [Box 7.3](#)).


Victoria's transport sector emissions are primarily from the use of cars and trucks. There is increasing potential to address these emissions through the 2020s and therefore to reduce Victoria's transport emissions by 2030. Given underlying pressures from economic and population growth, it is currently estimated that the sector could make a moderate contribution to reducing Victoria's total emissions by 2030.

Reducing transport emissions will be critical to meeting interim targets after 2030, and could provide one of the largest contributions over the 2030s. If current analysis is underestimating the potential for rapid uptake of electric vehicles (see [Box 6.1](#)), then this opportunity could be realised earlier. Early policy intervention and investment in infrastructure is required to realise these opportunities.

The major opportunities to reduce transport emissions are:

- **Improved energy/fuel efficiency in new motor vehicles:** This currently presents the most significant opportunity to achieve near-term emissions reduction. The Commonwealth Government has estimated that fuel efficiency and emissions standards for light vehicles could reduce national emissions from light vehicles by about 12 Mt CO₂-e in 2030 (equivalent to about 19% of BAU emissions from light vehicles in 2030), as well as significantly reducing fuel costs for motorists^{139,140,141}.
- **Growth in the use of electric vehicles (EVs).** This will reduce light vehicle emissions.

The use of EVs is likely to grow through the 2020s even without further policy action, with recent studies indicating they could make up about 4-10% of light vehicles in Australia by 2030^{142,143,144}. Policy action can build on this trend and accelerate take up. Modelling undertaken for the Clean Energy Finance Corporation and Australian Renewable Energy Agency indicates that about 25% of Australia's cars could be EVs by 2030 under favourable policy settings, such as direct financial incentives, investment in charging infrastructure and fuel efficiency regulations¹⁴⁵.



While the timing and scale of uptake will depend to some extent on further technology development and cost reductions, experiences from Norway suggests that rapid change can occur under supportive policies – EV vehicle sales in Norway increased more than sevenfold between 2013-2017¹⁴⁶ and represented 40% of Norwegian car sales in 2018¹⁴⁷.

Stakeholder submissions to the Panel, including from the Clean Energy Council, highlighted the significant emissions reduction potential of EVs, with several noting that achieving this potential is likely to rely on appropriate supporting policies, infrastructure development and investment.

- **Mode shift** from road vehicles to other forms of transport offers the potential for further emissions reduction. This would require significant investment to build new capacity given Victoria's trains, trams, buses and bike lanes are already well utilised. The emissions impact will increase over time and will require supporting changes to city and town planning and encouragement for behaviour change. The Intergovernmental Panel on Climate Change (IPCC) reports that mode shift can deliver savings of up to 50% or more in emissions per kilometre¹⁴⁸.

- **Heavy vehicles and freight** emissions could be reduced in the period to 2030 through improved logistics and vehicle efficiency. In Europe, targets have been proposed for lorries, buses and coaches for reductions in CO2 emissions per tonne kilometre of 15% by 2025 and 30% by 2030¹⁴⁹. While hydrogen and battery powered trucks are beginning to be manufactured these options will take time to fully commercialise and deploy¹⁵⁰.

The Victorian Government holds many of the levers required to address transport emissions. It oversees the State's transport network and is already making significant investments in expanding public transport capacity. Options to incentivise the uptake of EVs include state-based subsidies and rebates, emissions reflective fees and charges, a phased-in ban on registration of high-emissions vehicles and support for EV charging infrastructure. While the Commonwealth controls fuel efficiency and fuel quality standards, Victoria can play a role in advocating for standards at the national level and some of the state-based levers for EVs can also be used to encourage vehicle efficiency.

CASE STUDY: NORWAY'S TRANSITION TO ELECTRIC VEHICLES

Norway is leading the world in transitioning its car fleet to electric vehicles (EVs). In 2018, 40% of all new cars sold in Norway were EVs¹⁵¹. The Norwegian Government has set a target for all new private cars, city buses and light vans to be zero-emission vehicles by 2025, as part of an effort to reduce emissions, cut local pollution and reduce noise in urban centres¹⁵².

Norway's EV market leverages an electricity system that is already 98% renewable¹⁵³. The growth of the market to date has been driven by a package of incentives and state investment. This includes exemptions from the country's relatively high vehicle taxation rates, which includes registration costs, a 25% tax on new car sales, import duties and company car sales tax. The ongoing costs of EV ownership have been reduced through exemptions from road tolls and municipal parking charges. Other incentives seek to increase the relative convenience of EV ownership, such as allowing EV's access to bus lanes¹⁵⁴. The Norwegian Government agency, Enova, was set a target of installing a charging station every 50kilometres on main roads by the end of 2017¹⁵⁵.

This suite of measures has brought forward investment in EVs at a faster rate than anticipated by policymakers. A target of 50,000 vehicle registrations was met in April 2015, rather than the anticipated date of December 2017. This success prompted the extension of tax exemptions to 2020¹⁵⁶.

Despite recent rapid growth in sales, EVs currently represent only 7.8% of Norway's total car fleet. The remainder is a roughly even split between petrol and diesel vehicles¹⁵⁷. This demonstrates the long-term challenge of transitioning from an existing fleet of conventional vehicles, which requires early and sustained policy intervention.

A growing list of other countries are also targeting a switch to EVs. India, the Netherlands, Denmark, Ireland, Israel and Germany have indicated they will ban sales of petrol and diesel-powered cars completely by 2030, while the UK, Taiwan and France plan to do the same by 2040. China has indicated that it will ban both the production and sale of petrol and diesel vehicles, but is yet to confirm a date for the ban.

Built environment

Emissions from the built environment represent about 7.5% of Victoria's emissions (about 8.5 MtCO₂-e in 2016)¹⁵⁸. Emissions are produced in buildings from direct combustion of gas for cooking, space and hot water heating. There are some opportunities to reduce emissions from the built environment by 2030, despite Victoria's strongly growing population and service sector. This would make a modest contribution to reducing Victoria's total emissions.

Victoria is a large consumer of gas compared with other Australian states and territories, with residential and commercial buildings responsible for 39% and 12% of the State's total consumption respectively¹⁵⁹. Gas use has grown over recent years, driven by population and economic growth. However, even without further policy action, gas use in buildings is expected to remain relatively flat in the period to 2030 due to improved energy efficiency and some fuel switching to electricity in response to higher gas prices¹⁶⁰.

ClimateWorks analysis indicates that, with strong policy settings, electrification and energy efficiency measures could reduce emissions from Victoria's built environment by up to 15% by 2030¹⁶¹.

The major opportunities to reduce emissions from Victoria's built environment are:

- **Accelerating fuel switching from gas to electricity:** Many energy services in the buildings sector can be delivered by either gas or electricity. Switching from gas to electricity for services such as hot water, space heating and cooking presents substantial opportunities to reduce sector emissions to 2030, with the greatest opportunities in residential buildings¹⁶². It is important to note that achieving the full emissions abatement potential of fuel switching will rely on the decarbonisation of electricity supply (discussed in 'Electricity supply' sector above).

- **Accelerating improvements in gas energy efficiency:** Despite the potential for fuel switching to electricity, many buildings will continue to use gas in the period to 2030. Energy efficiency can reduce gas use and emissions from these buildings. There are opportunities to improve the efficiency of gas use in the residential sector by upgrading hot water and space heating appliances, and by improving the thermal efficiency of new and existing buildings¹⁶³.

Indirect (electricity) emissions from buildings

Electricity is used in the built environment for lighting, plug-in appliances and equipment, and heating, cooling and ventilation. Emissions associated with this consumption are considered "indirect emissions" and are counted in the 'Electricity supply' sector (see above).

Improvements in energy efficiency, as well as rooftop solar PV, offer substantial opportunities to reduce indirect emissions from buildings and deliver financial benefits for consumers. Electricity emissions are already decreasing in the residential sector through take-up of these measures,¹⁶⁴ a trend which is expected to continue¹⁶⁵. However, significant further opportunities remain¹⁶⁶.

Many energy efficiency (for both gas and electricity use)¹⁶⁷ and electrification measures¹⁶⁸ can save consumers money. Energy efficiency measures also offer multiple co-benefits, such as improving business productivity, thermal comfort and health.¹⁶⁹

Despite these benefits, history shows that improving energy efficiency in practice requires policy action to overcome various barriers. These barriers also apply to fuel switching and include inertia, lack of information and understanding of the actions and their net benefits, insufficient access to capital, and the presence of “split incentives” (that is, building owners bear the costs while tenants experience the benefits from lower bills and improved comfort)¹⁷⁰.

The Victorian Government has access to a range of policy measures to overcome these barriers. Fuel switching and energy efficiency measures may be encouraged in existing buildings through the provision of information and financial incentives, such as through the existing Victorian Energy Upgrades Program (Chapter 3), and through regulations, such as efficiency standards for rental properties and public housing. The efficiency of new buildings may be increased by influencing the establishment of minimum standards through the National Construction Code and by developing Victoria-specific building and plumbing regulations for installed appliances and building thermal efficiency.

Industry

The Victorian industrial sector gives rise to emissions through on-site combustion of fuels (9 MtCO₂e in 2016, primarily gas) fugitive emissions (3.2 MtCO₂e in 2016) primarily from gas production and transportation, and emissions associated with industrial processes and product use (4.1 MtCO₂e in 2016).

From a recent trend of relatively flat industrial emissions, there is potential for significant reductions in industrial emissions by 2030 including through accelerating energy efficiency and electrification and through existing Commonwealth legislation on refrigerants (which currently make up the majority of Victoria's industrial process and product use

emissions). As such, the sector could make a moderate contribution to reducing Victoria's total emissions by 2030, although Victorian industry would require support for the step change this implies.

For some industrial emissions, including processes requiring high heat and some chemical reactions in production processes, there are currently limited technical or cost-effective options.

The major opportunities to reduce Victoria's industrial emissions include:

- **Accelerating improvements in gas energy efficiency and fuel switching** (e.g. from gas, coal and oil to electricity and bioenergy).

Recent analysis of industrial gas use published by the Clean Energy Finance Corporation with Ai Group, found that Australian industry could reduce its reliance on gas by at least 25% in Australia through a combination of energy efficiency and fuel switching¹⁷¹. ClimateWorks estimates that under strong policy effort Victoria's industrial emissions could be reduced by more than a third by 2030, largely through gas energy efficiency and electrification¹⁷². Australian Renewable Energy Agency (ARENA) research found that renewable energy can be an alternative to gas in many industrial applications, with lower heat applications likely to be more cost-effective than high heat applications¹⁷³. For comparison, the UK Committee on Climate Change identified opportunities to reduce industrial direct combustion emissions by about 18% between 2017 and 2030¹⁷⁴.

While most energy efficiency measures are cost saving with short payback periods, fuel-switching technologies such as solar thermal, heat pumps and biomass will often have longer payback periods. Policies would be required to overcome this and a range of other barriers to uptake including available capital, skills and capacity.

Securing the full emission benefits from electrification is dependent on further decarbonisation of grid (or access to renewables).

- **Reducing industrial process and product use emissions:** Existing Commonwealth legislation, under an international agreement on refrigerants, will phase down imports of Hydrofluorocarbons (HFCs) by 85% between 2018 and 2036. This phase down is expected to help reduce industrial process and product use emissions in Victoria by 2030.
- **Reducing fugitive emissions:** Transitioning away from gas use in homes and businesses will help to reduce Victoria's fugitive emissions.
- **Resource efficiency:** Resource and materials efficiency could be expected to provide further emissions savings. The South Australian Government estimates a circular economy could reduce that State's emissions 6% by 2030¹⁷⁵. Recent ClimateWorks analysis shows the emissions benefits grow over time and are therefore likely to be greater after 2030.

There has been a perception historically that reducing emissions means reducing industrial activity and that energy intensive businesses can only be viable with electricity generated from fossil fuels. This is increasingly not the case, with energy intensives beginning to find renewable energy can provide electricity at stable and affordable prices (see below and **Chapter 3**). Further options are likely to emerge over the coming years for currently emissions-intensive industries. For example, Alcoa and Rio Tinto have formed a joint venture to develop and commercialise a zero emissions aluminium smelting process, with sales planned to begin in 2024¹⁷⁶.

Indirect industrial emissions:

Industrial activities are also associated with a significant but decreasing volume of indirect emissions from electricity consumption (decreasing from approximately 18 MtCO₂e in 2005 to 12 MtCO₂e in 2016). These emissions are counted in the electricity sector.

There is significant potential to reduce these indirect emissions through energy efficiency and the use of renewable energy, particularly given Australia's manufacturers are currently some of the most energy intensive in the OECD.¹⁷⁷ Examples of Victorian facilities already making the switch to renewables include BlueScope Steel's Westernport works¹⁷⁸, OneSteel's Laverton steel mill (**Chapter 3**) and Viva Energy's Geelong refinery¹⁷⁹. By signing agreements to purchase renewable power, these businesses have greater cost certainty and can save money.

However, many emissions reduction opportunities constitute a substantial investment for industrial and manufacturing businesses and can often be made more cost-effective when combined with existing plans to replace or refurbish facilities. As set out in **Chapter 7**, sectors and individual businesses will need to transition at different speeds and times and will need different levels of government support, depending on the availability of cost-effective measures.

Submissions to the Panel's issues paper from major industry groups highlighted the importance of recognising that emissions reduction opportunities and costs will vary significantly between industries. These groups noted that Victoria's manufacturing sector still comprises a significant part of its economy;

that electricity and gas are key cost drivers; that large, energy intensive manufacturing, particularly where it is trade-exposed, will face the biggest challenges in transitioning to a low-emissions future; and that future policies should recognise the particular needs of this sector.

The Victorian Government holds many key regulatory, subsidy and information levers to drive further direct and indirect emissions reduction in the industry sector, including the potential to build on existing schemes such as the Victorian Energy Upgrades program large

energy user opt in, and a range of information provision, grant and loan programs. While Victorian measures that increase efficiency would improve the competitiveness of Victorian industry, it is worth noting the benefits of action at the Commonwealth level to help manage interstate competitiveness issues. The National Energy Productivity Plan is aiming to improve energy productivity across the economy by 40%, with substantial opportunities identified in industry. For the largest emitters, the Commonwealth's Safeguard mechanism applies.

CASE STUDIES: VICTORIAN INDUSTRY REDUCING EMISSIONS

Industrial businesses in Victoria are already reducing emissions while reducing costs and improving the security of their operations.

Creating energy from waste – Maryvale Mill

Australian Paper is planning to reduce emissions from its Maryvale Mill in the Latrobe Valley by establishing a 225 MW waste to energy facility. The mill is the largest pulp and paper manufacturing site in Australia, producing over 600,000 tonnes of paper per annum. It uses both electricity and thermal energy to generate steam and is currently the largest industrial user of natural gas in Victoria. The waste-to-energy facility will use municipal, commercial and industrial solid waste from Melbourne and Gippsland as a fuel source to generate both electricity and steam. This will divert 650,000 tonnes of waste from landfill and reduce emissions by an estimated 550,000 tonnes per year¹⁸⁰. The project will reduce the mill's gas use and insulate the business from fluctuations in gas and electricity prices. The project is expected to support more than 400 jobs once operational in around 2020¹⁸¹, pending works approval¹⁸².

Improving gas and electricity efficiency – South Pacific Laundry

South Pacific Laundry has reduced its gas consumption by an estimated 4-6% through energy efficiency measures that will save the business about \$65,000 per year. The Melbourne-based business is a large consumer of gas, which it uses to generate steam and operate plant equipment. An energy assessment undertaken with assistance from Sustainability Victoria identified significant opportunities to improve the efficiency of the company's boiler equipment. The cost of upgrading the equipment is expected to be outweighed by the resulting reduction in energy costs within two years. The efficiency measures have also helped to improve the company's preventative maintenance scheme and therefore productivity and occupational health and safety¹⁸³.

Land sector (agriculture, forestry and land use change)

Agriculture

The agriculture sector accounted for 12% of Victoria's emissions in 2016 (13.9 MtCO₂e), making it Victoria's fourth-largest emissions sector. Emissions have remained relatively stable over time, fluctuating between 14 and 16 MtCO₂e since 2005. Without policy action, future emissions will depend on the balance of external factors that may increase emissions (e.g. raising more livestock to meet increasing food demand from international markets) and decrease emissions (e.g. drought, consumer demand for low-emissions products).

About two-thirds of Victoria's agriculture emissions come from livestock (methane produced from fermentation during digestion) – predominantly from cows. The other main sources are fertilisers and manure. On-farm energy and land use are counted in other emission sectors.

There are significant opportunities to reduce Victoria's agriculture emissions in the period to 2030, which would make a moderate contribution to reducing Victoria's total emissions. A report prepared for the New Zealand Biological Emissions Reference Group found that a combination of measures could reduce emissions from New Zealand's pastoral sector by up to 24% below 2005 levels by 2030.¹⁸⁴ This gives a good indication of the scale of reductions that could be achieved in Victoria's agriculture sector, given the similarities in the production and climate profile between the two places. While achieving this level of emissions reduction would require significant policy action, the Victorian Government holds a range of regulatory, financial and information-based levers to do so.

- **Reducing methane emissions from livestock:**

Given the majority of Victoria's agriculture emissions are methane emissions from livestock, targeting this source is likely to have the greatest impact in reducing emissions in the sector. Opportunities currently available include low-emissions feeds, selective breeding of low-emissions animals, and management practices such as milking cows once a day and reducing stocking rates.¹⁸⁵

Recent technological advances mean that significant new solutions are also on the horizon. One is methane inhibitors, which have the potential to reduce methane emissions by up to 30%.¹⁸⁶ One inhibitor, 3-nitrooxypropanol (3-NOP), is expected to be released into the world market in 2019. However, regulatory approval must be obtained before 3-NOP can be used by Victorian farmers, and policy intervention may be needed to overcome cost barriers. Another solution expected to be available by 2030 is a methane vaccine¹⁸⁷, which could also reduce methane emissions by up to 30%. While the scope of application of the vaccine and inhibitor overlaps¹⁸⁸, the vaccine is expected to be much cheaper to administer.

- **Reducing emissions from fertilisers and manure:** Options include nitrification inhibitors (which can coat fertilisers and be sprayed on dung and urine patches), minimising fertiliser application (by applying precisely the right quantity, in the right place, at the right time), and anaerobic digestors to treat manure.

Submissions from Farmers for Climate Action and the dairy industry (Dairy Australia, Australian Dairy Farmers, United Dairyfarmers of Victoria (part of the Victorian Farmers Federation) stated that while the agriculture sector's potential to reduce emissions remains more limited than some other sectors, there is scope to reduce emissions and improve productivity at the same time. The submissions also spoke of the need for policy action to overcome existing price, information and skills barriers.

Businesses in the agriculture sector are increasing their focus on reducing emissions, driven by consumer and competitiveness pressures. Both the dairy industry and the meat and livestock industry have established their own emissions reduction targets: Australian Dairy Farmers have an emissions intensity target, per kilogram of milk solid, of 30% below 2011-12 levels by 2020, and Meat & Livestock Australia has a target of net zero emissions by 2030^{189,190}. Major companies in the agriculture supply chain, whose decisions can have flow-on effects for agricultural production, are also setting targets; for example, Fonterra has set a target of climate-neutral growth to 2030 for pre-farmgate emissions from a 2015 base year and net zero by 2050, and Unilever has a target of reducing the emissions impact of their products by 50% by 2030 from a 2010 base year.

Other sources of on-farm emissions

Some significant emissions sources and sinks involved in farming systems are considered under separate emissions sectors: on-farm energy use emissions are counted under "direct combustion" and "electricity generation", and on-farm forestry is counted under "land use, land use change and forestry" (LULUCF) (see case study and forestry section below). There are opportunities for improved energy efficiency and for on-farm renewable energy generation, and significant opportunities for on farm forestry.



CASE STUDY: JIGSAW FARMS

Jigsaw Farms is an intensive producer of wool, prime lamb and beef, based on 6,700-hectares of land near Hamilton. Over the past 20 years its owners have focused their business on establishing a farming system that increases productivity, reduces emissions and builds resilience to climate change.

Jigsaw Farms is combining a profitable, high-input livestock and agroforestry operation with a plan for significant emissions reduction and sequestration. Measures taken to reduce emissions are delivering multiple co-benefits to the business.

Strategic changes in pasture and water management have more than doubled the number of stock that can be run on each hectare of land. Farm managers are also selectively breeding animals that reproduce more successfully and yield greater output per head of stock. Increased productivity is reducing the emissions intensity of the farm's outputs¹⁹¹.

About one million trees have been planted on an area equivalent to 20% of the farm's total area. The carbon storage provided by these trees reduced the farm's overall emissions by 48% between 2000 and 2014. Jigsaw Farms' emissions are expected to be completely offset by the planting over a 25-year period¹⁹². Forty-five per cent of the trees planted on the farm are for permanent farm forestry, which will be managed on a cycle of harvest and replanting. This provides off-farm income, making the business more resilient to market and climate conditions. The remaining land is dedicated to biodiversity.

The shelter provided by native vegetation has reduced wind chill, lifting pasture production by 6-8%. It has also improved lamb and calf survival rates, reduced the risk of waterborne diseases and is assisting to reduce salinity¹⁹³.

Forestry

Victoria's land use, land use change and forestry (LULUCF) sector is a net sink for carbon and reduced Victoria's annual emissions by 8.5% in 2016 (9.7 Mt CO₂-e). The sector sequestered an average of about 4 Mt CO₂-e per year over the decade from 1996-2016, with sequestration primarily taking place in Victoria's forests.

There are considerable opportunities to increase sequestration by Victoria's forests in the period to 2030 by changing forest and plantation management practices and increasing for-harvest and environmental planting on private land. As such, forestry could make a substantial contribution to reducing Victoria's total emissions by 2030. There are also substantial challenges to realising this potential, however, as it requires significant changes in land management practices. Effective policies would be needed, including to overcome predicted decreases in sequestration driven by harvesting of plantation forests established in the 2000s.

The major opportunities to reduce emissions through forestry are:

- **Management of public native forests:** 85% of Victoria's native forest area is located on Crown land and managed by public entities¹⁹⁴. They include Victoria's highland mountain ash forests, which contain the highest-known carbon density of any forests worldwide¹⁹⁵. Overall, forests and soils on public land are estimated to store 3,684 MtCO₂-e¹⁹⁶ – about 30 times the volume of Victoria's annual emissions. There are significant opportunities to increase sequestration by these forests in the period to 2030, through reduced harvesting and changes in silviculture and fire management practices¹⁹⁷. Restoring areas of native forest that were harvested historically but not fully regenerated also presents opportunities. There are a range of views in the Victorian community about the management of Victoria's native forests and the need to balance different values such as employment, recreation and biodiversity.
- **Maintaining and increasing forest plantations on private land:** Plantations established for harvesting since 1990 currently provide a carbon sink of about -7 MtCO₂-e¹⁹⁸. The area of forest plantation has been decreasing by about 3% since 2013 as the trees mature and are harvested without being replaced¹⁹⁹ and this trend is likely to continue without further policy action. However, if plantations are converted to long rotation, replaced or if new plantations are established the carbon sink can be preserved and increased. This will require new policy initiatives to overcome financial and other barriers.

- **On farm forestry** presents an opportunity to increase sequestration on private land and deliver co-benefits to Victoria's agricultural sector. Recent Victorian case studies²⁰⁰ indicate that mixed for-harvest and environmental plantings on up to 20% of agricultural land could deliver a net financial benefit to farmers by providing an alternative source of income and by increasing agricultural productivity, even without a carbon price (see Jigsaw Farms case study). Plantings on even a small percentage of Victoria's agricultural land could provide a significant carbon sink²⁰¹.

Increasing plantings on agricultural land will require a change in management practices by many dispersed land owners. New and effective policy drivers would need to be established to sustain widespread uptake by overcoming existing barriers. These include capital constraints and competing investment priorities, a lack of stable price signals, information gaps and concerns regarding the long-term impacts of land use change on communities, fire and water. Policies could build on growing agricultural industry ambitions to address emissions.

Forestry is an important part of the local economy in some parts of regional Victoria. Depending on policies chosen, increased carbon farming and sequestration could lead to increases or decreases in employment in different regions and for types of forestry related jobs. Increasing sequestration in Victoria's forests has the potential to improve biodiversity and water quality but careful consideration would need to be given to impacts on water supply.

The Victorian Government has access to a range of policy levers to increase forest sequestration including through its management of public forests, and by building on existing programs to provide information and support to the agricultural and forestry sectors. The key Commonwealth policy is the Emissions Reduction Fund, which provides financial incentives for farmers and land managers to plant and maintain trees on their land. However, there has been minimal uptake of this program in Victoria (less than 1% of total projects)²⁰². Modelling suggests that increased plantings could be incentivised in Victoria through programs that offered a carbon price higher than that delivered under the ERF²⁰³.

The New Zealand Government's One Billion Trees Fund provides an example of ambitious government action to incentivise substantial tree planting by private land owners and communities, including a combination of plantings of indigenous species for regeneration or erosion control and indigenous or exotic plantations.

CASE STUDY: NEW ZEALAND'S ONE BILLION TREES PROGRAM

The New Zealand Government expects the forestry sector to be the largest driver of cost-effective emissions abatement in achieving the country's target of net zero emissions by 2050. The Government estimates that forested land will need to increase by between 1.3 million and 2.8 million hectares to deliver emissions reduction of between 25 and 50 MtCO₂-e annual abatement by 2050 ²⁰⁴.

In November 2018, the New Zealand Government launched a target to support the planting of one billion trees by 2028. This is estimated to be double the rate of planting that would have occurred under pre-existing policies to support forest carbon; a combination of emissions trading and direct financial incentives²⁰⁵.

The Government has committed to amending the country's emissions-trading scheme to improve the price incentive for forestry activities and remove barriers to participation and compliance.²⁰⁶ In addition, it has launched several targeted policy initiatives to overcome existing barriers to tree planting:

- The \$240 million One Billion Trees Fund is providing direct grants to encourage the planting of native trees by private land owners, communities and partnerships.
- The Government-owned Crown Forestry is also seeking to enter joint ventures with land owners to establish commercial forestry plantations.
- The Government will fund the planting of a further 350,000 trees as memorials to honour New Zealand Defence Force members.²⁰⁷



The role of offsets

In principle, emissions reduction can be achieved in two different ways: through action to directly reduce emissions within the state, or by purchasing emissions reduction achieved somewhere else. Emissions reduction that are purchased in this way are commonly known as carbon offsets or carbon credits. Offsets are generated from the avoidance, reduction or sequestration of greenhouse gases. Common offset projects include planting trees, energy efficiency improvements and methane capture. To be used to meet interim targets, offsets would need to come from outside of Victoria. This is because any emissions reduction or sequestration from inside Victoria will already be accounted for in the state's inventory (e.g. sequestration from the land sector, or reduced emissions from energy efficiency programs).

Specific decisions relating to offset use are best made by the government in the context of other policy decisions. The principles of economic efficiency, flexibility, environmental integrity and equity should be addressed in making those decisions.

Stakeholders expressed varying views on the use of offsets to meet Victoria's emissions reduction targets. Submissions from most individuals, environmental and social non-government organisations and local councils opposed offset use. The key concerns raised were that offset use would shift responsibility for emissions reduction to others; delay the low-emissions transition in Victoria; and lacks the accompanying economic, environmental and social benefits associated with locally driven action.

Use of offsets was strongly supported in submissions from business groups and the energy industry. The most common reasons cited in support of offsets included the additional flexibility it gives to emissions

reduction programs, and that it helps ensure climate goals can be met at least cost. For example, Ai Group said: *"A tonne of carbon dioxide has the same impact on global temperatures no matter where it is emitted. However, the marginal cost of abatement can vary widely across different regions and economies."*

After considering these issues, the Panel has decided that it supports the use of offsets as one of the tools that can be used to help meet Victoria's emissions reduction targets. This is because the Panel finds the arguments of flexibility and least-cost emissions reduction compelling, and because the Panel believes that the potential risks associated with offset use can be effectively addressed as set out below and through existing policies including on human rights and trade. The Panel also notes that use of offsets is a feature of many emissions reduction schemes internationally.

In the Panel's view, the primary considerations on the appropriate role of offsets are:

- **Integrity of the target:** Offsets use should not undermine the environmental effectiveness of interim targets, including their effectiveness in driving emissions reduction over time.
- **Quantity:** The Panel considers that offsets are a useful tool that can potentially provide cost-effective flexibility in meeting interim targets but should not be a primary means of meeting targets. The Panel agrees with stakeholder views that the transition to low-emissions can provide significant benefits for Victoria, including investment opportunities and job creation. As such, emissions reduction in Victoria should be prioritised ahead of purchases of offsets from outside of the State. This will also help to manage Victoria's exposure to future carbon risk, as it is not guaranteed that low-cost offsets will be available in the future.

- **Quality:** To ensure environmental integrity, any offsets must reflect the global principles of offset integrity, including that they represent genuine, permanent and additional emissions reduction. This could be achieved by allowing those offset credits recognised by an accredited scheme such as the Commonwealth Government in its National Carbon Offset Standard. This would align with the position of other jurisdictions, and the Climate Change Act's principle of compatibility.
- **Accounting:** The government should establish robust accounting mechanisms to ensure that offsets are appropriately tracked and are not double counted. The purchase or holding of offsets is currently not tracked at the state level.
- **Obligations:** In developing policies to meet interim targets, the Victorian Government will determine where responsibility should lie in each instance for achieving emissions reduction (i.e. with government or business), whether companies should be able to access offsets to manage these liabilities, and which offsets are eligible.

The Panel notes that if offset use were allowed, Victoria would remain responsible for reducing emissions consistent with its own emissions reduction targets by either reducing emissions locally or funding emissions reduction elsewhere. Furthermore, participation by other countries and jurisdictions remains voluntary based on their views of the merits of hosting offset projects.

Conclusion: Scale of emissions reduction opportunities by 2030

Victoria's emissions have already reduced since 2005 and are projected to fall to about 18% below 2005 levels in 2020.

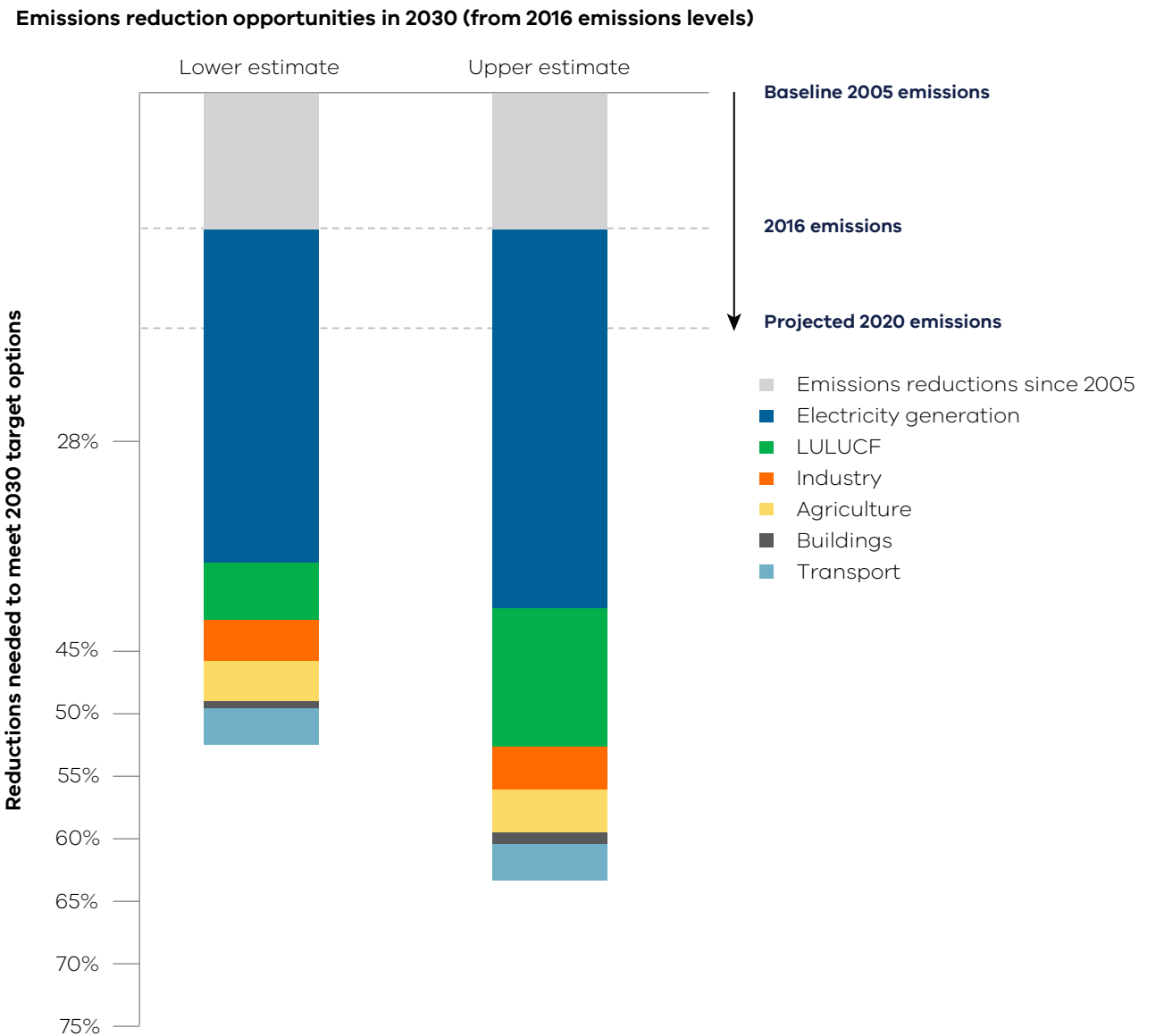
Emissions are likely to continue to fall to 2030 under existing policies. However, this will not be enough to achieve the target ranges recommended in the report or to keep Victoria on the pathway to net zero emissions by 2050.

As discussed in this chapter and summarised in **Figure 6.7**, there are significant opportunities for further emissions reduction across the whole Victorian economy by 2030. While not reflected in **Figure 6.7**, offsets would provide additional potential, and flexibility, to meet target options.

These illustrative estimates – based on the range of available evidence and on advice from experts – show that there are emissions reduction opportunities available that, if realised, could reduce Victoria's emissions by more than 45% and potentially as much as 60% or more by 2030. However, it is important to note that in some cases there are significant information, regulatory and cost barriers to realising these opportunities.

As shown in **Figure 6.7**, electricity generation provides by the far the largest opportunity. The second largest opportunity is from Victoria's forests (LULUCF), which is highly dependent on policy action. The difference between the higher and lower end of the range for LULUCF relates primarily to the amount and type of on-farm planting assumed. To avoid an increase in transport emissions and unlock greater reductions, early and strong policy action is required. Also illustrated is the reduction in emissions since 2005 (grey bars) and further projected reductions by 2020 (dotted line at 18% below 2005 levels).

Figure 6.7 Illustrative estimates of emissions reduction opportunities across the Victorian economy to 2030



Note: These illustrative estimates are based on the range of evidence and expert advice provided to the Panel and consider existing and, in a few cases, imminent technologies, barriers and Victorian policy levers. The estimates relate to different plausible scenarios for policy or uptake and are modelled outcomes. Waste sector emissions reduction opportunities were not estimated.

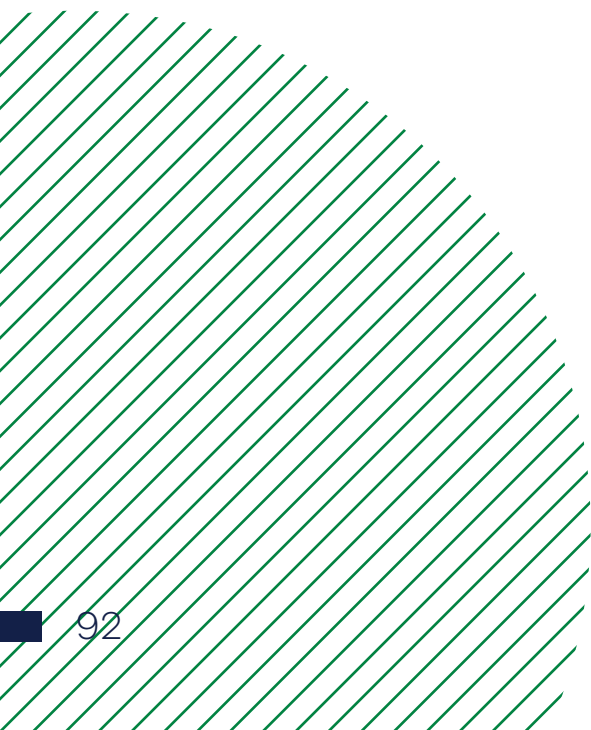
Based on the available evidence on emissions reduction opportunities, the Panel is confident that the Victorian Government and community can take actions to meet, and likely surpass, 45% below 2005 levels in 2030, using currently available measures and while the economy continues to grow. This is further supported by evidence on current progress to reduce emissions, technology development trends, growing action by businesses and support for climate action in the Victorian community (**Chapter 3**).

The Panel has chosen in part to recommend 60% as the higher bound of its target range given that the Victorian Government will need to work through significant implementation issues as it develops policies to reduce Victoria's emissions, and taking into account the scale of adjustment across the economy that would be required (**Chapter 5**). Implementation issues cannot be fully accounted for in broad-scale analysis of opportunities, and therefore not all of the emissions reduction opportunities identified are likely to be realised in practice.

However, based on the available evidence, the Panel believes that emissions reduction of 60% below 2005 levels could be achieved through strong policy action at both Victorian and Commonwealth level. Continued rapid technology development may also allow emissions to be reduced more easily and cheaply than analysis suggests today. Stronger

emissions reduction in 2030 are consistent with both better climate outcomes (**Chapter 5**) and lower overall economic costs to achieving net zero emissions by 2050 (**Chapter 7**).

The opportunities presented in this chapter provide a robust starting point for the Victorian Government, business and community to take actions and develop policies to reduce Victoria's emissions. In reaching the 45% end of the target range, the Victorian Government will have some options about which combination of emissions reduction opportunities to take forward. Reducing emissions further to reach 60% will require investigation of all available options.



7. IMPACTS OF INTERIM TARGETS: THE BENEFITS AND COSTS OF REDUCING EMISSIONS IN VICTORIA

SUMMARY:

- Victoria's transition to a net zero emissions economy presents a range of potential economic, social and environmental benefits and costs. The magnitude of these costs and benefits, and their distribution across regions, industries and households, will depend heavily on the policies implemented to achieve the targets.
- With the right policies, the transition to net zero emissions can unlock significant investment, create new jobs, provide the Victorian economy with a competitive advantage in a low-emissions world, and deliver significant health benefits and stronger ecosystems.
- As with any significant change in the economy, transitioning to net zero emissions will pose challenges for some people and communities.

KEY FINDINGS:

- The economic benefits for Victoria of avoiding climate change far outweigh the economic costs of reducing Victorian emissions.
- Several authoritative studies and recent experiences from other countries show robust economic growth can accompany strong emissions reduction. With the right policies, bold action to reduce emissions globally could boost global economic growth.
- Emissions reduction pathways that require stronger emissions reduction by 2030 have a lower economic cost to reach net zero emissions than those with weaker reductions to 2030. In other words, it is not cost effective to delay emissions reduction.
- It is important that Victoria builds on existing foundations to deliver a just transition. The Panel strongly encourages the Victorian Government to work with affected communities, including the Latrobe Valley, to develop a clear plan and measures to support local economic transition.
- With the right policies and investments, energy intensive and other currently emissions-intensive industries can have a strong place in the Victorian economy as they decarbonise.
- Actions to reduce emissions in Victoria can provide additional growth opportunities for Victorian businesses both locally and into a strongly growing global market for low-emissions goods and services.
- Reducing emissions can improve the health of Victorians by reducing associated local air pollutants. The health costs to Victoria of local air pollutants from electricity generation are currently estimated to be between \$420 and \$600 million per year, and those from road transport are estimated to be between \$660 million and \$1.5 billion per year.

Introduction

Victoria's transition to a net zero emissions economy presents a range of potential economic, social and environmental costs and benefits, ranging from impacts on industries and jobs to impacts on health, biodiversity and natural resources. The magnitude of these costs and benefits, and their distribution across regions, industries and households, will depend heavily on the policies implemented to achieve the targets²⁰⁸.

The Act requires the Victorian Government to develop sector strategies and pledges that will outline policies to contribute to meeting the interim targets before each interim target period begins. The Panel has provided advice on key considerations for developing these policies in **Chapter 8** of this report.

As a result of work undertaken by the Panel on interim targets, and as part of forthcoming "sector pledge" development, the Victorian Government and stakeholders will have more up-to-date information on the opportunities and risks of the transition to low-emissions to 2030 and beyond.

Economy-wide impacts of reducing emissions

Global and Australian studies

Several authoritative studies²⁰⁹ have assessed the impacts of climate change and of reducing emissions on the global and Australian economies. They have consistently found that:

- The economic benefits of avoiding the worst impacts of climate change through reducing emissions outweigh the costs of implementing emissions reduction measures (particularly over the long term);

- Economies can maintain robust growth under strong emissions reduction policies (see **Box 7.1**);
- Early action is cheaper than delayed action to meet internationally agreed goals; and
- The costs of global inaction are high (see also **Chapter 2**).

The CSIRO Australian National Outlook 2015 echoes these findings. It highlights the risks that weaker action to reduce emissions will damage the natural assets and life-support systems on which our long-term wellbeing and economic security depend²¹⁰.

More recent studies suggest that, with the right policies, bold action to reduce emissions could not just accompany economic growth but boost it²¹¹. The Global Commission on the Environment and the Economy, an independent body established by the governments of Colombia, Ethiopia, Indonesia, Norway, South Korea, Sweden and the United Kingdom, found that transitioning to a sustainable, low-emissions economic pathway could (conservatively) yield a direct economic gain globally of US\$26 trillion by 2030 compared with business as usual. This is given the falling costs of action and the strong benefits of investment in natural systems and more efficient infrastructure and does not account for other significant benefits such as improved health outcomes²¹².


Box 7.1 Economic growth under emissions targets: international experiences

In addition to economic studies, the experiences of other jurisdictions also demonstrate that significant emissions reduction can be accompanied by strong economic growth. The state of California met its 2020 target four years ahead of schedule, reducing its emissions to 13% below 2004 levels. During this time the Californian economy grew faster than any other US state, taking it from the tenth-largest economy in the world in 2012 to the fifth largest in 2018²¹³. The emissions intensity of California's economy declined by 38% between 2001 and 2016 while growing by 41%²¹⁴. Strong climate policy has supported the growth of California's clean energy sector, which represented almost 12% of major company revenue in 2018²¹⁵.

The United Kingdom reduced its emissions by 43% between 1990 and 2017, in pursuit of at least an 80% reduction by 2050.

The UK economy grew by 70% over this period²¹⁶. The electricity generation sector delivered around three quarters of the UK's total emissions reduction between 2012 and 2017²¹⁷. By 2017, electricity emissions were 65% lower than in 1990²¹⁸. Investment in new generation capacity has delivered lower average energy bills while maintaining security of supply²¹⁹. Emissions in the waste sector have been reduced by 48% since 2008, the result of EU regulations and a UK landfill tax²²⁰.

The World Resources Institute has identified a further 20 countries that have "decoupled" economic growth from emissions including the United States, Germany, France, Spain and the United Kingdom.²²¹



The Panel commissioned an expert review of existing evidence as this relates specifically to interim targets in Victoria. The review found:

- Based on Victoria-specific information in existing studies, significant emissions reduction can be achieved in Victoria at reasonably low overall economic cost, even for relatively strong emissions reduction trajectories. As an indication of scale, estimated impacts for Victoria of different scenarios in existing studies ranged from a 0.2% increase to underlying GSP growth by 2030 to a 3% reduction from underlying GSP growth by 2030. In other words, GSP growth reaches the same level as it would have in January 2030 around one-month earlier in one scenario or just over a year later in another;
- These results can be seen as an upper bound of the cost to the economy and the macroeconomic impacts of emissions reduction could be lower than past analysis has suggested. Past economic modelling has tended to under-estimate the opportunities for emissions reduction in the longer term and over-estimate the costs, particularly in sectors where disruptive technological change takes place. Technology costs are likely to continue to fall in the future, with disruptive change under way in the energy sector and beginning in transport (see also [Chapter 5](#));
- Based on existing developments and trends, future emissions reduction may in many cases be achieved without any additional costs, as low-emissions options become cheaper than high emissions options for new investments;
- Based on recent energy market modelling, the absence of credible emissions reduction targets and policies can increase the cost of transition and exacerbate dislocation. Policy intervention can reduce economic costs by alleviating investment uncertainty

and reducing the economic and social disruption from sudden, unanticipated change; and

- Existing analyses do not generally reflect the co-benefits of emissions reduction, some of which could be significant (e.g. improved health from reduced local air pollutants, see below), but also do not fully address the economics of emissions reduction at a regional or sector level, where adjustment costs may be significant in some cases (see also below).

The executive summary of the report containing this advice can be found at [Appendix H](#).

Assessing economy-wide impacts for Victoria of different target options

Given Victoria's legislated commitment to net zero emissions in 2050, decisions about different interim targets largely relate to the timing of emissions reduction between now and 2050 (rather than the absolute amount of emissions reduction undertaken – as considered in the studies above).

The Panel commissioned expert analysis to consider the potential impact on the Victorian economy of its draft interim target options (excluding the options of 60% and 75% reduction over 2005 levels in 2030²²²).

This analysis used information from a range of published studies to estimate the impact on the Victorian economy of different pathways to reach net zero emissions in 2050 within a fixed emissions budget (aligned with the 2°C-consistent emissions budget and associated trajectories discussed in [Chapter 5](#)). The analysis shows the potential cost implications of the timing of emissions reduction implied by different interim target options in 2030.

The expert analysis found that pathways with earlier emissions reduction (i.e. reaching 55% and 65% reductions below 2005 levels in 2030)

resulted in lower aggregate economic costs in reaching net zero emissions in 2050 than pathways with fewer emissions reduction to 2030 (i.e. reaching 28% below 2005 levels in 2030). In other words, the analysis found it was not cost effective to delay emissions reduction. This finding was robust across a range of assumptions and sensitivities including: the discount rate; the “cost curve” (i.e. how strongly Gross State Income (GSI) decreases with increasing amounts of emissions reduction over time); and the level of “business as usual” emissions over time. However, the differences between pathways and therefore the target options for 2030 were generally small.

One of the key factors determining the scale of impact on the economy is the shape of the “cost curve”. Some analysis suggests that impacts on the economy will increase only moderately as emissions are reduced by greater amounts over time (a shallow cost curve) while others suggest that impacts on the economy will increase more significantly (a steep cost curve).

A shallow cost curve is consistent with assumptions that:

- The costs of future emissions reduction will be reduced through:
 - learning by doing (for example, through improved Victorian skills and capacity in construction, siting and integration of wind farms into the electricity system); and/or
 - current policies to reduce emissions (e.g. by supporting low-emissions infrastructure or by spurring further research); and/or
- There are continued “no regrets” options (e.g. cost savings through energy efficiency).

A steep cost curve is consistent with assumptions that learning by doing effects are limited, that cost reductions are driven by global emissions policies and demand, and that low-cost opportunities are used up through initial emissions reduction.

The differing assumptions still provide the same overall finding that earlier action is likely to be cheaper overall and this result is stronger under a steeper cost curve.

In all cases, a target of 28% by 2030 is the costliest overall, even if very low discount rates are assumed, i.e. the higher costs implied by this pathway for Victorians in the future is given more weight (see note below).

The modelled present value impacts on GSI are provided in **Table 7.1** below.

Table 7.1 Reduction in the discounted value of Gross State Income (GSI) between 2020 and 2050 under emissions reduction pathways implied by the four 2030 target options considered

Cost curve	Discount rate	Emissions pathways: level of emissions reduction in 2030 (below 2005 levels)				Pathway with smallest reduction in discounted GSI 2020-2050
		28%	45 %	55 %	65 %	
Shallower cost curve	1.4%	-0.5	-0.4	-0.4	-0.3	65%
	4.0%	-0.4	-0.3	-0.3	-0.3	Equal: 45%, 55% and 65%
	7.0%	-0.3	-0.3	-0.2	-0.2	Equal: 55% and 65%
Steeper cost curve	1.4%	-3.6	-3.1	-2.7	-2.4	65%
	4.0%	-2.9	-2.5	-2.3	-2.1	65%
	7.0%	-2.2	-1.9	-1.8	-1.8	Equal: 55% and 65%

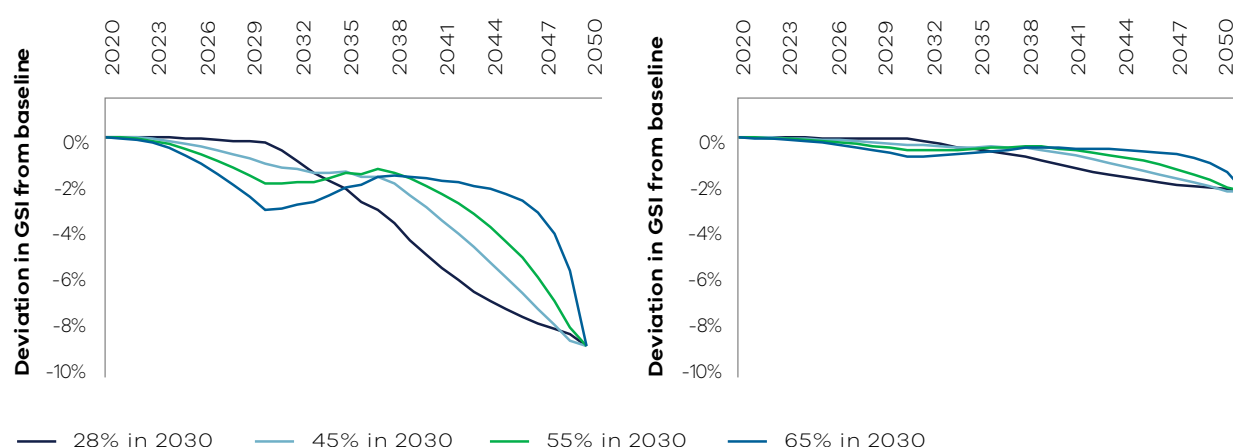
1. GSI loss between 2021 and 2050 is calculated in present value terms and expressed as a share of GSI in the baseline over the same time period.
2. The cost curve is the relationship between the implied loss of GSI (relative to baseline) for given reductions in emissions (relative to baseline). Two cost curves are presented here, based on existing studies and to show a range of potential results.
3. Discount rates relate to judgements about how future costs and benefits should be taken into account:
 - **1.4%:** Rate used for long term (>50 years) intergenerational decisions (in Stern 2006, for example). Based on zero (or very low) pure discount rate, but allows for some growth in real consumption. Some also argue that current real risk-free discount rate is very low.
 - **4%:** Designed to represent the market return on capital over the long term. In climate change, this is a rate typically used by analysts such as Nordhaus (2008). Also, frequently used as a lower bound in cost-benefit analysis.
 - **7%:** Represents opportunity cost of capital; a rate often used for government cost-benefit analysis and regulatory impact analysis. Generally, applies to periods less than 50 years.

Source: The CIE (2018), *Impact of timing of emissions abatement*

The expert analysis also noted that, despite these results, there may be some reasons to prefer pathways and target options that imply steady reductions over time given that the economic models used in this analysis do not incorporate some potentially important factors. Primary among these are the adjustment costs that are likely to be associated with movement of capital and labour from emissions-intensive industries into lower emissions industries (and, in many cases, between regional areas). These adjustment costs could potentially be significant for some regions and industries (see below).

Although targets of 55% or 65% in 2030, and by inference 60%, are estimated to be more cost effective in reaching net zero in 2050, they are estimated to have a greater absolute impact on the economy during the 2020s than targets that require fewer emissions reduction during the 2020s e.g. 45% and 28% in 2030. This is illustrated in **Figure 7.1**, which also shows GSI growth slows the most under a steep cost curve (i.e. if economic costs are assumed to increase more as emissions reduce further).

Figure 7.1 Macroeconomic impacts over time of emissions pathways implied by four of the Panel's draft 2030 target options assuming a steep (left) or shallow (right) cost curve



Note: GSI loss is undiscounted and expressed as a share of baseline GSI.

Source: The CIE (2018), *Impact of timing of emissions abatement*

The executive summary of the report containing this advice can be found at **Appendix I**.



Different impacts and opportunities for different communities, regions and sectors

The impact on the overall economy provides only part of the picture, as the opportunities and costs are likely to be spread unevenly across the Victorian community and different economic sectors and regions.

Avoiding the impacts of climate change will be particularly important to some sectors of the economy, particularly those that rely on the natural environment such as agriculture and tourism, but all sectors will be impacted to some extent through, for example, loss of productivity from increased heat and the impacts on infrastructure.

Sectoral, regional and socioeconomic impacts of reducing emissions

Sectors will be affected differently by emissions reduction policies, and some impacts may be concentrated in particular industries and communities. As discussed above, in some industries and regions these impacts may be significant and will need to be carefully managed.

Broadly speaking, as Victoria transitions to a net zero emissions economy, the structure of the economy would be expected to shift away from more emissions-intensive production methods, goods and services to less emissions-intensive ones. However, the Panel firmly believes that,

with the right policies and investments, energy intensive and other currently emissions-intensive industries have a strong place in the Victorian economy as they decarbonise.

Chapter 3 and the case studies in **Chapter 6** provide examples of energy intensive businesses that are already securing their operations and reducing emissions through use of affordable renewable energy.

Emissions and energy intensive, trade-exposed industries may see a decline in competitiveness, or movement of businesses to outside Victoria (“carbon leakage”) if other states and countries have weaker emissions reduction policies than Victoria²²³. These concerns were raised in submissions to the Panel’s issues paper from the Business Council of Australia and the Australian Industry Group. Large industrial emitters in Victoria include producers of plastics, chemicals, aluminium and glass, metal smelters, paper mills and oil refineries. Agriculture is also an important, emissions-intensive sector in Victoria which is trade-exposed. The strength of any potential carbon leakage effect is likely to be moderated by the fact that the majority of Australia’s other states and territories (Australian Capital Territory, New South Wales, Queensland, South Australia and Tasmania) have also committed to achieving net zero emissions by at least 2050 (**Chapter 3**).

Impacts such as a decline in competitiveness and carbon leakage can be avoided or minimised through careful policy design²²⁴:

- Sectors and individual businesses are likely to need to transition at different speeds and times, and will need different degrees of government support, depending on the availability of cost-effective emissions reduction measures. If policy schemes create an emissions reduction obligation on businesses, offsets could be one mechanism to provide emissions-intensive industries with flexibility to make emissions reduction investments at the right time (e.g. to align with turnover of plant).
- Some government support is already in place to help industry and agriculture to improve their energy efficiency and reduce energy costs; for example, through the \$30 million Agriculture Energy Investment Plan²²⁵, the \$6.1 million Boosting Business Productivity program²²⁶, and the Victorian Energy Upgrades Program (**Chapter 3**).

Communities that depend on (currently) emissions-intensive industries for employment may also face challenges, particularly where there are limited cost-effective emissions reduction options or alternative employment opportunities (an example of the adjustment costs discussed above). Specific measures should be considered to ensure a just transition for communities and industries likely to be directly negatively impacted by emissions reduction policies. Many submissions to the Panel's issues paper, from individuals and from organisations including the Clean Energy Council, Environment Victoria and the Victorian Trades Hall Council, emphasised the importance of retraining workers and creating alternative employment opportunities for those currently employed in emissions-intensive activities. This will be of particular importance in the Latrobe Valley (**Box 7.2**).

Box 7.2 The Latrobe Valley: a region in transition

The Latrobe Valley's coal-fired power stations have provided cheap, reliable power to Victorian households, businesses and industries for the past 40 years. The power stations and associated coal mines have also played a key role in the local economy and community, providing a significant source of employment and income. Work is under way to secure the future of the region's economy, including in low-emissions energy and manufacturing.

A structural transition away from coal power generation is now under way²²⁷. Rapid and ongoing falls in the costs of renewable energy technologies have made wind and large scale solar PV the cheapest form of new generation and created more challenging market conditions for coal generators. A hotter climate is also creating more difficult operating conditions for ageing plants.

As the power stations in the Latrobe Valley reach the end of their operating lives, alternative sources of income will be needed, implying significant economic change in the region. A number of key indicators related to unemployment, education and health show that the region is also more socially disadvantaged than the Victorian average.

Recognising the significant implications of a low-emissions transition for the Latrobe Valley, the Panel visited and engaged with local stakeholders in the region as part of its public consultation process. The importance of the Latrobe Valley was also emphasised by numerous stakeholders

responding to our consultation, including local community groups, energy companies, Environment Victoria and Environmental Justice Australia. The key messages were that the economic transition in the Latrobe Valley needs to be orderly and planned, with closures signalled in advance, and must involve investment to grow existing businesses and support new opportunities and retraining for workers. As with groups across Victoria more broadly, some stakeholders also noted concerns about increasing power prices.

Lessons can be learned from the move from coal to renewables under way in other countries and from actions taken in the Latrobe Valley in the wake of the closure of Hazelwood power station.

In the Ruhr region of Germany²²⁸, the Netherlands, Singapore and Spain²²⁹ actions to support a just transition have included economic diversification; staggered closures; re-skilling workers in new industries; bringing forward jobs in mine rehabilitation; and funding for workers to retire early. Experience in these regions shows that with forward planning, community engagement and investment, the impacts can be minimised and the long-term prosperity of the affected communities can be secured.

In response to the challenges facing the Latrobe Valley, and in particular the closure of Hazelwood power station in March 2017, the Victorian Government committed \$266 million to the region and established the Latrobe Valley Authority. The Authority is

implementing a range of programs and investments including to support workers and their families in finding new jobs and gaining new skills, to support local businesses to create and sustain local jobs and has established the Gippsland Hi-Tech Precinct to support research, business incubation and new product development.

More recently, SEA Electric announced it will build an electric vehicle assembly plant in the Valley, which will create an estimated 500 jobs.²³⁰

The Victorian Government has also established a requirement for the owners of Yallourn and Loy Yang A to provide at

least five years' notice of plant closure, as a condition of their mine licences being extended²³¹. Separately, the Australian Energy Market Commission has introduced a "three-year notice of closure" rule in response to the recommendations of the Finkel Review, which applies to all generators nationally. These notice periods will provide time for planning with the community and for appropriate supports to be put in place.

The Latrobe Valley Authority and its work provide a good basis for considering further support for the region.

Care also needs to be taken to consider the needs of low income households in the transition to a low-emissions economy. These households are more vulnerable to policies that increase the costs of essential services such as transport and electricity, as these represent a larger share of their disposable income²³². While analysis shows that electricity emissions can be reduced

without significant impacts on electricity prices (**Chapter 6**), low income households may not be able to afford the upfront costs of measures that can reduce emissions and household bills, such as solar PV panels and energy efficiency measures, as emphasised by some stakeholders including Environment Victoria.

New opportunities

The transition to net zero emissions in Victoria will require significant levels of investment, which can create economic opportunities such as new jobs and growing industries. Many submissions to the issues paper, including from small businesses specialised in renewable energy and energy efficiency, emphasised the new job opportunities associated with a transition to a low-emissions economy. Existing policies to reduce emissions in Victoria are already illustrating this potential: for example, the Victorian Renewable Energy Target is expected to create around 11,000 jobs over the life of the scheme²³³. Regional Victoria, particularly the west, is hosting a growing number of renewable energy projects. For example, the expansion of the Nectar Farms greenhouse facility (**Chapter 3**), and the construction of the Bulgana Green Power Hub to supply it with electricity is creating 600 direct jobs and more than 930 indirect jobs in the Northern Grampians Shire²³⁴. Recent months have seen the announcement of plans for an electric vehicle factory in Latrobe Valley (see **Box 7.2**) and a wind turbine factory in Geelong.

Clear and credible interim targets provide certainty that can increase industry confidence to invest further and can reduce the cost of capital and draw in low-emissions investment²³⁵.

Actions to reduce emissions in Victoria can provide additional growth opportunities for Victorian businesses through:

- The establishment of skills and capacity in areas of increasing demand as low-emissions sectors expand globally. According to one recent estimate, global trade in a selection of low-emissions goods and services could increase from around \$240 billion in 2015 to \$1.6–\$2.9 trillion in 2030, and to \$4.5–\$8.2 trillion in 2050²³⁶; and
- Tapping into growing consumer preferences for sustainable goods and services²³⁷. Businesses are increasingly seeing potential for additional growth and profit from sustainable practices such as reducing their emissions²³⁸.

One example of a potentially significant new economic opportunity is the production of hydrogen, which could help decarbonise heavy transport and industry in the future and also has export potential. Australia's Chief Scientist found that hydrogen exports could be worth \$1.7 billion to the Australian economy and support thousands of jobs by 2030²³⁹. Use of hydrogen domestically could also provide new job opportunities²⁴⁰ while helping reduce Victoria's emissions. This potential is already being explored in Victoria through the investments by the Victorian Government in generating hydrogen from renewable energy and a pilot program in the Latrobe Valley to use brown coal to produce and then export hydrogen to Japan. To avoid an increase in Victorian emissions, hydrogen would need to be produced with wind or solar, or incorporate the use of carbon capture and storage.

Victoria's New Energy Technologies Strategy states that Victoria is well placed to develop significant growth associated with renewable energy, energy efficiency, energy storage and demand management technologies. This is due to Victoria's strengths in information and communications technology, a highly skilled workforce, a well-developed freight and logistics system, advanced manufacturing and material engineering, and its abundant world-class renewable energy resources, smart meter infrastructure, and research and technological capabilities²⁴¹. Emissions-neutral agricultural produce, waste to energy, green finance and hydrogen fuel production (outlined above) represent other future growth opportunities.

Finally, a transition to a low-emissions economy can potentially lead to significant economic savings for businesses and households. For example, the Victorian Government has estimated that implementation of the Victorian Government Energy Efficiency and Productivity Strategy may save participants around \$6.7 billion off their energy bills between 2018 and 2030²⁴².

Co-benefits of reducing emissions

Health benefits

In addition to producing emissions, fossil fuel combustion (e.g. from coal-fired electricity generation and internal combustion engines in motor vehicles) produces local air pollutants that can be harmful to human health, such as sulphur dioxide, nitrogen oxides, and particulate matter. A significant body of literature has found these pollutants to be associated with cardiovascular and respiratory diseases, contributing to increased mortality rates²⁴³. Decarbonising electricity generation will have significant health benefits for communities in the Latrobe Valley, while moving away from internal combustion engines in the transport sector will have health benefits particularly for those living in Greater Melbourne (**Box 7.3**). Many individuals and some environmental organisations, such as Doctors for the Environment, highlighted the benefits of improved air quality as a key consideration in the transition to a low-emissions economy.

Box 7.3 Health benefits of emissions reduction through reduced local air pollution

Many measures that reduce greenhouse gas emissions also reduce local air pollutants. For example, the World Health Organisation (WHO) identifies shifting the generation of electricity from fossil fuels to renewables, decarbonising the transport sector through the electrification of vehicles and the increased use of public transport and active travel, as key opportunities to reduce local air pollution²⁴⁴.

Reducing emissions and associated local air pollutants can generate significant health benefits²⁴⁵. The WHO's COP24 Special Report on Health and Climate Change finds that achieving the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels could save about one million lives worldwide every year by 2050 through reductions in local air pollution alone.²⁴⁶

Local air pollution is currently harming the health of Victorians. The health costs created by local air pollutants from the electricity sector are estimated to cost Victorians between \$420 and \$600 million a year, while those from the transport sector are estimated to cost between \$660 million and \$1.5 billion per year.

These estimates build on existing studies of health damage costs associated with local air pollutants and were developed in consultation with the Environmental

Protection Agency (EPA). They consider the pollutants SO₂, NO_x, PM_{2.5} and PM₁₀, which are the most common harmful local air pollutants in Victoria. Ozone (O₃), which is also a common harmful pollutant in Victoria, has not been included in the estimates as damage costs are not readily available for O₃. These estimates may consequently be considered conservative.

Estimates of the costs of local air pollution from the electricity sector combine damage costs from existing studies^{247,248,249,250} with Victorian air pollutant emissions²⁵¹ and electricity generation data²⁵². The damage costs considered in these estimates have been adapted from international studies to reflect Victorian conditions, such as Victoria's population density, the emissions intensity of Victoria's brown coal and the stack height of Victorian coal-fired power stations. Estimates of the health costs of local air pollution from Victoria's motor vehicle fleet draw on Australian transport studies.^{253, 254}

The scale of health benefits from reducing Victoria's emissions will depend on the scale and type of emissions reduction undertaken. One study estimates that decarbonising Victoria's light vehicle fleet between 2018 and 2046 could deliver health benefits of between \$270 million and \$735 million²⁵⁵.

Source: Department of Environment, Land, Water and Planning (2018), 'Estimating the health costs of air pollution in Victoria'

Beyond local air pollution, many studies point to the health benefits of increased physical activity from walking, cycling and using public transport. Physical inactivity was estimated to cost Australia \$805 million in 2013 – \$640 million in direct healthcare costs and \$165 million in productivity losses²⁵⁶. One study estimated that cyclists save the Australian economy \$72.1 million in reduced health costs²⁵⁷. Literature is also emerging to indicate that reduced consumption of meat and of other animal products (which are generally emissions-intensive) can produce health benefits²⁵⁸.

Finally, improving the energy efficiency of homes can improve health outcomes, particularly for low-income households who may not otherwise be able to afford to heat or cool their home to a comfortable temperature. Victoria's Energy Efficiency and Productivity Strategy estimates that the \$17 million that the government is investing to support energy efficiency upgrades for 3,300 low-income households will generate \$9.6 million in health benefits (in addition to \$12.6 million in savings on energy bills over 15 years)²⁵⁹. Some submissions to the Panel's issues paper, such as that from Environment Victoria, emphasised this as an important issue not only for reducing emissions, but also for equity.

Environmental impacts

Joining the global effort to reduce emissions may help avoid or reduce the negative impacts that climate change is having on Victoria's environment (See **Chapter 2**).

Emissions reduction measures in Victoria would also deliver benefits for the environment. For example, reforestation and afforestation can support biodiversity and strengthen ecosystems which, in addition to storing carbon, provide services including nutrient cycling, water and air purification, and habitat for wildlife. Tree

planting can also remediate areas affected by dryland salinity by lowering the water table. There are, however, potential environmental risks associated with reforestation and afforestation, including reduced surface water flows, or monocultures (plantations of a single tree species) being detrimental to biodiversity^{260, 261}.

The net impact of energy-sector emissions reduction measures on water supply will depend on the technologies used. However, moving away from fossil fuel electricity generation may have benefits for water availability²⁶². Coal-fired power stations use more water per gigawatt hour than any other form of electricity generation except for hydroelectricity²⁶³, while certain low-emissions technologies such as CCS, solar thermal and geothermal generation plants also require water for generation and cooling.

In 2009, the National Water Commission estimated water use in Victoria's electricity generation sector to be 125 billion litres of water annually. To give a sense of scale, this is equivalent to around a third of Melbourne's annual water consumption²⁶⁴. Given Victoria's history of drought, the future pressures of climate change and population growth on water supply and the importance of water-dependent agriculture in areas surrounding the Latrobe Valley, this may present a significant co-benefit.

8. INTERIM TARGET DESIGN

SUMMARY:

- The Panel recommends that interim targets take the form of a percentage range in the final year of each target period, expressed as a reduction from 2005 levels, with a broader range in 2030 than in 2025.
- This target design provides a balance between flexibility to adjust to changing circumstances and certainty in the pathway to net zero emissions by 2050. It is also easy to communicate and is widely supported by stakeholders.
- By putting a limit on emissions every five years, this type of target will help minimise Victoria's cumulative emissions. In addition, policymakers should drive emissions down across the target period to minimise cumulative emissions.

General considerations

Interim targets can serve multiple objectives, and different target designs fulfil these objectives to a greater or lesser extent. The choice of the most appropriate target design is therefore a judgment based on the objectives of interim targets. In the Panel's view, informed by the *Climate Change Act 2017*, the two key objectives of the interim targets are to:

- **Set a clear pathway to net zero emissions by 2050 and drive Victoria's transition to a low-emissions economy** by giving investors, businesses, the community and the Victorian Government a credible and clear signal for planning, investment, innovation, behavioural change, and policy action; and
- **Maintain environmental effectiveness** (Panel principle) by ensuring that Victoria's emissions are reduced to net zero by 2050 in a way that is consistent with the international agreement to hold the global average temperature increase to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels (as set out in the Preamble to the Act).

Additionally, the Panel believes that interim target design should **provide flexibility to adapt to changing circumstances** (*Panel principle*); and **be easy to communicate**.

Recommended target design

Based on consideration of the available options and the objectives that interim targets serve, the Panel recommends interim targets should take the form of a percentage range in the final year of each target period (2025 and 2030), i.e.:

- a-b% in 2025
- x-y% in 2030

where $x > b$ so that the 2030 target constitutes a greater reduction in emissions than the 2025 target.

The Act requires interim targets to be expressed as a reduction from Victoria's 2005 emissions.

This target design is easy to communicate and can provide a clear pathway to net zero emissions by 2050. For example, the meaning of 40% below 2005 levels is easier to communicate than 51 MtCO₂e below 2005 levels. The target design is also consistent with Victoria's existing 2020 target (15-20% below 2005 levels) and the Commonwealth's 2030 target (26-28% below 2005 levels). The majority of individuals and

stakeholders responding to the Panel's issues paper also proposed targets in the form of percentage ranges at the end of the five-year target periods.

The Panel believes a range is appropriate to provide flexibility to adjust to changing information and circumstances. For example: future national climate and energy policy remains uncertain, and will have a material impact on Victoria's emissions and emissions reduction effort; future developments in technology may affect what emissions reduction are technically achievable and at what cost; future developments in climate science may change the level or urgency of action required; and emissions may vary year-on-year due to circumstances beyond the government's control, e.g. particular weather increasing/decreasing heating and cooling needs and therefore energy use.

The Panel has recommended target ranges that are relatively narrow, to maintain a clear signal about Victoria's emissions reduction trajectory to net zero by 2050. The range recommended for 2030 is wider than the one recommended for 2025 to reflect the greater uncertainty and hence need for greater flexibility further into the future. The Panel's recommended target ranges are 15 percentage points in 2030 and 7 percentage points in 2025.

The Panel believes that the target design should provide a balance between flexibility and certainty and that its proposed design achieves this equilibrium. Other designs such as annual targets provide greater emissions certainty but little flexibility. Making recommendations about

this type of target would require judgements about the precise course of emissions over the coming years. The Panel believes that such judgments would be infeasible.

Given that changes to the global climate are determined by cumulative emissions (due to the long-lived nature of greenhouse gases in the atmosphere), Victoria's emissions trajectory and resulting cumulative emissions to 2050 are important to achieving environmental goals. The Panel's chosen target design drives emissions reduction over time by specifying a limit every five years. As required by the Act, the range for 2030 can and should sit completely below the range for 2025 to ensure declining emissions in each five-year period. Consideration of cumulative emissions should also inform the development of emissions reduction policies, with the aim of ensuring, to the extent possible, that emissions reduction are made across the interim target period. Otherwise, a larger share of Victoria's total 2°C-consistent emissions budget could be used by 2030 than anticipated in the Panel's analysis, and a smaller share would remain post-2030. This would make deeper emissions cuts (and more stringent targets) necessary post-2030 to remain within Victoria's 2°C-consistent emissions budget and a fair share of global effort. In the same vein, the Panel believes that determination of interim targets post-2030 should take into consideration progress in reducing Victoria's emissions and the implication of this progress for the emissions budgets for Victoria developed by the Panel ([Chapter 5](#)).

9. ACHIEVING INTERIM TARGETS: POLICY CONSIDERATIONS

SUMMARY:

- A broad range of policy options are available to reduce Victoria's emissions. The Victorian Government should design policies and take actions now that will improve the potential to reduce Victoria's emissions more quickly or cheaply in later interim target periods.
- The *Climate Change Act 2017* provides a set of mandatory considerations that apply to all government decision-making under the Act, including to the determination of interim targets and the development of policies to achieve them through the "sector pledge" process.
- Having considered the objectives and principles of the Act, the Panel highlights the following issues of particular relevance to developing policies, programs and measures to meet interim targets:
 - the long-term target of net zero emissions by 2050 should be integrated into decision-making (particularly about long-lived infrastructure). Policies and actions should be designed to prepare Victoria to undertake [ongoing/greater] emissions reduction in later interim target periods;
 - Traditional Owners are already contributing to — and can further support and benefit from — actions to reduce Victoria's emissions. Policy development should incorporate the unique role and rights of Traditional Owners and seek to overcome barriers to their participation in and management of projects to reduce emissions.
 - consideration should be given to when it is appropriate for the Victorian Government to implement its own policies, and when it would be more efficient or cost effective to seek action at the national level;
 - clear, stable, credible policies that are compatible with policies operating at the national level are important to underpin "business confidence" to plan for and invest in a net zero emissions future; and
 - cost-effective policy instruments should be prioritised. These tend to be broad-based, flexible and market driven.

Developments in technology, business practices, market factors, consumer preferences and existing emissions reduction policies mean that a low-emissions transition is already under way ([Chapter 3](#)). However, further policy action will be needed for Victoria to achieve the interim targets for 2025 and 2030 and net zero emissions by 2050.

A broad range of policy options could be pursued by the Victorian Government to achieve the interim targets. While it is not the

Panel's role to propose specific policy options or instruments, the Panel does wish to emphasise that policy choice will strongly influence the costs and benefits of meeting the targets and the distribution of these costs and benefits across sectors, regions and sections of the community ([Chapter 7](#)).

The *Climate Change Act 2017* provides a framework and a set of mandatory considerations for government decision-making that may influence Victoria's emissions

or be impacted by a changing climate. These considerations apply to both the determination of interim targets and the development of policies to achieve them through the “sector pledge” process. In particular, the Government must consider the policy objectives of the

Act (s22), the guiding principles of the Act (s23-28) and must integrate climate change considerations into government decision-making (s20). These sections of the Act are summarised below (**Box 9.1**)

Box 9.1 Summary of the policy objectives and guiding principles in the *Climate Change Act 2017*

S. 20 DECISION AND POLICY-MAKING

The Government of Victoria will endeavour to ensure that any decision made by the Government and any policy, program or process developed or implemented by the Government appropriately takes account of climate change, if it is relevant, by having regard to the policy objectives and the guiding principles.

S. 22 POLICY OBJECTIVES

The policy objectives of this Act are –

- a. To reduce the State’s emissions consistently with the long-term emissions reduction target and interim emissions reduction targets; and
- b. To build the resilience of the State’s infrastructure, built environment and communities through effective adaptation and disaster preparedness action; and
- c. To manage the State’s natural resources, ecosystems and biodiversity to promote their resilience; and

- d. To promote and support the State’s regions, industries and communities to adjust to the changes involved in the transition to a net zero emissions economy, including capturing new opportunities and addressing any impacts arising from the need to reduce emissions across the economy; and
- e. To support vulnerable communities and promote social justice and intergenerational equity.

IN SUMMARY, THE GUIDING PRINCIPLES OF THE ACT ARE:

S. 23 PRINCIPLE OF INFORMED DECISION-MAKING

Action should be based on a comprehensive analysis of the best practicably available information about the potential impacts of climate change. Actions should consider the potential contribution to the State’s emissions.



S. 24 PRINCIPLE OF INTEGRATED DECISION-MAKING

Action should integrate the competing long-term, medium-term and short-term environmental, economic, health and other social considerations relating to climate change to ensure that all relevant issues are taken into consideration, there is a proper examination of all the issues and any actions are cost effective.

S. 25 PRINCIPLE OF RISK MANAGEMENT

Action should be based on an assessment of the likelihood, consequence and risks of climate change. It is a guiding principle of the Act that a lack of full scientific certainty should not be used as a reason to postpone taking action.

S.26 PRINCIPLE OF EQUITY

Action should have regard to opportunities to increase the capacities to adapt to climate change of those people most vulnerable to climate change, and that present generations should minimise the impact of climate change for future generations.

S.27 PRINCIPLE OF COMMUNITY ENGAGEMENT

Actions should include providing appropriate information and opportunities to the community. Actions should be developed with adequate consultation with the community.

S.28 PRINCIPLE OF COMPATIBILITY

Actions should seek to promote a coherent policy framework within the State and seek to achieve cohesion with the climate change actions of other states, the Commonwealth, other countries and international bodies.

Having reflected on the application of these principles and objectives in considering its recommendations for interim targets, the Panel would like to highlight several issues of particular relevance to developing policies, programs and measures to meet the interim targets.

Consistency with the long-term target (net zero emissions by 2050) (s22 (a)) will be particularly important when making decisions about long-term infrastructure (e.g. related to urban planning, transport, energy generation and distribution and industry policy) that will influence emissions for decades to come. Investments in high-emissions infrastructure will either “lock in” high emissions, making it more difficult to reach net zero in 2050, or risk creating ‘stranded’ assets that need to be decommissioned before end of life, creating unnecessary economic losses.

It will also be important to consider whether current policies and actions adequately prepare Victoria to undertake emissions reduction more quickly or cheaply during later interim target periods. This could include considering research (e.g. on agricultural emissions reduction and negative emissions), building market capacity (e.g. in revegetation) and establishing infrastructure (e.g. electric vehicle charging stations).

The role of Traditional Owners in reducing Victoria’s emissions should be considered and integrated early in the policy process (see **Box 9.2**). All of the Objectives and Guiding Principles of the Act will be relevant to working with Traditional Owners. The additional principle of self-determination should guide all collaboration with Traditional Owners as First Peoples with rights, authority and obligations for managing Country.

Box 9.2 Emissions reduction and Victoria's Traditional Owners

Traditional Owners are already contributing to — and can further support and benefit from — actions to reduce Victoria's emissions, particularly in realising the significant emissions reduction opportunities in the land sector and renewable energy generation. Activities are already being undertaken by Traditional Owners and other Aboriginal people that are mitigating climate change while caring for Country.

Victoria has an established legal framework for recognising Traditional Owner rights and role in managing their Country, with legally recognised Traditional Owner groups across nearly 70% of the State. Twelve Traditional Owner groups are recognised under the Aboriginal Heritage Act, Native Title Act and Traditional Owner Settlement Act as the cultural custodians of their Country. This figure is set to grow as native title claims are resolved over the next few years. Traditional Owner Settlement agreements currently relate to 36% of the State. They provide Traditional Owners with legally recognised rights to own, manage and use natural resources and develop economic and investment opportunities. They also create responsibilities for government to engage and involve Traditional Owners in decisions relating to these rights.

The Federation of Victorian Traditional Owner Corporations (the Federation) informed the Panel that Traditional Owners have strong interests in carbon sequestration activities and the multiple economic, cultural and environmental benefits these can deliver. Indeed, climate

change adaptation and mitigation activities are undertaken as part of undertaking Traditional Owners' cultural obligations for caring for Country.

The Federation noted that the processes under the Climate Change Act (to set interim targets, and to develop a climate change strategy and sector pledges) provide an opportunity to integrate Traditional Owner values and participation, as occurred through other Government policies including Biodiversity 2037 and Water for Victoria. The Federation also stressed the importance of early engagement.

There are a range of barriers to participation by Traditional Owners in emissions reduction that the Victorian Government should seek to overcome in developing emissions reduction policies and programs. These include:

- access to suitable land for carbon sequestration
- rules that restrict Traditional Owners deriving income from carbon sequestration, for example under joint management arrangements
- access to start-up capital
- training in new skills required to identify opportunities and undertake emissions reduction activities.

The Federation suggested a helpful initial step would be the commitment of resources for the development of a Victorian Traditional Owners strategy on climate change mitigation. Policies could

also support and expand activities already undertaken by Traditional Owners that sequester carbon by protecting, restoring or regenerating indigenous vegetation. These activities could be supported through access to carbon offsets and, or government procurement.

The Victorian Government should also support Traditional Owners to partner in and benefit from the development of

renewable energy projects. This could initially include providing support for the development of a Traditional Owner renewable energy roadmap that would identify Traditional Owner rights and interests in relation to renewable energy generation, enable inclusion of these in the regional and statewide Renewable Energy Roadmaps already under way and surface projects that could generate benefits for Traditional Owners.

The principle of compatibility (s.28) highlights that Victoria will be acting to reduce its emissions in the context of national policies and within the constraints of the powers available to it. Consideration should be given to when it is appropriate for the Victorian Government to implement its own policies, and when it is preferable to seek action at the national level. In some cases, important policy levers sit with the Commonwealth Government; examples include vehicle emission standards and fuel taxes. In other cases, the Victorian Government has powerful levers to influence emissions, such as environmental regulation, urban planning or funding of public transport infrastructure.

In cases where there are overlapping Commonwealth and state powers, such as building regulations, energy policy and industrial policy, judgment will be needed about efficiency and desired policy outcomes. As emphasised by business stakeholders, including the Australian Energy Council and Australian Industry Group, there may be some areas where the state has the levers to act but it may not be practical, efficient or economically desirable to do so on its own. In these cases, Victoria should seek to act jointly with other states and territories to influence Commonwealth policies and/or co-ordinate state level policies. Indeed, this will be critical to the achievement of the interim targets

given that they rely significantly upon emissions reduction in the electricity sector, in which national policy plays a significant role.

Clear, stable, and credible policies that are compatible with policies operating at the national level will provide certainty and increase industry confidence to invest in and plan for a net zero emissions future. This was a key message emerging from the Finkel Review into the future security of the electricity market²⁶⁵ and has been a consistent message the Panel has received from stakeholders throughout its public consultation process.

Cost-effective policy instruments should be prioritised (s 24). These tend to be broad-based, flexible and market-driven approaches. For example, in its *Policy options for Australia's electricity supply sector – Special review research report (2016)*, the Climate Change Authority found market mechanisms to reduce emissions in the electricity generation sector do so at a sometimes significantly lower cost than technology-pull or regulatory instruments. The CCA also found the market mechanisms it explored to be more flexible, more scalable, and less exposed to risk²⁶⁶. However, to capture the full efficiency benefits, this approach is likely to be best implemented at a national or cross-state level.

10. CONCLUSIONS AND RECOMMENDATIONS

RECOMMENDATIONS:

The Panel recommends interim emissions reduction targets for Victoria of:

- 32-39% below 2005 levels in 2025;
- 45-60% below 2005 levels in 2030.

The Panel also recommends that:

- The Victorian Government takes actions now that will increase the potential to reduce emissions more quickly later, given this will be important in pursuit of the Paris goal and for reaching net zero emissions by 2050;
- The Victorian Government reviews its 2030 interim target in 2023, taking into account developments in climate science, technology, global action and further progress in reducing Victoria's emissions.

Introduction

Guided by the *Climate Change Act 2017*, the Panel has considered a broad range of evidence to inform its advice on interim targets, trajectories and emissions reduction opportunities. As set out in this report, this evidence includes:

- Scientific evidence on the significant risks that climate change poses to Victoria;
- The actions that Victoria and others are already taking to reduce emissions – including the commitment of the international community, through the Paris Agreement, to limit warming to well below 2°C and to pursue efforts to limit the increase to 1.5°C above pre-industrial levels, in order to avoid the worst impacts of climate change;

- The implications of Victoria contributing its fair share to limiting global temperature increases in accordance with the Paris goal (emission budgets for Victoria);
- The availability of significant emissions reduction opportunities across the Victorian economy; and
- The potential economic, social and environmental benefits and costs of Victoria's transition to a net zero emissions economy.

Interim target recommendations

The period from 2021-2030 is a crucial decade for Victoria's emissions reduction pathway to net zero emissions. The climate science and economic analysis are clear that the transition should not be delayed.

Following consideration of all the evidence presented in this report, the Panel recommends interim emissions reduction targets for Victoria of:

- 32-39% below 2005 levels in 2025
- 45-60% below 2005 levels in 2030

These ranges will set Victoria on the right pathway to achieving net zero emissions by 2050. They will enable Victoria to capture the benefits of the low-emissions transition and provide flexibility to manage uncertainties and the impacts on specific communities. They can be consistent with the global commitment, supported by the Victorian Government, to keep temperature increases to well below 2°C above pre-industrial levels and to pursue efforts to limit warming to 1.5°C.

Achievability

The Panel is confident that the Victorian Government, business and community can take actions to reduce emissions to meet, and likely exceed, 45% below 2005 levels by 2030. This is particularly so, given existing progress to reduce Victoria's emissions (emissions are projected to be 18% below 2005 levels in 2020), growing action by businesses, technology development trends and support for climate action in the Victorian community.

The recommended ranges allow for Victoria to reduce emissions further where it can, in line with evidence that greater emissions reduction in the period to 2030 are likely to be lower cost overall in reaching net zero emissions by 2050. The higher end of the range (60%) could be reached with strong policy action at both the State and Commonwealth level. Continued rapid technology development may also allow emissions to be reduced more easily and cheaply than analysis suggests today.

The Panel has recommended a range (as opposed to a point target) to reflect the

significant uncertainties about Victoria's future emissions – including the timing of emissions reduction from Victoria's largest emitters in the electricity sector and broader industry, from the uptake of electric vehicles, and whether the Commonwealth will take additional action. The wider range recommended for 2030 compared to 2025 reflects that later periods have inherently higher levels of uncertainty.


Benefits and impacts

The transition to a low-emissions global economy is under way. Interim targets will help Victoria to manage this transition to its advantage and, where needed, provide support for businesses and communities to adjust.

Strong action to reduce Victoria's emissions in the period to 2030 will unlock significant investment and create new jobs. It can also bring forward a future where being low-emissions and powered by renewables is part of Victoria's competitive advantage and helps secure market access in a decarbonised world. Victorians will also enjoy the co-benefits of cleaner air, improved health and, depending on policies, enhanced biodiversity and ecosystem services.

The evidence is clear that the economic benefits for Victoria of avoiding climate change far outweigh the economic costs of reducing Victoria's emissions. Climate change will impose costs on all sectors of the Victorian economy, but avoiding the worst impacts is particularly important to provide protection to climate exposed sectors such as agriculture and tourism.

Even if the long-term economic benefits of avoiding climate change are not accounted for, the costs to the economy of reducing Victoria's emissions is low. In some cases, reductions may occur at no additional cost as low-emissions technologies become cheaper than existing alternatives. For example, solar and wind are already the cheapest forms of new electricity generation, even with the costs of firming, and



electric vehicles are predicted to become cost competitive during the 2020s. In other cases, acting now to reduce emissions will provide savings to the community and economy. For example, improving the energy efficiency of Victoria's housing and vehicles can provide lifetime savings for households.

The Panel recognises that its recommended target ranges do imply significant changes in the Victorian economy and, as with other structural economic changes, this will create real impacts for some people and communities. The ranges provide flexibility for the Victorian Government and community to manage these impacts and the broader costs of adjustment. It is important that Victoria builds on existing foundations to deliver a just transition and support those most affected. The Panel strongly encourages the Victorian Government to work with affected communities to provide a clear plan and to develop measures to support local economic transition. This will be especially important for the Latrobe Valley community as the coal-fired power stations reach the end of their lives.

Climate science and emissions budgets

Given the pressing threat to Victoria and to the world that climate change represents, it is important that Victoria contributes its fair share to achieving the Paris goal. Otherwise, Victoria cannot expect others to strengthen their actions and therefore avoid the worst impacts of climate change.

The Panel's thinking on interim targets has been significantly guided by the 2°C-consistent and 1.5°C-consistent emissions budgets it developed for Victoria, as these provide a tool for linking emission targets and trajectories to global temperature goals and for understanding the trade-offs between earlier and later action. The use of emissions budgets as a guide to decision-making was widely supported by stakeholders and individuals responding to the Panel's public consultation.

The world cannot continue to emit at current levels if the Paris goal is to be achieved – and neither can Victoria. At 2016 emissions levels, the Panel's 2°C-consistent emissions budget for Victoria will be exhausted in 2032, and the 1.5°C-consistent budget will be exhausted in 2026 – well before 2050. The global 2°C emissions budget will be exhausted in 2034 at current emissions levels.

Based on its assessment of 2°C and 1.5°C emissions budgets for Victoria, the Panel is confident that a target range of 45-60% below 2005 levels in 2030 is consistent with the Paris goal while providing a feasible emissions reduction pathway and a steady transition of the Victorian economy to net zero in 2050. The greater the amount that emissions are reduced by 2030, the greater the probability of being consistent with well below 2°C.

Greater emissions reduction by 2030 would also provide increased confidence that Victoria's emissions to 2050 could be limited to be consistent with a 1.5°C outcome. This limit – or emissions budget – would be larger and easier to meet if large scale deployment of negative emissions technologies becomes feasible globally.

Many individuals, councils and environment groups participating in the Panel's public consultation process supported a target of 75% or higher in 2030, based on a desire for Victoria to act strongly and immediately to address the significant global threat of climate change. However, this is higher than what is required, on a straight-line basis, to be consistent with 1.5°C (67% below 2005 levels in 2030). A target of 75% would also concentrate economic adjustment costs in the period before 2030 and therefore place a substantial burden on current Victorians.

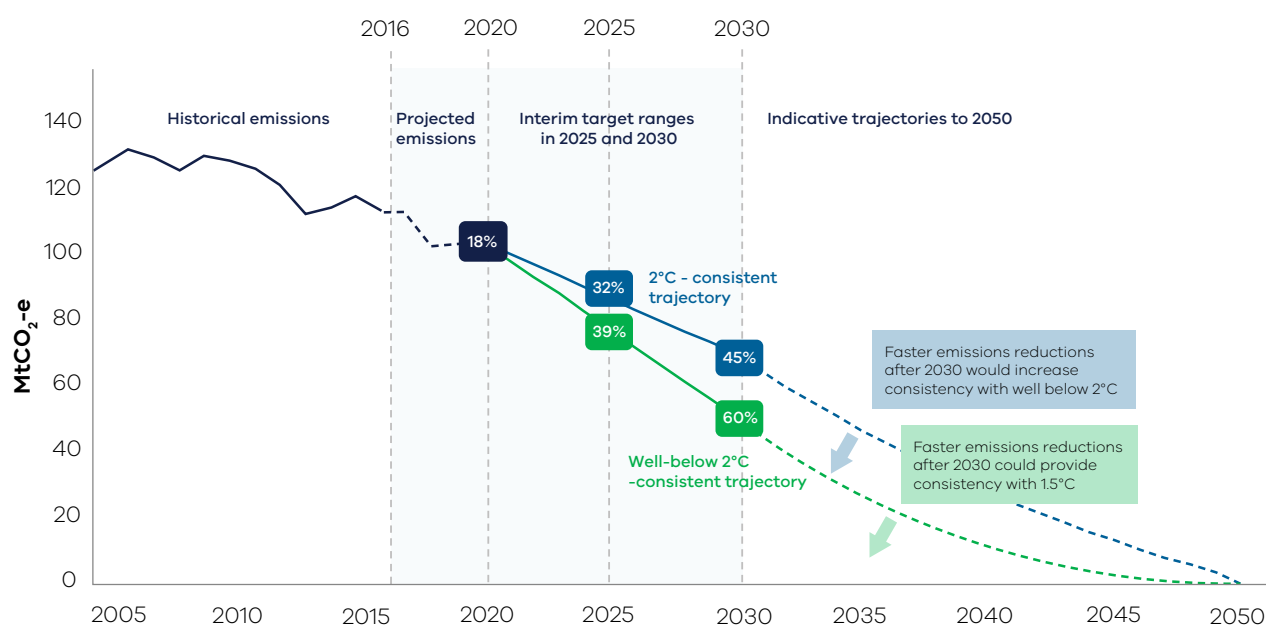
Relationship with national targets

- In submissions to the Panel's issues paper, most business and energy sector stakeholders supported a 28% Victorian emissions reduction target in 2030 in line with the national target. This was based on a rationale of achieving national coherence, minimising compliance burdens, maintaining competitiveness of trade-exposed industries, and expectations that technology developments will make reducing emissions easier and cheaper in the future.
- However, while national coherence can offer some benefits, the Panel's analysis shows that a 28% target for Victoria in 2030 would imply very rapid emissions reduction after 2030 if Victoria was to contribute its fair share to limiting warming to well below 2°C. This would shift a significant burden to Victorians in the future, and concentrate economic adjustment costs in the period after 2030. A 28% target is also incompatible with pursuit of 1.5°C. Furthermore, expert advice found, based on existing analysis, that the 28% target option was likely to result in a higher overall economic cost to reach net zero emissions by 2050.
- The Panel has also reflected on the fact that the Paris Agreement includes processes for review of each country's initial target with the aim of strengthening global emissions reduction pledges to align with the agreed Paris goal. It is therefore likely that over the next decade, Australia's national targets will become stronger than the current commitment of 26-28% below 2005 levels by 2030.

Trajectories to net zero emissions by 2050

The Panel has developed indicative trajectories to 2050 based on the recommended interim targets and guided by consideration of 2°C and 1.5°C emissions budgets for Victoria (**Figure 10.1**).

Figure 10.1 Indicative trajectories to net zero by 2050 consistent with the recommended interim target ranges



Under an emissions reduction target of 45% below 2005 levels in 2030, emissions reduction would need to accelerate slightly to reach net zero by 2050 to be consistent with 2°C. This is illustrated by the top blue line in **Figure 10.1**. However, Victoria's emissions reduction would need to accelerate more rapidly if Victoria's emissions were to remain consistent with the Paris goal of well below 2°C.

If emissions reached 60% below 2005 levels in 2030 and continued to decline relatively steadily to reach net zero in 2050 – as represented by the bottom green line in **Figure 10.1** – this would be consistent with a well below 2°C outcome.

Rapid emissions reduction after 2030 could bring consistency with 1.5°C within reach.

Reaching 60% in 2030 would also provide the flexibility to have more gradual emissions reduction after 2030, which may help manage the risk that remaining emissions are harder and more costly to reduce.

Whatever the level of emissions reduction achieved in 2030, the steeper the emissions trajectory post-2030, the higher the probability of Victoria acting in accordance with a lower global temperature goal and a safer climate outcome.

Emissions reduction opportunities

The electricity generation sector is by far the largest source of Victoria's emissions and, in the period to 2030, Victoria's largest emissions reduction opportunity. The State has excellent renewable energy resources, and the costs of renewable energy and storage technologies are continuing to fall. Transition of the electricity sector will be critical to achieving interim targets to 2030, particularly given this can unlock further emissions reduction through switching from direct combustion of fossil fuels to electricity in vehicles, buildings and industry. With careful management and planning, this can be achieved while ensuring ongoing reliability, security and affordability.

While the electricity generation sector is key, achieving the Panel's recommended target ranges – and putting Victoria on the pathway to achieving net zero emissions by 2050 – will require action across the entire Victorian economy. The Panel identified emissions reduction opportunities in all sectors, including particularly significant potential from on-farm forestry and changes in forest management on public land. While most opportunities are available now, strong government policies will be needed to unlock them. Measures to reduce emissions include improving energy efficiency; moving towards lower emissions agricultural practices; incentivising tree planting; and accelerated switching away from gas towards low-emissions electricity.

Victoria's rapidly growing population is putting upward pressure on transport emissions. It is therefore critical that the Victorian Government puts in place strong policies and investments now to drive a transformation of the sector and reverse this trend. Support for low-emissions vehicles and public transport can reduce emissions by 2030, will be critical to achieving interim targets after 2030, and can provide substantial health benefits.

While the Panel has aimed to present the full suite of opportunities based on current knowledge, it is for the Victorian Government and community to decide which of these to take forward and at what scale, based on further consideration of the benefits and costs.

Additional recommendations

The Panel recommends that, alongside taking strong action to reduce Victoria's emissions over the coming decade in line with the recommended interim targets, the Victorian Government takes actions now that will increase the potential to reduce emissions more quickly later. This includes:

- Creating a stable set of policies for emissions reduction across the economy now and into the future, including to drive transformation in the transport sector;
- Supporting measures for emissions that are currently harder to reduce (e.g. in some parts of agriculture, industry and transport). This includes improving resource efficiency; growing the circular economy; and development of agricultural technologies, hydrogen and carbon capture and storage; and
- Supporting the development of negative emissions technologies.

These actions are particularly important for reaching net zero emissions by 2050 and in pursuing efforts to limit global temperature increase to 1.5°C; without them, remaining emissions may become harder and more costly to reduce over time.

Finally, the Panel reflects that even in the short time of its deliberations, there have been significant developments in the prospects for and the urgency of emissions reduction. As such, the Panel recommends that in 2023 the Victorian Government reviews its interim target for 2030 to take into account developments in climate science, technology, global action and further progress in reducing Victoria's emissions.

APPENDIX A: BIOGRAPHIES OF INTERIM TARGETS INDEPENDENT EXPERT PANEL MEMBERS

CHAIR

The Hon. Greg Combet AM

The Hon. Greg Combet AM is the Chair of IFM Investors, Chair of Industry Super Australia and a Director of ME Bank. Mr Combet also consults to industry and governments.

Mr Combet held numerous Ministerial and Parliamentary Secretary roles in the Australian Government from 2007 to 2013, including Minister for Industry and Innovation, Minister for Climate Change and Energy Efficiency, and Minister for Defence Personnel, Materiel and Science.

Prior to this Mr Combet held the role of ACTU Secretary for eight years and worked as a trade union official and in the mining industry in previous years.



SCIENCE EXPERT

Dr Penny Whetton

Dr Penny Whetton is an Honorary Research Fellow with the University of Melbourne and CSIRO. In Dr Whetton's 25-year career with CSIRO she took a leading role in Australian science on projecting regional climate change and the use of projections in impact assessment. Through this and her community engagement she has made a unique contribution to national understanding of, and preparedness to respond to, climate change. Dr Whetton was a lead author of the regionalisation and climate scenarios chapters of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the regional projections chapter of the Fourth Assessment Report of IPCC, and of the Australasia chapter of the Fifth Assessment Report.



ENERGY/INDUSTRY EXPERT

Dr Lorraine Stephenson

Lorraine has over 30 years of experience in the energy sector and has worked on climate change policy and strategy since 1998. As a consultant, she works with clients to create opportunities to respond to climate change risks including options to drive investments in low emission technologies.

Dr Stephenson's other roles include Non-Executive Director of Queensland Electricity Transmission Corporation Limited (Powerlink), Non-Executive Director of Good Environmental Choice Australia and member of the NSW Climate Change Council. She was formerly the Chief Clean Energy Advisor to the Queensland Government, a Partner at Ernst & Young, Non-Executive Director of Ergon Energy and Non-Executive Director of the Australian Industry Greenhouse Network. Dr Stephenson is a Fellow of the Academy of Technology and Engineering and has formal qualifications in governance, management and science.



APPENDIX B: TERMS OF REFERENCE – INTERIM TARGETS INDEPENDENT EXPERT PANEL

Introduction

The *Climate Change Act 2017* (**the Act**) provides Victoria with a world-leading legislative foundation to manage climate change risks; maximise the opportunities that arise from taking decisive action; and drive Victoria's transition to a net zero emissions, climate-resilient community and economy. The Act came into effect on 1 November 2017.

In January 2017, the Victorian Government released Victoria's Climate Change Framework. The Framework included a target to reduce Victoria's emissions by 15-20 per cent below 2005 levels by 2020.

Section 10 of the Act requires the Premier and the Minister responsible for administering the Act (the Minister for Energy, Environment and Climate Change, hereafter **the Minister**) to set five-yearly interim targets to keep Victoria on track to meeting the Act's long-term target of net zero greenhouse gas emissions by 2050. The Victorian Government will announce the first two interim targets – for 2021-25 and 2026-30 – in 2018.

Section 12 of the Act requires the Minister to "obtain advice from one or more persons who are appropriately qualified, in the Minister's opinion, to act as an independent expert". The Interim Targets Independent Expert Panel (**the Panel**) has been established for this purpose. The Panel will consist of a Chair and two members.

Section 12 of the Act sets out the scope of advice to be provided by the independent expert(s) and the issues they must consider in formulating their advice. The following scope of work has been framed in light of the provisions of the Act.

Scope of work

1. Section 12 of the Act requires the Panel to provide advice to the Minister on:
 - a. One or more recommended interim targets for reducing greenhouse gas emissions for the periods 2021-2025 and 2026-2030. These must have the following characteristics:
 - i. Each interim target must constitute a greater reduction in greenhouse gas emissions than any previous interim emissions reduction target, as per Section 14(d) of the Act;
 - ii. Each interim target must be expressed against a 2005 base year, as per Section 11(1) of the Act.
 - b. Indicative trajectories for Victoria to achieve the long-term emissions reduction target (net zero greenhouse gas emissions by 2050) based on each option identified under 1a).
 - c. Potential opportunities across the Victorian economy as a whole to reduce greenhouse gas emissions in the most efficient and cost-effective manner in each interim target period.
2. In forming advice in relation to 1), Section 12 of the Act requires the Panel to consider the following:
 - a. Victoria's legislated long-term target of net zero emissions by 2050.
 - b. Relevant up-to-date climate science.
 - c. Technologies relevant to climate change.

- d. Economic circumstances – in particular the likely impact of the interim targets on the economy and the competitiveness of particular sectors of the economy.
- e. Social circumstances – in particular the likely impact of the interim targets on the health and wellbeing of Victorians.
- f. Environmental circumstances – in particular the benefits to the environment of emissions reduction.
- g. Existing national and global action on climate change, including any undertakings relating to the reduction of greenhouse gas emissions that Australia has given under international climate change agreements.
- h. Progress to date towards the reduction of greenhouse gas emissions in Victoria. This includes the government's 2020 emissions reduction target and trends in emissions reflected in annual greenhouse gas emissions reports such as State Greenhouse Gas Inventories while recognising the lags inherent in inventory data.
- i. The policy objectives of the Act, as laid out in Section 22 of the Act. These are:
 - i. To reduce the State's greenhouse gas emissions consistent with the long term and interim emissions reduction targets;
 - ii. To build the resilience of the State's infrastructure, built environment and communities through effective adaptation and disaster preparedness action;
 - iii. To manage the State's natural resources, ecosystems and biodiversity to promote their resilience;
 - iv. To promote and support the State's regions, industries and communities to adjust to the changes involved in the transition to a net zero greenhouse gas emissions economy, including capturing new opportunities and addressing any impacts arising from the need to reduce greenhouse gas emissions across the economy;
 - v. To support vulnerable communities and promote social justice and intergenerational equity.
- j. The guiding principles of the Act, as laid out in Sections 23 to 28 of the Act. These are:
 - i. Informed decision-making;
 - ii. Integrated decision-making;
 - iii. Risk management;
 - iv. Equity;
 - v. Community engagement;
 - vi. Compatibility.



Process

In formulating its advice, the Panel may obtain specialist technical advice regarding the considerations listed under Section 2(2) of this Terms of Reference.

DELWP will work with the Panel to design and implement public consultation, with the objective of informing the Panel in developing its advice on interim targets.

The Panel will be supported by a Secretariat provided by the Department of Environment Land Water and Planning (DELWP).

Outputs and timetable

The Panel will submit a final report to the Minister providing advice on the matters listed under Section 2(1) of this Terms of Reference by 29 March 2019.

The final report and recommendations will be tabled in Parliament and made publicly available in accordance with the requirements of Section 13 of the Act.

The Panel will not publish any form of the report before it has been published by the Victorian Government.

APPENDIX C: STAKEHOLDERS AND EXPERTS CONSULTED IN THE DEVELOPMENT OF THIS ADVICE

This list includes stakeholders and experts that the Panel met individually, at roundtables, and that provided submissions to the Panel's issues paper.

- AGL Energy
- Agribusiness Gippsland
- Alcoa
- Alinta Energy
- Anna Skarbek, CEO, ClimateWorks Australia
- Australian Conservation Foundation
- Australian Dairy Farmers
- Australian Energy Council
- Australian Gas Infrastructure Group
- Australian Industry Greenhouse Network
- Australian Industry Group
- Basalt to Bay Landcare Network
- Baw Baw Shire Council
- Bayside Climate Change Action Group
- Beyond Zero Emissions
- Bruce Mountain, Director Victorian Energy Policy Centre
- Business Council of Australia
- Carbon Markets Institute
- Central Victorian Greenhouse Alliance
- Centre for Climate Safety
- Clean Energy Council
- Climate Council
- Committee for Gippsland
- Dairy Australia
- Darebin City Council
- Darebin Climate Action Now
- Australian Energy Market Commission (AEMC)
- Australian Energy Market Operator (AEMO)
- Doctors for the Environment
- Eastern Alliance for Greenhouse Action
- Echo Group Australia
- Ecocern P/L
- Environmental Evolution
- EnergyAustralia
- Engie
- Environmental Justice Australia
- Farmers for Climate Action
- Federation of Victorian Traditional Owner Corporations
- Frank Jotzo, Director Centre for Climate Economics and Policy, Australian National University
- Environment Victoria
- Erwin Jackson
- Friends of the Earth
- Global CCS Institute
- Grattan Institute
- Green Building Council Australia
- Hugh Saddler, Honorary Associate Professor, Crawford School of Public Policy, Australian National University
- Latrobe City Council
- Latrobe Health Assembly
- Latrobe Valley Authority
- Law Institute of Victoria
- Lawrence Gebert, Senior Associate, Advisian
- Lighter Footprints Inc
- Macedon Ranges Shire Council
- Malte Meinshausen, Director, Australian-German Climate & Energy College
- Minerals Council Australia
- National Centre for Climate Restoration
- Northern Alliance for Greenhouse Action

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- Onsite Energy Solutions Pty Ltd, Energy Makeovers Pty Ltd, Energy Inspection Pty Ltd and Energy Renovations Insulation Services Pty Ltd
 - Port Phillip Ecocentre
 - Rail, Tram and Bus Union
 - Richard Eckard, Director, Primary Industries Climate Challenges Centre
 - Ross Garnaut, Professor of Economics, University of Melbourne/Australian National University
 - Ryde Gladesville Climate Change Action Group
 - South East Environment Network
 - Tony Wood, Director Energy Program, Grattan Institute
 - Trust for Nature
 - United Dairy Farmers of Victoria
 - Victorian Aboriginal Heritage Council
 - Victorian Association of Forest Industries Inc
 - Victorian Employers' Chamber of Commerce and Industry
 - Victorian Council of Social Services
 - Victorian Trades Hall Council
 - Victorian Farmers Federation
 - Voices of the Valley
 - Westwind Energy Pty Ltd

APPENDIX D: PRINCIPLES FOR PROVIDING ADVICE ON INTERIM TARGETS

The Panel has adopted a set of principles to guide their decision-making in providing advice on interim targets. These principles reflect and build upon the guiding principles in sections 23-28 of the Act that the Panel is obliged to consider.

The principles are:

1. **Environmental effectiveness**

The recommended targets and trajectories should be informed by up-to-date climate science and ensure that Victoria achieves its objective of net zero emissions by 2050 in a way that is consistent with keeping global temperature rise this century to below 2°C above pre-industrial levels.

2. **Economic efficiency**

The recommended targets and trajectories should facilitate the lowest cost approaches to emissions reduction, and take into account the economic and environmental impacts and opportunities they may create. This includes consideration of the competitiveness of Victorian industries, and of cost-effective trajectories to reach net zero emissions by 2050.

3. **Equity**

The Panel should have regard to the potential social impacts and opportunities created by emissions reduction opportunities and the recommended targets and trajectories:

- between regions;
- between socio-economic groups; and
- between current and future generations.

The Panel should have particular regard for Victoria's vulnerable communities.

4. **Flexibility**

The recommended targets should incorporate sufficient flexibility to allow Victoria to take account of and adjust to changes in the climate policy and ambition of the international community, the Commonwealth Government and Australia's other states and territories. Flexibility is also desirable to adjust to other changing circumstances, such as developments in emissions accounting rules, climate science and low-emissions technology.

5. **Investor certainty**

The recommended targets and trajectories should provide businesses with the confidence to undertake long-term investments in energy generation, low-emissions technology, infrastructure and processes.

6. **Policy coherence**

The recommended targets, trajectories and opportunities identified should be consistent with Victoria's other relevant policy objectives to promote a coherent policy framework within the state.

APPENDIX E: APPLYING CLIMATE CHANGE AUTHORITY EMISSIONS TARGETS TO VICTORIA

Frank Jotzo, Australian National University and Salim Mazouz, EcoPerspectives
7 March 2018

Summary

This briefing paper provides analysis on issues to consider when applying the Climate Change Authority's²⁶⁷ recommendations for Australia's emissions targets to Victoria.

1. The CCA's method for determining a range for future emissions targets for Australia remains valid today.
2. Differences between Australia's national and Victoria's emissions profiles, emissions intensity of the economy and emissions per capita are minor on the whole, implying that national targets derived on CCA methodologies are broadly applicable also to Victoria.
3. There have been developments since 2014 on international climate policy, global and national emissions growth, and the cost of low-emissions technologies. Some of these changes may suggest changes to the recommended targets; however, in our expert judgement the sum of these changes leaves the CCA's findings broadly unchanged.

4. Together these findings suggest that the CCA recommended targets for Australia – specifically the 40-60% reduction range at 2030 relative to 2000, equivalent to approximately a 45-65% reduction with 55% mid-point below 2005 – can be considered as by and large applicable to Victoria today.
5. The Panel has requested separate work on global carbon budget. If this were to result in a revised global carbon budget, it would result in adjustments to the CCA's recommended targets.

Producing a recommendation for future emissions targets involves large elements of judgement, as was the case for the CCA recommendations. The Panel will want to assess the CCA recommended targets in light of other information and considerations. This includes aspects such as the choice of a target range versus different scenarios for target

The full report is accessible on the Engage Victoria website “Climate change targets 2021-2030”:
<https://engage.vic.gov.au/climate-change-targets-2021-2030>

APPENDIX F: RESEARCH AND ANALYSIS TO INFORM GREENHOUSE EMISSIONS BUDGETS FOR VICTORIA

Malte Meinshausen, Yann Robiou du Pont, Anita Talberg
Australian-German Climate and Energy College
6 June 2018

Executive Summary


In 2015, the Paris Agreement established a global goal of limiting the increase in warming to well below 2°C. State-level action on greenhouse gas emissions reduction in Australia can be a significant driver for meeting the Paris Agreement goals and delivering an Australian contribution to the common global challenge of avoiding dangerous levels of climate change. This report on emissions budgets is provided for consideration of the Independent Expert Panel to support their work in advising the Victorian Government on interim targets.

In 2014, the Climate Change Authority (CCA) determined a global 2000-50 budget of 1700 GtCO₂eq for a 67% chance of global warming staying within 2°C. The CCA then determined Australia's "fair share" of the global budget at 0.97%, resulting in 10.1 GtCO₂eq for 2013-50. Since 2014, there have been many studies on emissions budgets.

In Part I of this report, we review recent studies on carbon and emissions budgets to assess whether the CCA budget remains valid in the context of scientific and methodological developments, and update the budget where there are direct scientific means for doing so. From this we derive an Australian 2017-50 budget. In Part II, we propose and test various budget-sharing approaches to determine a Victorian share of the Australian budget and present resulting trajectories for a range of 2030 emissions reduction targets. In Part III, we explore how Victoria's target could account for the Paris Agreement's decision to pursue a 1.5°C warming limit, from a budget perspective.

We find that the global CCA budget still represents a 'likely' chance of staying below 2°C, where 'likely' is defined as 67% to 90%. However, using new scenario families from the Intergovernmental Panel on Climate Change (IPCC), the CCA budget is closer to a 90% likelihood than a 67% likelihood. We also suggest that it places Australia in line with the Paris Agreement's decision to limit warming to well below 2°C. After updating the CCA budget to recent measures of global warming potential and subtracting 2013-16 Australian emissions of approximately 2.3 GtCO₂eq due to the passing of time, we derived an Australian 2017-50 budget of 8.1 GtCO₂eq.

To divide this budget among states and territories we tested a series of budget-sharing approaches. These yielded a range of Victorian 2017-50 emissions budgets. The range for four of these approaches was 1758 to 1918 MtCO₂eq, with an average of 1851 MtCO₂eq. In percentage terms, this results in a Victorian share of Australian emissions as 22.9%. Comparing the trajectories derived from the budget-sharing approaches to proposed 2005-30 emissions reduction suggests that mitigation targets of 28% and 45% would require greater emissions reduction rates after 2030 than before; pursuing a 55% target or higher mostly results in less steep reduction rates beyond 2030. However, these conclusions are heavily dependent on the chosen trajectory. For a Victorian budget of 1851 MtCO₂eq, a purely linear trajectory from 2020 to 2050 suggests a 48.8% emissions reduction target in 2030 on 2005 levels.



Due to developments in climate scenarios and the continued global growth in emissions over the last few years, options are limited for tightening the CCA's 2017-50 budget to be in line with lower levels of global warming, such as pursuing a limit of 1.5°C. We must instead look to the 2050-2100 period. We find that for a 90% chance of staying within 2°C, global emissions from 2050 to 2100 remain constant at 2050 levels (which is net-zero carbon emissions). This would provide a 50% chance of staying below 1.5°C by 2100. For a 67% chance of staying

below 1.5°C by 2100, and to be in line with the Paris Agreement to aim well below 2°C and “pursue best efforts to limit warming at 1.5°C”, a downward trajectory of emissions is needed post-2050. This means that CO₂ must be removed from the atmosphere so that the result is net negative emissions.

The full report is accessible on the Engage Victoria website “Climate change targets 2021-2030”:
<https://engage.vic.gov.au/climate-change-targets-2021-2030>

APPENDIX G: DERIVING A GLOBAL 2013-2050 EMISSION BUDGET TO STAY BELOW 1.5°C BASED ON THE IPCC SPECIAL REPORT ON 1.5°C

A/Prof. Malte Meinshausen, The University of Melbourne, 19 March 2019

Summary

This paper provides advice to the Victorian interim targets Independent Expert Panel on developing a 1.5°C greenhouse gas emissions budget for Victoria for the period 2017-2050. It builds on decisions taken by the Independent Expert Panel based on advice provided to the Panel by Meinshausen, Robiou du Pont and Talberg in May 2018 on developing a 2°C emissions budget for Victoria for the period to 2050.

The IPCC Special Report on 1.5°C provides the latest scientific assessment on scenarios and information on 1.5°C carbon budgets. This new information is here used to derive a global emission budget that can be useful for the deduction of Australian and Victorian state level emission budgets.

This 2013-2050 global emission budget to stay below 1.5°C is **800 GtCO₂ eq**, including all major greenhouse gases (using a GWP-100 AR4 metric). This is derived from the central IPCC Special Report on 1.5°C result that to keep warming below 1.5°C with a 50% chance, cumulative carbon emissions have to be kept below 580 GtCO₂ from January 2018 onwards.

When using value judgements regarding Australia's and Victoria's respective fair shares of the global emissions budget, and subtracting historical Australian and Victorian emissions for the period 2014-2016, this global emission budget can be turned into a remaining emissions budget for Victoria of **1.25 GtCO₂ eq between 2017 and 2050**.

The full report is accessible on the Engage Victoria website "Climate change targets 2021-2030": <https://engage.vic.gov.au/climate-change-targets-2021-2030>

APPENDIX H: INTERIM EMISSIONS REDUCTION TARGETS FOR VICTORIA: A REVIEW OF EXISTING ANALYSIS

Frank Jotzo, Australian National University and Salim Mazouz, EcoPerspectives
17 June 2018

Summary of findings

1. Significant emissions reduction can be achieved in Victoria, as in Australia overall, at reasonably low overall economic cost, even for relatively strong emissions reduction trajectories.

A large body of work over the past decade shows this for Australia (including for Victoria), and more recent modelling and sector-level analysis confirms this specifically for Victoria (The material reviewed for which Victorian detail was provided estimated GSP impacts by 2030 ranging from +0.2% to -3%).

2. There are however distinct gaps in the available analyses.

There is a relative paucity of detailed analysis on the economics of emissions reduction options at the sector level; on how sector specific adjustment processes are likely to play out in practice; and on suitable policy approaches that can underpin credible emissions targets at the State level.

Some analyses lack full consideration of latest industry-specific information. Analysis is needed of a wide range of possible future emissions outcomes, taking into account the possibly rapid evolution of technologies and relative costs.

3. Economic modelling has tended to underestimate the opportunities for emissions reduction in the longer term and overestimate the costs in sectors where disruptive technological change is taking place. Typical results from past emissions

reduction modelling exercises are suitable as upper bounds on costs and emissions levels, but not as a guide to most likely outcomes (though given recent technology cost developments, older modelling results would need to be adjusted down to even provide an upper bound).

Cost reductions in low-emissions technologies such as solar PV have been systematically under-estimated. A status quo bias is apparent in assumptions about persistence of structures, behaviour and technologies, including for example the development and uptake of electric vehicles. In many cases the assumptions are not supported by detailed analysis of most recent information. Model-based cost estimates have declined over time, but latest modelling (e.g. AEMC) again does not foresee strong future reductions in clean technology costs.

The failure of most published analyses and all relevant modelling exercises to anticipate the closure of the Hazelwood power station in 2017 is an important example of how the potential for rapid change can be severely understated. Most analyses continue to assume that all three remaining Latrobe Valley power plants will operate at least into the 2030s under their reference cases. These assumptions need to be questioned.

Economic modelling of emissions reduction typically omits benefits from reduced local air pollution, increased local amenities and investment in alternative technologies; it also tends to omit costs of the transition such as regionally concentrated job losses.

4. The absence of credible emissions reduction targets and policies can increase the cost of transition and exacerbate dislocation. Fine-grained analysis of economic change and policy options can help underpin the credibility of low-emissions strategies.

Future emissions reduction in many cases may be achieved without any additional costs, as low-emissions options become the cheaper option for new investments. Policy intervention can reduce economic costs by alleviating investment uncertainty and reducing the economic and social disruption from sudden, unanticipated change. Some of the latest electricity sector modelling shows lower electricity costs for scenarios with policy interventions that include a low carbon component than for the reference case.

5. Power generation is the single most important factor for consideration in Victoria's interim emissions targets to 2030.

The key question is how brown coal-fired power generation will evolve, even in the absence of climate policy, as well as what will replace any reductions in brown-coal generation.

Existing modelling does not do justice to the uncertainties affecting the sector, including possible trajectories for reduced brown coal-fired generation over time and the factors driving change, especially technological development and change in relative costs (with the cost of solar PV in some power purchase agreements this year being lower than was forecast for 2050 in many of the studies reviewed).

Developments and policy interventions in other sectors also matter substantively for Victoria's interim emissions targets. Given emerging technology disruption in the transport sector and its overall importance to Victoria's emissions, it is the next most important sector after the electricity sector to understand. Energy efficiency improvements and electrification in direct combustion in industry and buildings are also subject to disruption (though perhaps to a lesser extent) and also offer significant potential for emissions savings. These sectors may also benefit from detailed analysis of plausible developments.

The extent of emissions savings from electrification and greater energy efficiency in electricity use depend on how these changes affect electricity generation and which sources fulfil the increased demand.

Land use change and forestry, agriculture as well as industrial processes, fugitive emissions and waste also offer significant options for net emissions reduction. In some cases, there are potentially very large options to reduce emissions, especially in the longer term beyond the first two interim target periods. Similar principles as laid out for the electricity sectors also apply but the pace of technological change is less pronounced and existing modelling may be applied more reliably.

The full report is accessible on the Engage Victoria website "Climate change targets 2021-2030":
<https://engage.vic.gov.au/climate-change-targets-2021-2030>

APPENDIX I: IMPACT OF TIMING OF EMISSIONS ABATEMENT

The Centre for International Economics
29 May 2018

The issue

This report uses information from a range of published studies to consider the relative costs of different Victorian emissions reduction pathways.

We consider four pathways, each consistent with:

- Victoria achieving net zero greenhouse gas emissions (of CO₂e) by 2050; and
- Total Victorian emissions between 2017 and 2050 being constrained to a budget of 1.9 GtCO₂e

The four pathways involve different targets for 2030 emissions relative to 2005. These are 28, 45, 55 and 65% reductions (relative to 2005).

In contrast to most literature, the issue here is specifically one of relative costs of different paths to achieve a specified endpoint and budget.

What factors determine optimal timing of abatement?

Essentially, the best timing for abatement is determined by:

- The discount rate.
 - higher discount rates tend to imply later abatement, and lower discount rates imply early abatement.
- The evolution of the cost of abatement over time, partly determined by technology.
 - if costs are declining over time because of exogenous (outside Victoria) developments, then other things equal abatement should be delayed

- if costs decline in response to previous abatement (“learning by doing”) then other things equal, abatement should take place earlier.
- Policy developments.
 - The cost of abatement in the future may be a function of policy choices today.

What does existing modelling suggest?

We use existing studies to derive “cost curves” for abatement: the implied loss of GSI (relative to baseline) for given reductions in emissions (relative to baseline).

We derive these cost curves from results from Treasury and DIICSTRE 2013 (which imply a relatively steep cost curve) and from a confidential DELWP internal report (which imply a relatively flat cost curve). These two studies provide a good range for costs.

We calculate the loss of GSI under each of the four scenarios using three different discount rates: 1.4%, 4% and 7%.

The results of these calculations are set out in **Table 1**

Table 1 Interaction of discount rate and cost curve: summary

Discount rate	Nature of abatement cost curve	
	Flat cost curve	Steep cost curve
	<i>Incremental abatement comes at low additional cost; consistent with learning by doing; no regrets options; good policy configuration</i>	<i>Incremental abatement comes at higher cost: limited learning by doing, abatement opportunities used up in early actions</i>
1.4% <i>Rate used for long term (>50 years) intergenerational decisions (in Stern 2006, for example). Based on zero (or very low) pure discount rate, but allows for some growth in real consumption.</i> <i>Some also argue that current real risk-free discount rate is very low.</i>	GSI reduction: 0.3% to 0.5% Lowest GSI loss in VIC emissions (65% 2030)	GSI reduction: 2.4% to 3.6% Lowest GSI loss in VIC emissions (65% 2030)
4% <i>Designed to represent the market return on capital over the long term. In climate change, this is a rate typically used by analysts such as Nordhaus (2008).</i> <i>Also, frequently used as a lower bound in cost-benefit analysis.</i>	GSI reduction: 0.3% to 0.4% Equal lowest GSI loss in VIC emissions (65% 2030), VIC emissions (55% 2030) and VIC emissions (45% 2030)	GSI reduction: 2.1% to 2.9% Lowest GSI loss in VIC emissions (65% 2030)
7% <i>Represents opportunity cost of capital; a rate often used for government cost-benefit analysis and regulatory impact analysis. Generally, applies to periods less than 50 years.</i>	GSI reduction: 0.2% to 0.3% Equal lowest GSI loss in VIC emissions (65% 2030) and VIC emissions (55% 2030)	GSI reduction: 1.8% to 2.2% Equal lowest GSI loss in VIC emissions (65% 2030) and VIC emissions (55% 2030)

Note: Emissions scenarios are ranked based on results to one decimal place. GSI loss between 2021 and 2050 is calculated in present value terms and expressed as a share of GSI in the baseline over the same time period.

Source: CIE calculations

These results show that:

- Of the four paths for emissions reduction, the path VIC emissions (65% 2030), consistently implies the lowest or equal lowest loss of GSI (in present value terms) under different assumptions.
- If a flat cost curve is assumed, the differences between implied GSI loss across the scenarios are very small, almost negligible.
- While there are differences in the absolute amount of GSI loss for different choices of cost curve, the choice of cost curve does not affect the ranking of the options.
- While there are differences in outcomes from different discount rates, the rankings of the pathways are not affected by the choice of discount rate.

Overall, for different combinations of cost curves and discount rates the ranking of options is consistent, with emissions paths that imply higher initial reductions implying lower total GSI losses (relative to paths that imply lower initial reductions).

These results also hold for a range of sensitivity analyses.

In considering these pathways results, it is important to note that both academic reviewers for this project, and the CIE, consider that the 65% and 55% pathways may not be credible as they involve periods of time with no abatement taking place.

What factors are missing from the modelling?

There are several factors not explicitly considered in the modelling which are likely to affect the relative costs of alternative pathways.

First, emissions reduction requires capital and labour to be reallocated from emissions-intensive industries into low-emissions industries. This will likely create adjustment costs not incorporated in the modelling.

Second, the adoption and integration of new technologies into the economy and sequestration and afforestation may also create adjustment costs depending on the policy framework adopted.

Third, the modelling assumes that policy is implemented through an "ideal" carbon tax. Policies actually implemented may involve additional distortions and costs not covered in the modelling.

Concentrating emissions reduction in one particular period will likely exacerbate any costs associated with adjustment and actual policies. This implies planned emissions reduction should be even over time.

The full report is accessible on the Engage Victoria website "Climate change targets 2021-2030": <https://engage.vic.gov.au/climate-change-targets-2021-2030>

END NOTES

- 1 In this report, “emissions” refer to greenhouse gas emissions. The greenhouse gases covered by the Kyoto Protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride (added for the second commitment period of the Protocol).
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