CLIMATE COUNCIL

CRITICAL DECADE 2017: ACCELERATING CLIMATE ACTION

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Key Findings

1

This decade is the critical window of time to tackle climate change.

- Since the 1980s, thousands of scientists have warned that human activities are driving global climate change, posing dire risks for humanity. Today those risks have increasingly become a reality.
- In this decade remarkable progress has been made to tackle climate change, with the global energy revolution driving a seismic shift from fossil fuels to renewable energy.
- While global greenhouse gas emissions have recently flat-lined, more must be done to ensure they are trending strongly downwards by the end of this decade, and then reach zero well before 2050.
- Climate change is happening apace with global warming driving substantial changes in many planetary systems that support humanity. Efforts must be redoubled worldwide to avert much worse, potentially catastrophic climate change risks.

2

The consequences of climate change are now happening all around us, from worsening extreme weather, to sea level rise and damage to iconic ecosystems.

- Climate change has increased the frequency and/or intensity of many extreme weather events – heatwaves, bushfire weather, coastal flooding, and drought.
- Extreme weather will worsen further unless greenhouse gas emissions are rapidly reduced.
- The impacts of climate change on human wellbeing are significant – increased mortality from extreme heat and bushfires, and drowning and water-borne disease from more severe flooding. Agricultural zones, coastal infrastructure and natural ecosystems are under increasing pressure.
- Global temperature rises near or above 2°C increase the risk of triggering feedbacks that amplify warming, creating extreme conditions that could threaten the viability of our civilisation.

3

Solutions to the climate challenge are well known, cost effective and available today. There has been a dramatic upswing in climate change action with a global renewable energy revolution underway.

- The burning of fossil fuels - coal, oil and gas - is the primary cause of global warming. Reducing fossil fuel emissions deeply and rapidly remains imperative.
- Renewable energy is already replacing ageing, polluting fossil fuels as the energy system of the future, with the installation of solar and wind systems globally doubling every 5.4 years. This has been accompanied by a precipitous drop in coal consumption, particularly in the US and China.
- Maintaining this rate of renewable expansion could see the world's energy systems completely eliminate greenhouse gas emissions by 2040.

4

Australia is failing to tackle climate change with emissions rising and a lack of any coherent, national approach to reduce emissions in the short, medium or long term. We are known as a global climate laggard.

- Australia is highly vulnerable to many of the consequences of a changing climate, from worsening heatwaves, droughts and bushfires, to devastating coral reef bleaching, and most of our population centres being exposed to sea-level rise.
- Australia's greenhouse gas emissions have climbed upwards every quarter since March 2015, while much of the developed world has begun the journey towards net-zero emissions.
- Amongst the G20 countries, Australia's emissions reduction target – a reduction of 26-28% on a 2005 baseline – is unusually weak, nowhere near what is required for us to play our fair share in tackling climate change.
- A decade of interference by vested interests and a lack of political courage on climate and energy policy have left Australia in the dangerous position of having no coherent national approach to climate change.
- The Australian Government's approach, if adopted globally, would condemn us to a dramatic rise in global temperatures, resulting in worsening extreme weather events and catastrophic damage to natural systems that support human life.

5

Failure to rapidly and deeply reduce greenhouse gas emissions increases the risk of deteriorating human health and well-being, massive forced migration and conflict, crippling economic damage around the world, and the Earth's sixth great extinction event.

- Quick, decisive national action is required by Australia to create a comprehensive, cross sectoral climate change mitigation strategy compatible with a 2°C carbon budget. This action must include: a) a rapid phasing-out of Australia's thermal coal industry; b) ensuring no new coal or gas resources, such as those in the Galilee Basin, are developed; c) fast-tracking the transition to renewable energy; and d) reducing land clearing.
- Decisions in the next three years are likely to determine whether or not our children and grandchildren will have a fighting chance for a bright future or will be scrambling to survive in a disintegrating and increasingly dangerous global society trying to cope with a chaotic, rapidly changing climate.

Recommendations for Policy Makers

By 2020, the end of the Critical Decade, we propose that Australia's leaders implement the following five recommendations, if we are to do our fair share to protect Australians, our economy, infrastructure and natural ecosystems from the unacceptably high risks of climate change.

1

Build a unified, bipartisan, consensus approach to climate change that takes the issue out of the current divisive, 'political football' landscape.

- The approach must provide policy certainty for the private sector to invest and for other sectors of society to take action with confidence.
- The Federal Government implements a long-term climate and energy policy that rapidly reduces carbon pollution by ramping up the uptake of renewables and storage technologies, while making improvements in energy efficiency.

2

Create a well-defined pathway towards a net-zero emissions Australia by the mid-2040s at the latest.

- Eliminate greenhouse gas emissions from the energy sector by the mid-2030s, and achieve net-zero emissions in the transport, agriculture and other sectors by the mid-2040s.
- Provide policy and regulatory certainty for the big polluting sectors (energy, transport and agriculture) to transition to net-zero emissions.
- Support employment, re-training opportunities and other social policies and instruments that may be required to help these sectors restructure in a net-zero emissions economy.

3

Revitalise the Climate Change Authority, strengthen its climate science capacity, and build policy actions on science-based targets and pathways.

- Allow the Climate Change Authority to provide independent and authoritative expert-based policy guidance, free of any external influence, when setting targets and pathways.
- Collect and make key data available in a timely fashion enabling the Australian and international community to track progress on climate change, particularly on greenhouse emission trajectories.

4

Support and accelerate the many effective actions on climate change that are already being undertaken by states, territories and local governments.

- Build an integrated policy approach across all levels of government to create a net-zero emissions Australia.
- Provide financial and other forms of support to states and territories to accelerate their transition to renewable energy systems and the decarbonisation of other sectors.

5

Transform Australia's position on the global stage from a laggard to a leader on climate change.

- Re-position Australia to take strong moral and ethical leadership to protect human societies and the rest of nature from the accelerating risks of climate change.
- Drive the social, technological and economic transformation of Australia towards a just and prosperous society in a net-zero emissions world.

1. Introduction: Approaching a Turning Point in Climate Action?

Over many decades, thousands of scientists and institutions from around the world have warned that human activities are driving changes to the global climate, posing dire risks for humanity. In 2011 the forerunner of the Climate Council – the Climate Commission – published its first report declaring this decade was the Critical Decade for action on climate change. We concluded that the decisions made this decade would be defining for this century, and even further ahead. Failure to tackle climate change effectively could lead to the global climate being "so irreversibly altered we will struggle to maintain our present way of life".

Today the Critical Decade is drawing towards a close. Over the decade remarkable progress has been made, with the near universal Paris Agreement of 2015 representing a high point of global commitment to action in the last 30 years. A global energy revolution is underway transitioning economies from fossil fuels to clean, renewable energy. However, at the same time climate change continues apace with extreme weather events occurring with escalating frequency and severity.

We are now at a critical point in efforts to stabilise the climate on which humanity depends. We are more than three-quarters of the way through the Critical Decade, the period in which humanity must clearly set the course for a net-zero emissions economy. Fortunately, some encouraging signs are emerging that we may be approaching a social/political tipping point to put us on track to meet the climate challenge.

Global emissions of carbon dioxide (CO_2), the most important of the greenhouse gases driving climate change, have flat-lined in the last three years after decades of inexorable increases (Le Quéré et al. 2016). Most importantly, this is the first time that greenhouse gas emissions have stalled while global economic growth has continued. Could this mark the beginning of a strong downturn in global emissions?

A global energy transformation to renewable power is accelerating.

Political action on climate change took an important step forward in Paris in December 2015. Nearly all countries on Earth – 195 in total – agreed to take action on climate change. Under the Paris Climate Agreement, world leaders, including those from Australia, agreed to limit global temperature rise to well below 2°C above pre-industrial levels, and to pursue efforts to limit temperature rise to only 1.5°C. While 2°C may not sound like much, this level of temperature rise will have serious impacts on the lives and livelihoods of people all over the world. Already, at only about 1°C above pre-industrial levels, climate change is intensifying extreme weather events, raising sea level and changing rainfall patterns. Although the current Paris Agreement pledges are not enough to prevent the worsening impacts of climate change, a report-and-review mechanism allows pledges to be strengthened through time.

An important development through the Critical Decade has been the acceleration of a global energy transformation from fossil fuels to renewable power. This is critical given that the burning of fossil fuels to produce electricity, heat or to power transportation represents a very significant proportion of the global greenhouse gas emissions that are driving climate change. Renewable energy capacity has doubled every 5.4 years since 2000 (Rockström et al. 2017), putting us on track to completely transform the world's energy sector by 2040. The cost of renewables, particularly solar photovoltaic (PV) and wind, is dropping dramatically and renewables are now cheaper than any new fossil fuel plants. Energy efficiency is improving, reducing energy costs and, along with improved energy storage and control systems, contributing to more flexible and resilient energy systems.

Global political leadership has also grown strongly through the Critical Decade. China, the world's largest emitter and previously a global laggard, has become a leader in stopping the growth of global emissions. In just the last two years, China's use of coal has swung from an increase of 3.7% in 2013 to a decrease of 3.7% in 2015 (BP Global 2016), a trend that looks likely to continue (IEA 2017a; WRI 2017). In addition, China's investment in renewable technologies has ramped up dramatically over the past decade. The European Union and the United States, both large emitters, have also taken significant steps to reduce their emissions. By 2017, 49 countries around the world had committed to achieving net zero emissions by 2050 (Rockström et al. 2017). In addition, more than 170 countries now have renewable energy targets (REN21 2017).

In Australia, while national action has stalled or gone backwards over the past several years, sub-national action, led by South Australia and the Australian Capital Territory, has stepped into the breach and led the charge towards renewable energy (Climate Council 2017a; Figure 1). Other states and many cities, towns and shires are also taking rapid and significant action on climate change (Climate Council 2017b), putting the pressure back on the national government to develop a coherent, long-term plan for achieving a net-zero emissions Australian economy.

But there are still storm clouds on the horizon. As the global climate rapidly warms, it is critically urgent to build further political momentum for rapid, unstoppable emission reductions.

The impacts of a warming climate are more severe than expected.

Global CO_2 concentration is now over 400 ppm (parts per million) (WMO 2017), higher than at any other time for millions of years, and is increasing at about 2 ppm per year (Le Quéré et al. 2016). Global temperature is over 1°C higher than temperatures before the industrial revolution, an unprecedented scale and rate of change for human societies and the ecosystems on which we depend (Steffen et al. 2016).

The impacts of a warming climate are more severe than expected just a decade or two ago. Many extreme weather events have already become more intense and damaging, and are occurring more frequently. Iconic ecosystems such as the Great Barrier Reef are reeling from the impacts of rising temperature and face a bleak future if we don't rapidly and deeply reduce emissions (Hughes et al. 2017).

The more we learn about climate change, the riskier it looks.

While the Paris climate summit marked a big step forward in international action on climate, subsequent political events in the United States have raised questions about climate policies and actions in that large emitter. There are also signs of 'climate fatigue' and wavering on climate action in some parts of Europe, and India appears to be sitting on the fence in terms of coal versus renewables.

In Australia, there is a renewed fightback from the fossil fuel sector, with a push for the opening of new coal mines in the Galilee Basin in Queensland and the expansion of gas for domestic electricity generation. Renewables are under attack from some quarters and energy efficiency policy is weak. Effective national-level policy on climate change has been wound back, bogged down in a political quagmire.

Like the tobacco industry before it, there is now a large volume of evidence to show that the fossil fuel industry has sought to delay action on climate change to retain their market power (Oreskes and Conway 2010). In a country like Australia this has been highly detrimental to efforts to tackle climate change.

The science-based carbon budget approach warns that the permissible amount of global CO_2 emissions consistent with the 2°C Paris target is being consumed at a rapid rate, with only about two to three decades remaining before the global economy must achieve net-zero emissions (Collins et al. 2013; Le Quéré et al. 2016). Every year of inaction matters.

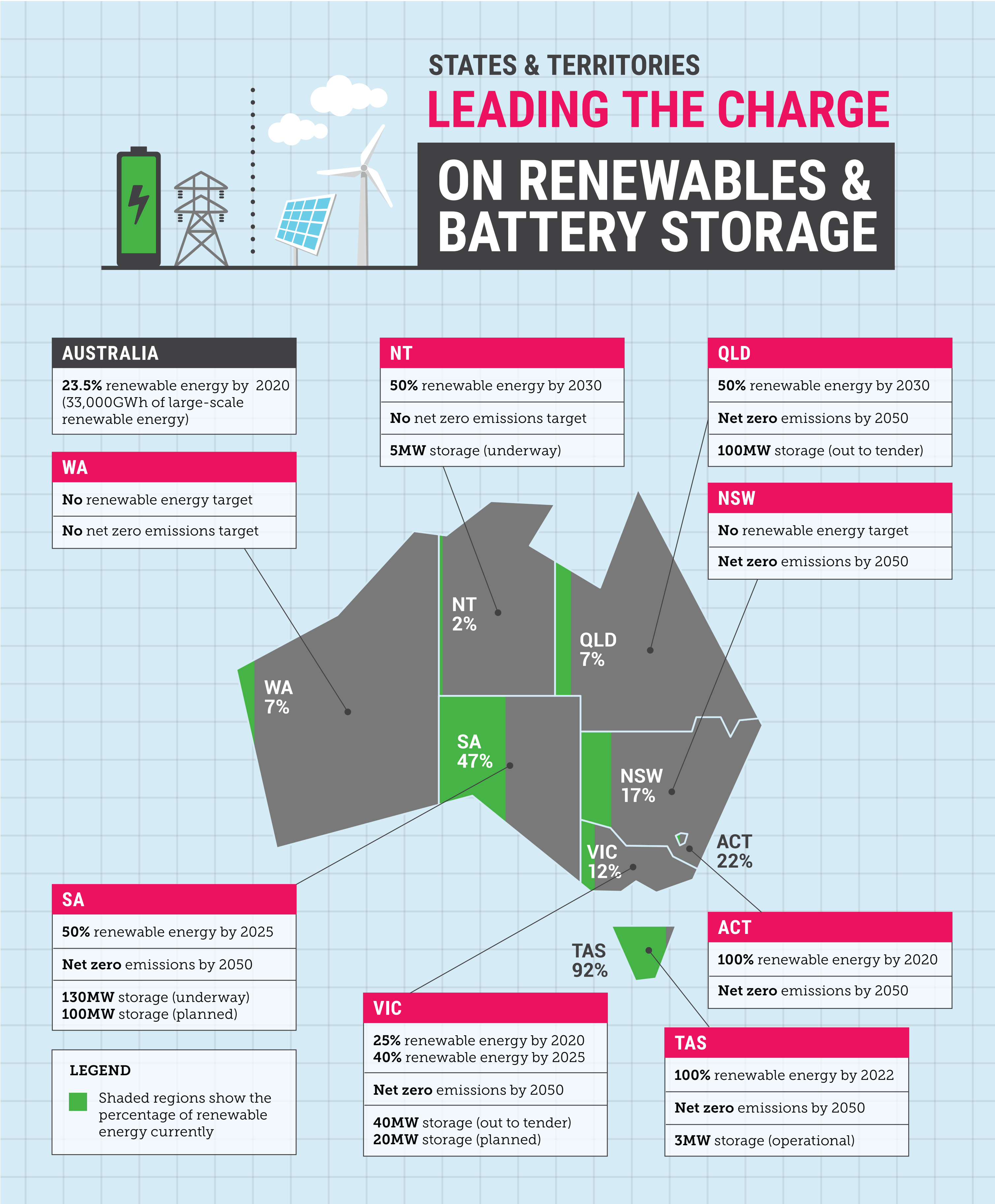
Climate change can no longer be characterised as a challenge of a scientific or technical nature only. For many years now our knowledge of the science has been irrefutable and the solutions available and cost effective. The true challenge has been finding sufficient political leadership, particularly in a country like Australia that has had a powerful set of vested interests obstructing action. With leadership building worldwide during the Critical Decade it is time for Australia to step up. Australia is one of the top 15 largest emitters worldwide and has an important role to play.

The window of opportunity to limit worsening climate impacts is closing.

We are indeed sitting at a critical point in the Critical Decade. It's time for strong leadership and effective action. There is no time to lose.

In this report, we first describe some of the climate solutions already underway, including the rapid uptake of renewables, gains in energy efficiency and advances in battery technologies. We then provide a reality check by describing a science-based analysis of the magnitude and speed of the required emissions reductions if we are to tackle climate change effectively. Next, we look at how Australia is a lagging behind our major partners and trading allies when it comes to climate action. We then describe the accelerating risks of climate change that have gathered pace through the Critical Decade, including worsening extreme weather events like bushfires and heatwaves, and dramatic bleaching of coral reefs around the world. Finally, we put the pieces together, emphasising how the last quarter of the Critical Decade will be crucial if we are to prevent catastrophic climate impacts.

Figure 1: Renewable energy and net zero emissions targets of states and territories, as well as battery storage capacity.
Sources: Climate Council 2017a and references therein; Hydro Tasmania 2014; Northern Territory 2017; South Australia Government 2017; Victoria Government 2017.



2. Solutions Underway

Climate change is primarily driven by the burning of fossil fuels, like coal, oil and gas, that releases greenhouse gases into the atmosphere. A number of very encouraging trends have emerged globally and in Australia during the Critical Decade to bring down these emissions. Momentum has been building rapidly in both technology and finance to move decisively away from fossil fuels towards clean energy and transport, delivering not only climate but also economic and health benefits. Many solutions to transport emissions, land sector and agricultural emissions, and other industrial emissions are increasingly available and cost effective. In the meantime, as we will see in Section 5, the costs of failing to act decisively and at scale have become increasingly obvious.

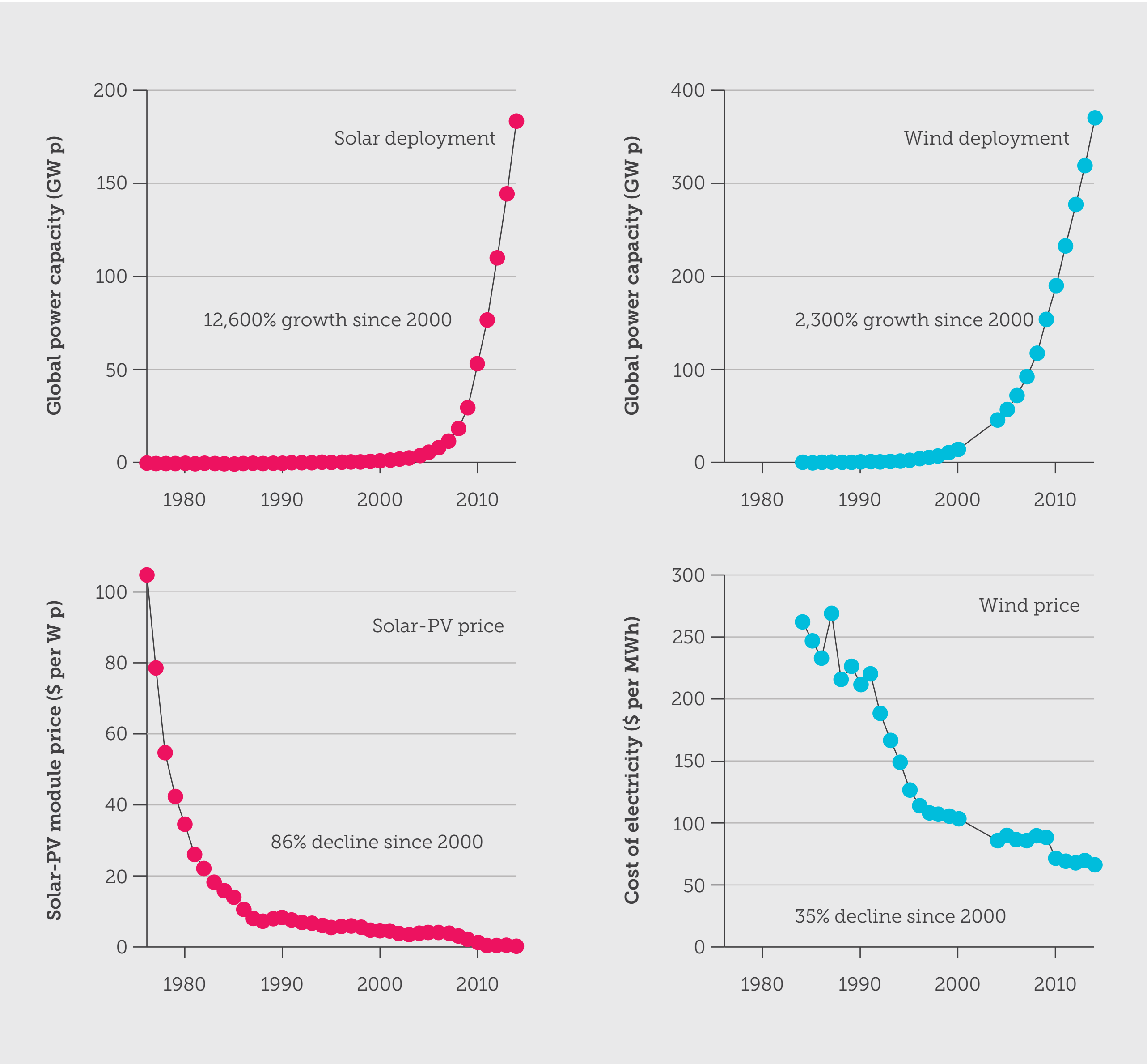
2.1 Renewables Uptake Accelerating, Coal in Decline

Efficient use of renewable energy has already replaced fossil fuels as the energy system of the future. Since 2000, in terms of global power capacity, there has been 12,600% growth in solar PV deployment and 2,300% increase in wind deployment (Figure 2; Schellnhuber et al. 2016). Increases in absolute terms are equally impressive. In 2016 at least 70 GW of new solar PV capacity was added globally, an increase of about 20 GW over 2015 (BNEF 2017a). The surge was led by China with nearly 35 GW of new installations, followed by the US with 13 GW and Japan with 10.5 GW.

As uptake of renewable energy has surged, the price per unit energy produced has dropped dramatically. The cost of solar PV fell by 58% over the 2010-2015 period (IRENA 2016) and is expected to fall by a further 40-70% by 2040 (IEA 2016). Solar is now close to wind in the cost of new power installations in Australia, and both are much cheaper than new ultra super-critical coal plants, and very much cheaper than coal plants with carbon capture and storage (Table 1). As a result, by 2009, investment in new renewable energy generating capacity, mainly solar PV and wind, had surpassed investment in new fossil fuel generating capacity (REN21 2015).

Uptake of solar PV and wind power is accelerating exponentially.

Figure 2: The explosive growth of global installed solar and wind capacity over the past four decades (top panels) and the dramatic drop in costs over the same period. **Source:** Schellnhuber et al. 2016.



The cost of renewable energy has plummeted and is cheaper than new coal.

The installation of solar and wind systems globally is currently doubling every 5.4 years. Maintaining that rate into the future means that the world's energy systems could completely eliminate greenhouse gas emissions by 2040, consistent with meeting the 2°C Paris target. However, this requires rapid and significant policy shifts in many countries – immediate abandonment of coal expansion, elimination of fossil fuel subsidies by 2020, aggressive funding of renewables and the execution of clear emission reduction pathways in all major countries (Rockström et al. 2017).

The exponential increase in renewable energy uptake has been accompanied by a precipitous drop in coal consumption. In the US, at least 27 coal companies have filed for bankruptcy in the last few years. In China, the volume of coal consumption has decreased by 2.9%, 3.7% and 4.7% over the last three years, respectively (National Bureau of Statistics 2015; 2016; 2017). The country's five-year plan for the 2016-2020 period calls for an acceleration of the transition away from coal in favour of enhanced renewable energy targets (Carbon Tracker 2016; IEA 2016). Global investment in coal-fired power plants has likely already peaked and is set to dramatically decline (IEA 2017b).

In Australia, the uptake of renewable energy, particularly solar, has increased remarkably in the last decade, due to the actions of state and territory governments, local councils and the Federal Government's Renewable Energy Target. Australia is a world leader in household rooftop solar; more than 1.7 million households have rooftop solar systems installed (Clean Energy Regulator 2017; Figure 3). Queensland and South Australia lead the way with about 30% of households with rooftop solar. Industrial-scale solar PV is now taking off, with rapidly increasing installations in airports, mines,

Table 1: Cost of new build power plants in Australia. **Sources:** BNEF 2017b. 1. Government of South Australia 2017. 2. Recent prices for wind are even lower - Stockyard Hill Wind Farm "well below" $60/MWh. 3. Based on gas prices of $8/GJ. Current gas prices are much higher than this.

Power technology	Levelised Cost of Energy (LCOE)$ (AUD)/MWh
SA Solar Thermal Plant	$78[1]
Wind	$61 - 118[2]
Solar PV	$78 - 140
Gas Combined cycle	$74 - 90[3]
Coal	$134 - 203
Coal with Carbon Capture and Storage (CCS)	$352

Coal is in decline in key economies China and the US.

healthcare facilities, towns and businesses (Climate Council 2017c). Over 20 industrial-scale solar PV projects totalling over 1 GW of capacity are likely to reach financial closure in 2017 with a further 3.7 GW in the pipeline (RenewEconomy 2017). This activity has been brought about by a long-standing national Renewable Energy Target, independent government agencies such as the Clean Energy Finance Corporation and the Australian Renewable Energy Agency, as well as a variety of effective state government policies.

While Australia has been heavily reliant on coal in the past, our coal fleet is ageing, inefficient and will require replacement in coming years. Nine large plants have closed since 2012 due to age and lack of economic viability. There is no investment appetite in Australia for new coal-fired power stations because they are not economic compared to new renewable technologies.

Figure 3: Worker installing solar panels on rooftop. Australia is a world leader; more than 30% of dwellings in Queensland and South Australia have rooftop solar.

2.2 Increasing Energy Efficiency

Energy efficiency involves delivering equivalent (or better) products and services while reducing the overall amount of energy needed (The Climate Institute 2013).

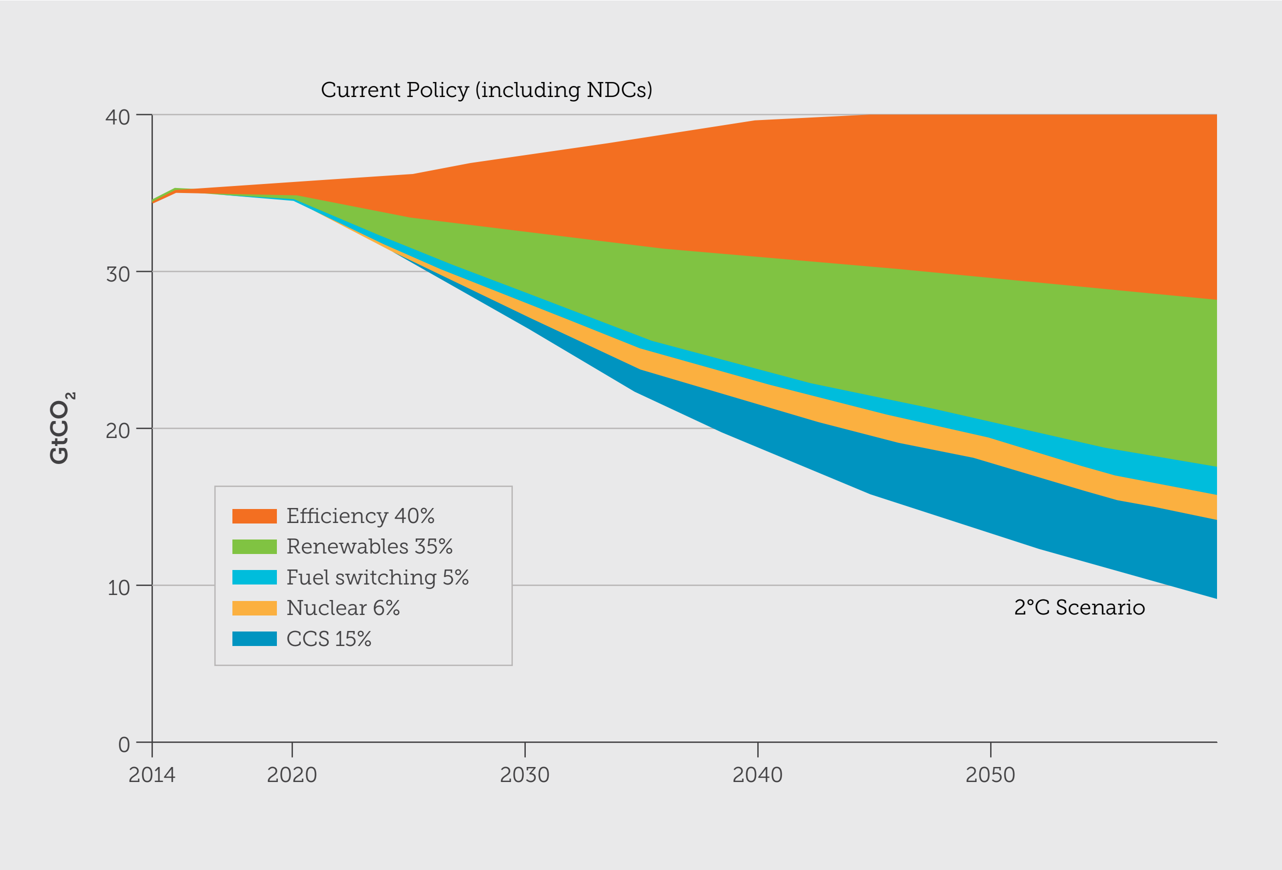
The potential contribution of efficiency gains to emission reductions is very large. A recent global analysis suggests that to meet the 2°C climate target, both gains in energy efficiency and increases in renewable energy will be required (IEA 2017c; Figure 4). In Australia, a 1% increase in energy efficiency each year is estimated to increase GDP in 2030 by $25 billion while reducing emissions (The Climate Institute 2013). In terms of built infrastructure, wood, stone and carbon fibre are being explored as net-zero emissions building materials, and research on emissions-free concrete and steel is underway (e.g. Beyond Zero Emissions 2017).

Increases in energy efficiency – sometimes referred to as a reduction in the "energy intensity" or increases in the "energy productivity" of an economy – are already playing a significant role in global emission reductions. China's dramatic reduction in the energy intensity of its economy, coupled with its rapid deployment of renewables, has enabled it to meet its 2030 Paris commitment over a decade ahead of schedule (Climate Action Tracker 2017), an achievement that has played a major role in the levelling off of global emissions over the last three years (Le Quéré et al. 2016).

Projections for the future show the potential for ongoing, long-term gains in energy efficiency to complement the rapid deployment of renewable energy technologies in driving emissions down rapidly. Figure 4 shows that out to 2050 and beyond, emission reductions derived from increasing energy efficiency are as large as those attributable to the transition to renewable energy. Together, they can account for 75% of the emission reductions needed to achieve the 2°C Paris target. In Australia, a doubling of energy productivity by 2030 could play an important role in not only emission reductions, but also in driving greater economic productivity (ClimateWorks 2015; Skarbek 2015).

Energy efficiency is critical to reducing emissions.

Figure 4: Energy efficiency and renewable energy are the key to meeting the Paris 2°C target, by contributing 75% of the reduction in emissions necessary. **Source:** IEA 2017c, p.17.



2.3 Electricity System Revolution: Battery Storage and Distribution

The renewables revolution is being accompanied by a revolution in the way electricity is being stored and distributed, leading to electricity systems that are more nimble and resilient than old systems built around a few large fossil fuel power plants and ageing poles-and-wires grids.

Battery storage, a key component of a 100% renewable electricity network, is undergoing a revolution of its own. The costs of batteries have plummeted, dropping by an average of 14% per year from 2007 to 2014. Battery prices are expected to drop even more steeply in the next few years (RenewEconomy 2016), leading to projections that battery storage capacity will grow 50-fold in less than a decade. Household-scale batteries are leading the way, creating 'behind the meter' approaches such as paired solar PV plus battery systems that minimise the need to purchase expensive electricity from the grid and reduce the need for costly gas 'peaking plants'. Commercial uptake of batteries is also experiencing a rapid expansion.

In addition to battery technologies, hydro-electricity systems are a well-established approach for storing energy with a potential for very high capacity. When more electricity is being generated than used, for example by renewables, the excess can pump water back up into higher reservoirs, ready to provide on-demand energy at peak periods. Thermal storage – off-peak electric hot water services and chilled water storage for cooling – is an inexpensive, widely used storage method.

Changes in electricity distribution are also important to build reliable and resilient power systems. The key requirements are a flexible, 'smart' grid, diverse energy sources and demand management, together with storage where it is needed. In particular, higher levels of renewable energy generators such as solar and wind require more flexibility in the operation of the grid, which can be provided by "dispatchable" generators that can deliver electricity on demand (e.g., hydro, biomass, solar thermal), interconnections between states and demand management (IEA 2017b).

Smart grids and storage are key to reliable and resilient future power supplies.

2.4 Finance Driving Energy Transformation

The finance sector is playing a key role in the energy transformation. In Australia, the Clean Energy Finance Corporation has been working with financiers to accelerate investment in efficiency improvement, renewable energy and energy storage. Complementing this approach, the divestment campaign has grown rapidly into a global social movement that is convincing major investors to turn away from new fossil fuel projects. In 2014 the divestment movement accounted for US$50 billion in fossil fuel-related divestments, and by early 2015 the amount had grown to US$2.6 trillion (Arabella Advisors 2015).

Fear of stranded assets is also convincing many institutional investors to move away from fossil fuels (OECD 2015; Figure 5). A 'stranded asset' is defined as an "asset that has suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities…" (Caldecott et al. 2013, p. 7). With a 30 to 40-year lifetime for fossil fuel projects to be financially viable, the speed of the renewable revolution is convincing a growing number of financial players that renewables are the more secure investment for the future. As fossil fuel infrastructure increasingly becomes stranded assets in the US and China, the pressure on Australia's financial sector is rising with all of the Big Four banks (ANZ, NAB, Commonwealth Bank and Westpac) withdrawing from funding the proposed Adani Carmichael coal mine in Queensland.

Australian companies and their directors now have a legal duty to consider risks associated with climate change when making business decisions (Centre for Policy Development 2016). Those directors who do not consider climate change, including not only environmental risks (e.g., worsening extreme weather events) but also social and economic risks (e.g. stranded assets, need to reposition to capture emerging opportunities), could be held legally liable for breaching their duty of due care and diligence (McLeod and Wiseman 2016). For example, in a world-first case, Commonwealth Bank is being sued by its own shareholders for allegedly failing to properly disclose the risks to business posed by climate change (Foerster and Peel 2017).

Figure 5: The Anglesea coalmine in Victoria became a stranded asset once it closed in 2016 after the coal plant owner Alcoa was unable to find a buyer for the power station.

2.5 Cutting Emissions from Other Major Sectors: Transport and Agriculture

Cars, ships and airplanes powered by fossil fuels (mainly oil) contributed about 14% of global greenhouse gas emissions in 2010, and transport emissions are projected to double by 2050 (IPCC 2014). Action on reducing these emissions is beginning. Although strong emission standards for cars can help in the short term, complete elimination of emissions from cars will ultimately be required. Several European countries have recently announced the probable phase-out of internal combustion engines by 2030 at the latest (Rockström et al. 2017), while the UK and France are banning petrol and diesel car sales by 2040. In Australia, cars are responsible for roughly half of all transport emissions. Collectively, Australian cars emit roughly the same per year (43 Mt CO_2-e) as Queensland's entire coal and gas fired electricity supply (Australian Government 2017; Queensland Renewable Energy Expert Panel 2016).

Figure 6: Sydney City light rail. The New South Wales Government is currently considering using renewable energy to power the light rail system, which would minimise emissions.

Key climate solutions to drive down transport emissions involve shifting from cars to public and active (cycling and walking). Several cities – Canberra, Sydney City, Parramatta, Adelaide and the Gold Coast – are installing light rail systems, with Canberra's system running on 100% renewable energy from its opening in late 2018 (Figure 6). Electrifying our ground transport, and powering it by 100% renewable energy, is critical for positioning Australia to achieve zero emissions by 2050 (ClimateWorks 2014). Electric vehicles run on electricity and plug-in rechargeable batteries. Globally, the rollout of electric vehicles is picking up speed, going from almost zero on the road in 2010 to passing two million electric vehicles in 2016. Yet, the uptake of electric vehicles in Australia is being held back by the lack of policy support or incentives, higher upfront cost, choice of available electric vehicles for sale in Australia, and the availability of public vehicle charging infrastructure (Business Insider 2016).

Reducing emissions from the aviation and shipping sectors is also important. The development of net-zero emission aviation fuels is still very much in the experimental stage with more research required before such fuels can be deployed. Synthetic liquid fuels, bio-methane and hydrogen are the most promising possibilities at present. The aviation challenge is complicated by the additional indirect impacts of emitting exhaust gases and water vapour at high altitudes, which increase aviation's contribution to climate change.

Agriculture is Australia's fourth largest source of greenhouse gas emissions, which come from methane and nitrous oxide from enteric fermentation in livestock, manure management, rice cultivation, agricultural soils, and field burning of agricultural residues, along with CO_2 from the use of fossil-fuel driven energy sources in agricultural production systems (Australian Government 2017). Reducing greenhouse gas emissions from agriculture is focused on methane and nitrous oxide, both important greenhouse gases, in addition to CO_2. On the other hand, rural communities could achieve significant benefits from contributing to the energy transformation. These include more secure and affordable power, insulated from the price blowouts associated with fossil fuels; elimination of risks to water resources associated with unconventional gas extraction; and new income streams derived from the installation of renewable energy systems in rural areas.

Although Australia's land sector has been a net sink for carbon over the past decade or two (net flux of carbon from the atmosphere to the land largely due to natural processes, primarily the fertilisation effect of the rising concentration of CO_2 in the atmosphere, and not due to changes in land-use management), this climate benefit has been overshadowed by our fossil fuel domestic emissions and exports. Furthermore, much of the carbon that has been taken up by land systems is vulnerable to return to the atmosphere by natural (e.g. bushfires) and human (e.g. land clearing for human settlement or agriculture) changes. (Climate Council 2016).

2.6 Social Benefits of Reducing Carbon Pollution: Health and Economic

Eliminating the heavily polluting fossil fuel energy sector, particularly coal (or indeed any other carbon-intense sector, e.g. transport), will generate large health benefits. Every component of coal's lifecycle, from mining through combustion to the disposal of waste, drives adverse effects on health, including lung cancer, bronchitis, heart disease and other conditions of ill health, often leading to premature death (Epstein et al. 2011). Hundreds of thousands of deaths occur each year in China and India from the burning of coal for power. In the United States, 50,000 deaths annually are attributed to air pollution from coal-fired power stations, with coal contributing to four of the five leading causes of mortality (Jones et al. 2016).

In Australia, air pollution from coal mine fires pose health risks for nearby populations, such as respiratory and heart diseases, and cancers. At least 11, and up to 23, people died from the effects of the 2014 Hazelwood mine fire in Victoria, and coal miners in Queensland have experienced a re-emergence of black lung disease. The impacts of coal on the health of Australians cost taxpayers about $2.6 billion every year (Climate Council 2017d; Figure 7).

A rapid transition to efficient, smart renewable energy systems is also generating benefits for the economy. The increase in employment driven by the energy transformation is impressive, with the solar energy sector now employing 2.8 million people globally. In the United States, solar now provides twice as many jobs as coal.

In Australia, the solar energy sector already employs over 8,000 people and will create thousands of more jobs as it continues to grow. If Australia adopted a target of 50% renewable electricity by 2030, 28,000 additional jobs would be created, more than the number of jobs lost in the coal-fired electricity generation sector, resulting in a net gain in jobs across the country, and within each state (Climate Council 2016d). Increasing energy efficiency also creates many jobs, shifting activity from low job-intensity heavy industry to higher job-intensity light manufacturing and services.

Figure 7: Uncovered coal train wagons in the Hunter Valley, New South Wales. Despite extensive international research on the health risks of coal mining and burning, there is very little research in Australia on the health impacts of coal.

3. Reality Check

Efficient, smart renewable energy technologies that are now mainstream and the emergence of other solutions to the climate change challenge are very encouraging. However, a fundamental science-based analysis of the magnitude and speed of the required emissions reduction effort yields a simple, sobering result. We are rapidly running out of time to avoid dangerous climate change. It is urgent that the global community make the right investment decisions now and greatly speed up action.

Why the urgency? The carbon budget approach provides a clear and convincing answer.

The carbon budget is an intuitively simple yet scientifically robust way of measuring the magnitude of the emission reduction challenge and progress towards meeting this challenge. It is based on a simple, nearly linear relationship between the amount of CO_2 emitted from human activities and the rise in global average temperature. That is, the more carbon we emit, the higher temperature rises in proportion to our emissions (Box 1).

Like a household budget where there is a certain amount of money available, the carbon budget articulates the amount of carbon that can be "spent".

The higher the amount of CO_2 in the atmosphere, the higher global temperature will become. Fossil fuels, like coal, oil and gas, are the primary driver of the increasing amount of CO_2 in the atmosphere. It is widely accepted that a 2°C rise in global temperature is a threshold that should not be crossed due to rapidly increasing risks of grave consequences for humanity above that limit. At just over half this level of temperature rise, climate change has already significantly intensified extreme weather events like heatwaves, bushfires and droughts. The carbon budget can tell us how much additional CO_2 can be "spent" while having a strong chance of staying below a certain rise in global temperature. It is calculated using probabilities, so the less CO_2 emitted, the greater the chance of limiting temperature rise. For more information about the carbon budget, please refer to the Climate Council report, "Unburnable Carbon: Why we need to leave fossil fuels in the ground".

In 2015 a global agreement was signed in Paris by 195 countries that committed to limit global temperature rise to well below 2°C. The text also goes further to state that parties will pursue efforts to limit the temperature increase even further to 1.5°C. Nations that are highly vulnerable to climate change impacts, like Pacific island countries, strongly put the case for this stronger target. Evidence shows that many of these nations will not be viable due to sea-level rise, storm surges and other climate change impacts beyond 1.5°C of warming.

Given that it has taken significant time to ramp up action on climate change globally, there is now only a relatively small carbon budget left. The carbon budget approach allows us to quantify the amount of fossil fuels that can be burned to have a good chance of remaining under a 2°C rise in global temperature, the upper warming limit agreed to in Paris in 2015. More than 140 governments around the world, including Australia, have already ratified the Paris Agreement. Anything more than 2°C warming is considered too dangerous for humanity, not only for unacceptably large increases in direct impacts such as extreme weather events, but also for crossing climate 'tipping points', where further small increases in temperature can trigger large, often rapid and potentially irreversible changes in the climate system (Church et al. 2016). Examples of these tipping points are the loss of the Greenland and West Antarctic ice sheets, thawing of permafrost in Siberia and loss of the Amazon rainforest. Applying this 'carbon budget" approach to the 2°C Paris target shows that we can emit only 1,000 Gt carbon (as CO_2) from the beginning of the industrial revolution if we want a 66% chance of meeting the target (IPCC 2013; Collins et al. 2013). A higher chance of meeting the target would require a smaller budget. Also, if we aim for the aspirational 1.5°C Paris target, we would be bound by a much smaller carbon budget. The difference between 1.5°C and 2°C of warming is a shift into a more destructive climate with, for example, longer heatwaves, greater droughts and threats to crops and coral reefs (Schleussner et al. 2016), as well as significantly increasing the risk that some tipping points could be crossed.

The 1,000 Gt C budget is excessive for a couple of reasons. The budget is based on CO_2 emissions only, and does not include other important greenhouse gases such as methane and nitrous oxide. Including these reduces the budget to 790 Gt C (IPCC 2013). In addition, the budget does not include some important natural sources of carbon that amplify warming, such as emissions of CO_2 and methane from thawing permafrost. Including this so-called 'carbon feedback' would reduce the budget even further (Ciais et al. 2013).

Human emissions of CO_2 since the beginning of the industrial revolution total about 565 Gt C (Le Quéré et al. 2016). This means that from the 1,000 Gt C budget (see Box 1), we have 435 Gt C remaining, but including the non-CO_2 greenhouse gases reduces the budget further to about 225 Gt C. Current CO_2 emissions are about 10 Gt C per year (Le Quéré et al. 2016). This means that to keep temperatures below 2°C, we have little more than two decades-worth of emissions before the global economy must achieve net zero emissions. Clearly every year counts!

BOX 1: THE CARBON BUDGET

The carbon budget is a useful way to comprehend the magnitude of the emission reduction challenge ahead, and the emission reduction pathways that are required to meet that challenge.

- Both comparison of (i) past temperature rise with past emissions and (ii) future projected temperature rise with future emissions show the robust, linear relationship between emissions and temperature (Figure 8a).
- The carbon budget uses a probabilistic approach to account for uncertainties. That is, the budget for a 66% chance of meeting a 2°C target is more stringent that the budget for a 50% chance of meeting the same target.
- The carbon budget initially assumes all warming results from CO_2 and ignores other greenhouse gases (Figure 8b, red bar). Accounting for non-CO_2 GHGs such as methane and nitrous oxide reduces the CO_2 budget significantly (Figure 8b, orange bar). For the 2°C target, the remaining budget would be exhausted by 2039 at current rates of emission.
- Accounting for carbon loss from melting permafrost and other biosphere carbon feedbacks not included in the IPCC analysis reduces the permissible budget further (Figure 8b, yellow bar). For the 2°C target, the remaining budget could be exhausted as early as 2029 at current rates of emission, depending on the magnitude of these feedbacks.
- For the Paris 1.5°C target, the remaining carbon budget is only about 50 Gt C and would be exhausted by 2022 at current rates of emission (Figure 8b, green bar).
- Very steep emission reductions are required to meet the 2°C Paris target, and most of the proposed pathways require the removal of CO_2 from the atmosphere ("negative emission technologies"), as shown by the example in Figure 8c.

Note that here and throughout this report, we use billions of tonnes ("gigatonnes" or Gt) of carbon (i.e., Gt C) as the units to measure the magnitude of carbon emissions, carbon uptake or a carbon budget. To convert these numbers to Gt of CO_2 (carbon dioxide), multiply them by 3.664. So 1 Gt C = 3.664 Gt CO_2.

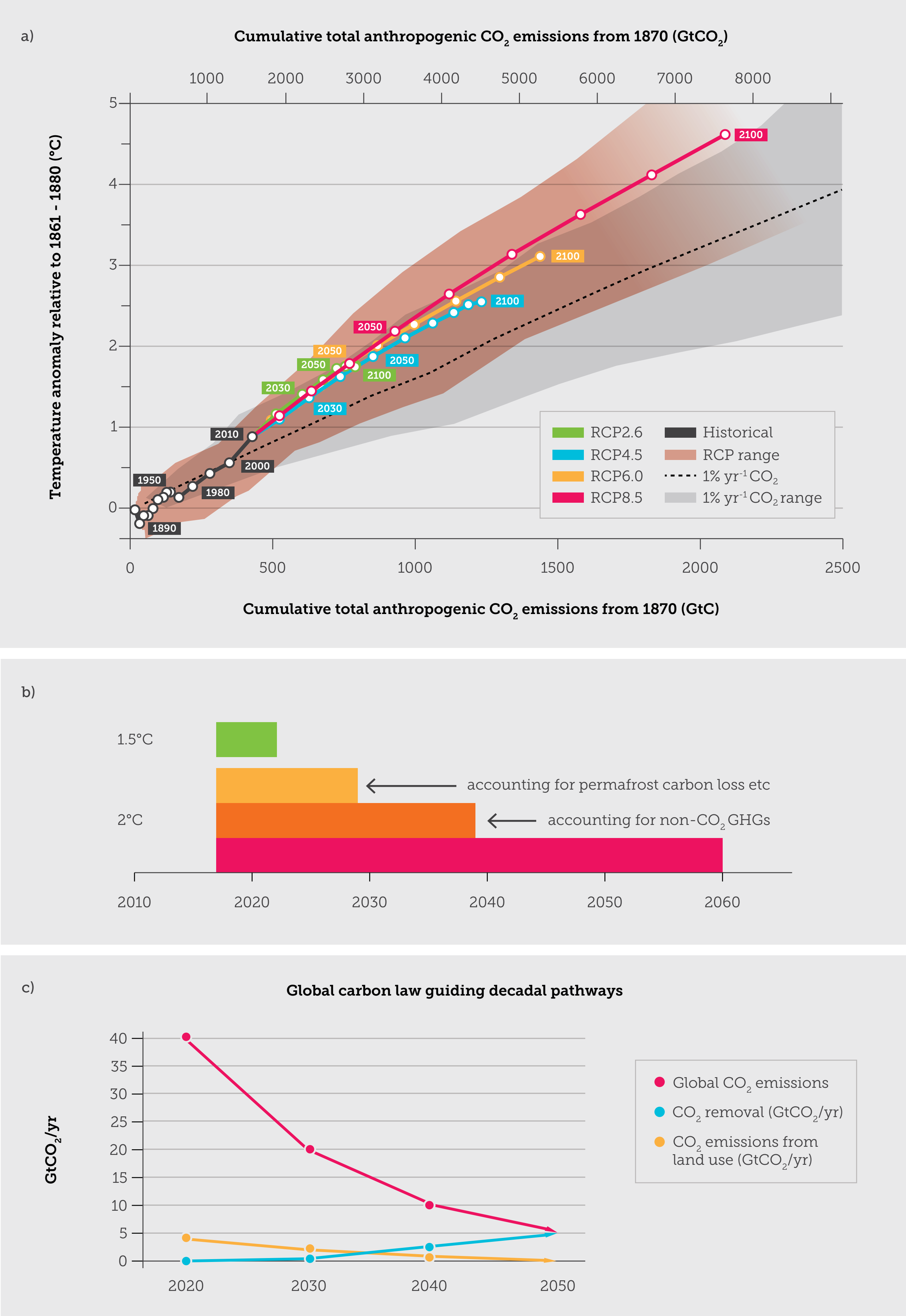


Figure 8: **(a)** Scientific basis for carbon budget approach; **(b)** Years of carbon budget remaining from 2017 assuming constant emissions of 10 Gt C per year (current emissions) and a 66% chance of meeting a 2°C target; **(c)** An emission reduction pathway to meet a 2°C carbon budget. **Sources:** IPCC 2013; Collins et al. 2013; Carbonbrief 2016; Rockström et al. 2017.

The carbon budget has important implications for Australia, both for exploitation of reserves, as well as continuing to use fossil fuels for electricity and transport.

Based on an economic analysis of how much each type of fossil fuel – coal, oil and gas – can be burned within a very generous budget (only 50% probability of meeting the 2°C Paris target), 95% of Australia's coal reserves and 51% of our gas reserves must be left in the ground, unburned (McGlade and Ekins 2015; Figure 9). 'Reserves' are defined as the fraction of fossil fuel resources that are exploitable under current economic conditions and have a specific probability of being produced. Thus, reserves are a sub-set of resources. In terms of resources, Australia's coal resources are so vast that exploiting them would consume two-thirds of the entire global carbon budget for a 75% chance of meeting the 2°C Paris target! Furthermore, the carbon budget does not allow for any exploitation of unconventional oil or gas resources (McGlade and Ekins 2015).

Only a very rapid phase-out of Australia's thermal coal industry is compatible with a 2°C carbon budget. Moreover, no new coal resources can be developed, including the huge resources in the Galilee Basin in Queensland.

Furthermore, current levels of reliance on gas power in Australia must be reduced to play our role in limiting global temperature below 2°C. Expanding gas usage is inconsistent with tackling climate change as it locks in emissions for decades into the future. Therefore, gas fares little better than coal in the budget. For a 75% chance of meeting the 2°C Paris target, over 70% of Australia's existing gas reserves must be left in the ground, unburned, and no new gas resources can be developed. In addition, greater use of gas in Australia's domestic energy mix will very likely drive higher power prices, and trigger a massive expansion of expensive, risky unconventional gas (Climate Council 2017e).

The carbon budget approach can also be used to evaluate national energy and climate policies, such as those proposed in the Finkel Review or the National Energy Guarantee (Finkel 2017). Australia's current emissions reduction target is 26-28% by 2030 compared to a 2005 baseline. This target is woefully inadequate when compared against our carbon budget allowance for a 2°C target. In fact, nearly all of Australia's entire carbon budget would be consumed by 2030 under the present target. To be consistent with the 2°C carbon budget, the Climate Change Authority recommended that the appropriate 2030 target for Australia should be a 45-65% reduction in emissions by 2030, from 2005 levels (Climate Change Authority 2015).

Most of Australia's gas reserves must remain in the ground.

Tackling climate change and protecting Australians from worsening extreme weather requires our electricity system to produce zero emissions before 2050. Any credible national energy plan must explicitly include a pathway for achieving net zero emissions within a 2°C carbon budget.

In summary, any analysis of the carbon budget shows that reducing fossil fuel emissions deeply is now a matter of urgency. The magnitude of the problem and the timeframe required for the solutions clearly show that minor modifications to ‘business-as-usual’ have failed and need to be abandoned. Feasible and cost-effective solutions have already appeared and become mainstream. The constraints to deep emission cuts are no longer lack of appropriate technologies or the costs of transition, but rather inertia, politics, ideologies, and vested interests. This is where the challenges to ramp up action lie.

Figure 9: If we are to stay within 2°C of warming, all coal plants must be phased out rapidly and any new mines or plants cannot be developed.

4. Australia in the World

The climate is part of a single, planetary-level system (the 'Earth System'), so the solution to halting climate change has to be global (Steffen et al. 2004). All countries, especially wealthy countries like Australia, are expected to do their fair share in tackling climate change. In addition, Australia is highly vulnerable to many of the consequences of a changing climate, from worsening heatwaves, droughts and bushfires, to extreme coral bleaching, to most of our population centres being highly exposed to sea level rise.

Australia must do its fair share to tackle climate change.

How is the world tracking on meeting the climate change challenge? Is Australia doing its fair share?

The 2015 Paris climate conference was a landmark in the global effort to tackle climate change. For the first time virtually all the nations on the planet – large and small, developed and developing – signed the agreement and pledged to reduce their greenhouse gas emissions. All of the world's largest emitters – China, the United States, the European Union, India – and all of the fossil fuel-producing nations such as oil giant Saudi Arabia and coal-rich Australia – signed the agreement.

The goal of the Paris Agreement is to limit global average temperature rise to well below 2°C and to pursue efforts to limit warming to 1.5°C. The current global average temperature is about 1°C above the pre-industrial baseline (late 19th century levels), so emission reductions need to be deep and rapid if we are to have a chance of meeting the Paris target.

Unlike the failed approach to reach agreement in Copenhagen in 2009, the Paris accord is not legally binding. The signatories set their own emission reduction targets and devise and implement their own strategies to meet the targets. The approach is very much bottom-up, with an important provision for periodic 'review and revise' meetings in which national pledges and actions can be ratcheted up.

China's emissions are peaking; US emissions are decreasing.

The review and revise approach to national targets is crucial, as the aggregated result of the individual national commitments at Paris is a temperature rise by 2100 of about 3°C above preindustrial (Rogelj et al. 2016). This level of warming is far above the agreed targets and would drive devastating impacts on human societies and the natural world (Section 5) as well as push the climate system towards or over dangerous tipping points (Schellnhuber et al. 2016; Section 5.3).

Yet, just two years after the Paris accord, there are encouraging signs that the biggest emitters are already moving faster to reduce their emissions. China pledged to peak its emissions by 2030, but recent data suggest that, in a remarkable effort, China may already have peaked its emissions (Le Quéré et al. 2016). The United States, despite the policies of President Trump, may also continue its downward trend in emissions as cities and states across the US, notably California and the northeastern states, are intensifying their efforts to slash emissions, generating considerable benefits for their citizens. For example, California's climate policies created an economic boom of $9.1 billion and 41,000 jobs from 2010 through to 2016 (University of California 2017). The European Union is also ramping up its efforts to tackle climate change.

How do Australia's efforts stack up against this rapidly changing global picture?

Unfortunately, the picture is not so encouraging in Australia. Amongst the G20 countries, our emission reduction target – 26-28% on a 2005 baseline – is unusually weak, nowhere near what is required for us to play our fair share in meeting the Paris target (Box 2). Worse yet, we are not even on track to meet this very weak target. Both Australian Government projections and independent analyses show that Federal Government climate policy (e.g. the Emissions Reduction Fund) is failing to meet its emission reduction targets (UNEP 2017). The National Energy Guarantee policy has very little detail on how it will actually achieve the required emission reductions in Australia's largest emitting sector, electricity (Climate Council 2017f). As noted in Section 3, to do our fair share to meet the 2°C target would require emission reductions in the 45-65% range by 2030 on a 2005 baseline (Climate Change Authority 2015). Unfortunately, this more balanced target has been removed from the Federal Government's climate change discourse (e.g. Climate Change Authority 2016; Finkel 2017), including in the Australian Government's latest energy policy, the National Energy Guarantee. This implies that the Australian Government's approach is to accept much higher levels of warming than 2°C, with all of their grave and potentially catastrophic implications.

BOX 2: AUSTRALIA, THE GLOBAL LAGGARD

A comparison of Australia's commitments at the 2015 Paris climate conference to those of other OECD countries (Table 2) shows that Australia is far behind the level of climate action around the world. Australia's commitment is inconsistent with limiting temperature rise to no more than 2°C above pre-industrial.

Compared to an average annual rate of emission reductions of 2.6% pledged by many developed countries, Australia's proposed rate of emissions reduction is only 1.6% per annum. Worse yet, our emissions continue to rise!

Table 2: Comparison of the emission reduction targets pledged by various countries as part of the Paris Climate Agreement. Note that per capita emissions are given in tonnes of CO_2-e. To convert to tonnes of C, the value in the column should be multiplied by 0.273. **Source:** Adapted from The Climate Institute 2015.

	Consistent with 2°C?	Annual rate of emissions reductions	Per capita emissions (t CO_2e)	Emissions intensity (t CO_2e/ GDP PPP)	Change on base year		
		Post-2020	2030	2030	2005	2000	1990
Australia	NO	-1.6%	16	198	-26%	-19%	-20%
Canada	NO	-1.6%	14	190	-30%	-18%	+6%
EU	POSSIBLE	-2.6%	6	104	-34%	-33%	-40%
Germany	NA	-2.6%	7	89	-45%	-46%	-55%
Japan	NO	-2.4%	8	134	-25%	-25%	-19%
New Zealand**	NO	-0.5%	11	175	-30%	-23%	-10%
Norway	POSSIBLE	-1.5%	4	41	-18%	-20%	-40%
Excluding LULUCF		-1.5%	5	51	-44%	-44%	-40%
Switzerland	POSSIBLE	-4.1%	3	32	-51%	-51%	-50%
UK	NA	-5.1%	5	74	-49%	-51%	-64%
Average (excluding Australia)		-2.6%	7	105	-35%	-33%	-34%

- Not consistent with 2°C
- Green is credible pathways to 2°C exist*
- Worst among developed countries
- Australia in worst three
- Blue is best among developed countries

Notes: NA - Not applicable as country is part of the EU and independent assessments of their contribution to the 2°C goal have not been undertaken. * Consistent on some assessments - credible pathways to 2°C exist, high probability of avoiding 2°C requires an acceleration of effort to 2050. ** Excluding LULUCF

Australia's emissions continue to increase.

While greenhouse gas emissions are dropping in the US and Europe and flat-lining in China, they have actually risen in Australia every quarter since March 2015 (Australian Government 2017). In 2016 emissions rose by 1.4%, with electricity generation accounting for 35% of emissions. There is no doubt that, in many ways, Australia stands out as the global laggard on climate change (Germanwatch 2017; UNEP 2017). Indeed, Australia is ranked fifth last out of the 58 top emitters worldwide, in terms of climate change performance (Germanwatch 2017).

In contrast to a dismal national picture, many cities and states across the country are beginning to take stronger action on climate change. South Australia and the Australian Capital Territory are leading the way, with almost 50% of SA's electricity now produced by renewables and the ACT on track to source 100% of its electricity from renewables by 2020. Other states, like Victoria, Queensland and the Northern Territory, now also have strong renewable energy targets (Climate Council 2017a). In fact, all states and territories except Western Australia now have strong renewable energy targets and/or net-zero emissions targets in place. These targets are broadly consistent with the level of renewable energy needed across Australia by 2030 to keep global temperature rise below 2°C (Jacobs 2016).

The race is on at the city level as well. Adelaide is striving to become the world's first carbon neutral city, while the City of Melbourne is working towards net-zero emissions by 2020 and Sydney is aiming to reduce its emissions 70% by 2030.

Solar energy uptake in Australia is accelerating with households leading the way. Australia is a world leader in household solar, adding more solar power each year than the combined capacity of the recently closed Playford and Northern coal-fired power stations in South Australia. Industrial-scale solar is set to expand rapidly, with over 20 new large-scale projects due to come online in 2017 with even more projects in the pipeline.

In 2017, more than three-quarters of the way through the Critical Decade, Australia is in a dangerous position. Despite growing action at the city and state level, gridlock reigns at the national level. A decade of toxic, divisive climate politics has left Australia's greenhouse gas emissions drifting upwards while much of the developed world has begun the journey towards net-zero emissions. Our reputation as a responsible global citizen is plummeting, replaced by our position as the world's climate change laggard (e.g. ABC 2016; Morgan 2017). Worse yet, we are in danger of dropping out of the energy revolution that is sweeping across the world, leaving us with stranded fossil fuel assets, weakening our economy and losing out on the jobs that the renewables boom is generating (Climate Council 2017g).

5. Accelerating Risks

The Critical Decade has been marked by accelerating action by nations and a dramatic increase in deployment of renewable energy. The decade has also been marked by accelerating impacts of climate change, which are now being witnessed with increasing regularity worldwide. Consequences that scientists had warned us about have now come to pass during the Critical Decade, including worsening extreme weather events like bushfires and heatwaves, and dramatic bleaching of coral reefs around the world. Climate change is already driving serious impacts on our health, our economy and on natural ecosystems. While progress has been encouraging, the scale of the challenge remains daunting and the urgency of further action has only increased.

All extreme weather events are now being influenced by climate change.

Understanding the nature and severity of these risks is based on rapid advances in the climate research community. The scientific evidence is now overwhelming and incontrovertible – global temperature is rising at unprecedented rates (Figure 10), rainfall patterns are changing, polar ice is melting and sea level is rising. There is no doubt about the cause: human emission of greenhouse gases, primarily from burning coal, oil and gas.

Climate science has made particularly strong advances in establishing the direct link between climate change and worsening extreme weather. Many extreme weather events – heatwaves, bushfires, coastal flooding – are occurring more frequently and becoming more damaging. The focus of this section is on Australia, although extreme weather is also worsening in many countries and regions around the globe.

The evidence for the link between climate change and worsening extreme weather relies on three lines of evidence:

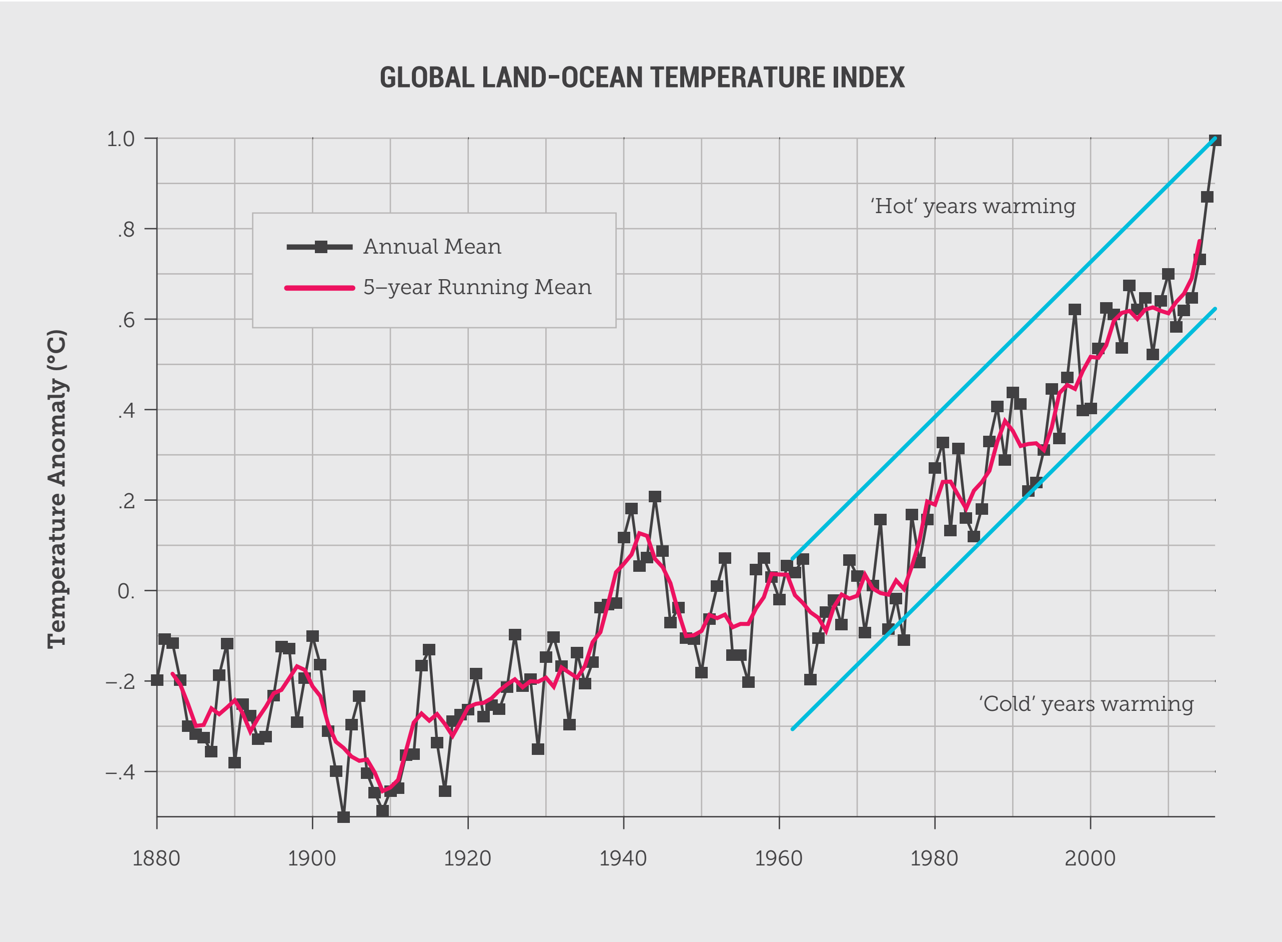
Basic physics: all extreme weather events are now occurring in a more energetic climate system with a hotter, moister atmosphere (Trenberth 2012).

Observations: For many types of extreme weather events, long-term data reveal trends towards more intensity and higher frequency (IPCC 2013; CSIRO and BoM 2015; Climate Council 2017h).

Attribution studies: Climate model simulations with and without the additional greenhouse gases from human activities show how climate change has increased the probability that specific extreme weather events would have occurred (e.g., Herring et al. 2016).

The consequences of failing to adequately tackle climate change are enormous. Continuing on our present emission trajectory would significantly increase the risk of deteriorating human health and well-being, massive migration and conflict, crippling economic damage around the world, and the Earth's sixth great extinction event.

Figure 10: Global Land-Ocean Temperature Index, from 1880 to present, using 1951-1980 as a baseline period. The average temperature of both hot and cold years has risen rapidly since the 1970s. **Source:** NASA 2017.



5.1 Worsening Extreme Weather in Australia

All three lines of evidence support the significant role of climate change in increasing the frequency and intensity of many of the extreme weather events that are typical of Australia's climate – heatwaves, bushfires, floods and storms.

Extreme heat: Record hot days have more than doubled since the mid-20th century, accompanied by an increase since the 1970s in the number of days over 35°C across much of Australia (CSIRO and BoM 2016). Heatwaves – periods of three consecutive days or more of unusually high maximum and minimum temperatures – have increased in both duration and frequency over much of the country over the past few decades, and heatwaves have become even hotter over the south of the continent (Perkins and Alexander 2013; Figure 11). Australia's record hot year of 2013 was virtually impossible without climate change; it would have occurred only once in 12,300 years without human-driven climate change (Lewis and Karoly 2014). Climate change has increased the risk of experiencing severe heatwaves by two- and three-fold in terms of their frequency and intensity (Perkins et al. 2014).

Figure 11: Heatwaves are becoming hotter, lasting longer and occuring more often.

Bushfires: The influence of climate change on bushfires is measured through increases in the Forest Fire Danger Index (FFDI), which estimates the conditions under which dangerous fires are likely to break out – high temperature, low humidity, high winds and preceding dry conditions. Since the 1970s, extreme fire weather, as measured by the FFDI, has increased, particularly in the populous south and east (CSIRO and BoM 2015). Consistent with this increase, the area burned by bushfires has increased in seven out of eight forest biomes in the southeast over the 1973-2009 period (Bradstock et al. 2014). Particularly destructive fires in the last 15 years include the Black Saturday fires in Victoria in 2009, the 2013 fires in Tasmania, and the 2003 Canberra and alpine fires.

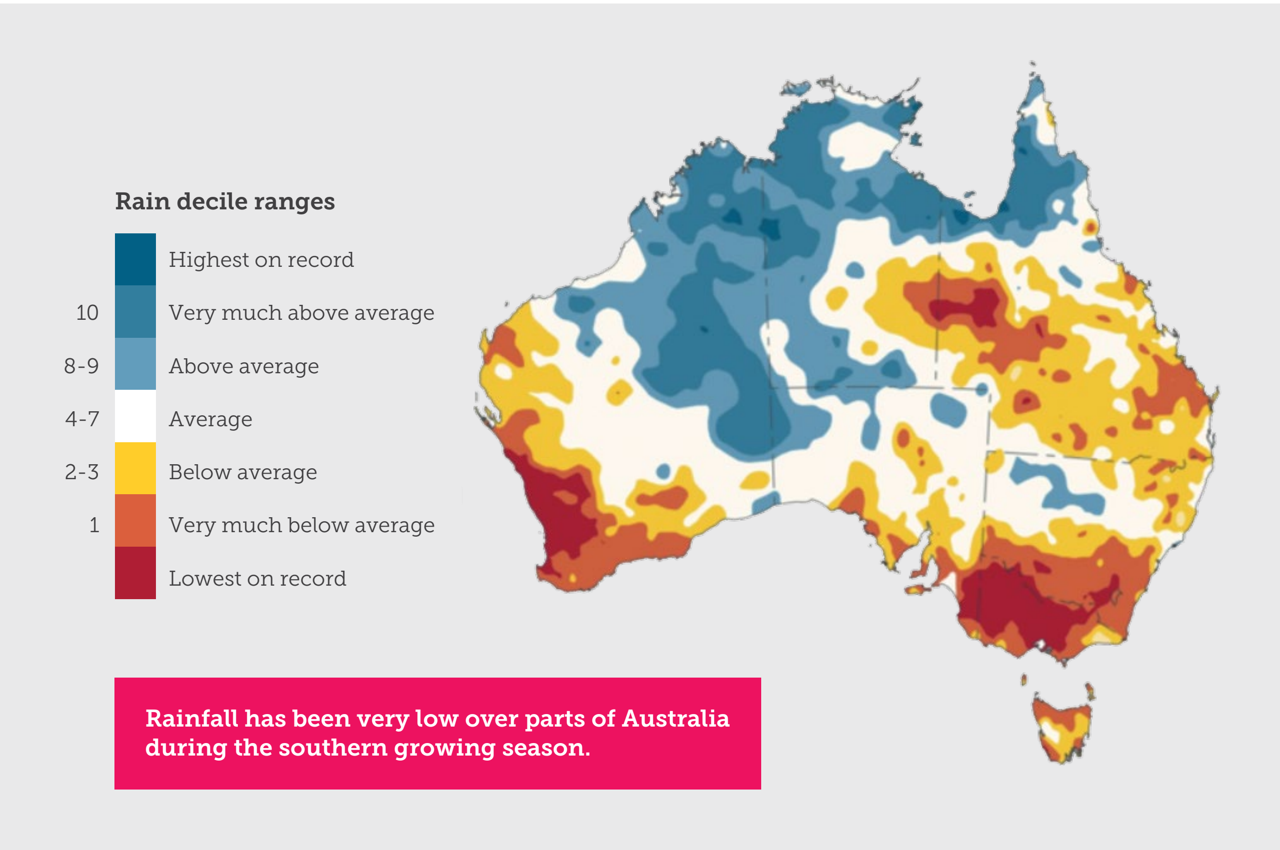
Coastal Flooding: Global average sea level has risen by about 20 cm since the mid-19th century (IPCC 2013). Although this rise doesn't appear to be much, it raises the base level on which storm surges, driven by high winds and/or reduced atmospheric pressure, drive elevated levels of water onto coastal lands (e.g. Figure 12). During the 20th century, coastal flooding has increased three-fold on both the east (Sydney) and west (Fremantle) coasts of Australia as a result of sea-level rise (Church et al. 2006). In the United States, where more data are available, during the 1955-1964 period 45% of coastal flood days occurred as a result of sea-level rise. This rose to 76% of flood days during the 2005-2014 period (Strauss et al. 2016).

Figure 12: An example of damage to a road from coastal flooding at Mission Beach, in Queensland.

Drought: Defined as an abnormally long dry period compared to the normal pattern of rainfall, drought is a common occurrence in Australia. Climate change is likely making drought worse in the country's southeast and southwest agricultural zones (CSIRO and BoM 2016). Rainfall in the April-October growing season has declined by 11% since the mid-1990s, a trend that is particularly strong in southwest Western Australia with a drop since 1970 of 19% compared to the long-term average (Figure 13; 14). These decreases are related to the poleward shift of the cool season, rain-bearing fronts from the Southern Ocean, a trend that is consistent with changes in atmospheric circulation expected from a warming climate (Timbal and Drowdowsky 2012).

Storms: There are not yet sufficient Australian data to discern any significant trends in frequency or intensity of hail and thunderstorms, intense rainfall, tropical cyclones or extra-tropical cyclones such as east coast lows. Where there are enough data, such as in the North Atlantic, an increase in intense hurricane (referred to as "tropical cyclone" in Australia) activity has been observed since the 1970s (IPCC 2013). In the future, Australia is expected to experience an increase in intense tropical cyclone activity, and conditions conducive to the development of severe thunderstorms are projected to become more frequent in southern and eastern regions of the country (CSIRO and BOM 2015; Allen et al. 2014).

Figure 13: Southern Australia has experienced a severe drying trend in the April-October period from 1996-2015 (CSIRO and BoM 2016).



5.2 Climate Change is Adversely Affecting People, the Economy and the Australian Environment

Worsening extreme weather events are already exacting a large toll on the health and well-being of Australians, damaging livelihoods and economic assets, and threatening many of our most iconic ecosystems.

Health and well-being: While both cold and hot weather cause pre-mature deaths, climate change is increasing the risk of heat-related deaths (Barnett 2015). Of all extreme weather events, extreme heat is by far the biggest cause of death amongst Australians. The Melbourne heatwave of 2009, for example, led to an estimated 374 excess deaths, and led to steep peaks in demand for health services.

An estimated 2,900 Australians have died from extreme heat from 1890 to 2013, more than the deaths from bushfires, tropical cyclones, earthquakes, floods and severe storms combined (DIT 2013). Heatwaves affect health and well-being in many other ways. For example, absenteeism and reduction in worker productivity during the extreme heat of the 2013/14 summer resulted in losses of about $8 billion to the Australian economy. Hot weather also increases the frequency of work accidents because of lapses in concentration, and leads to poor decision-making and higher levels of fatigue (Morabito et al. 2006; Tawatsupa et al. 2013; Tamm et al. 2014).

Figure 14: South Australia in drought in 2008. Severe and prolonged drought can exacerbate mental health problems amongst farmers and social problems in rural communities.

Other types of extreme weather damage health and well-being. Bushfires are particularly damaging, with impacts on both physical and mental health (Johnston 2009). In addition to fatalities, bushfires affect health through the respiratory irritants and inflammatory and cancer-causing chemicals in smoke (Bernstein and Rice 2013). Heavy rainfall and flooding lead to death from drowning, and create other health risks, such as contamination of drinking water and food as well as making access to health services more difficult (Lane et al. 2013). Intense storms can also damage health, as shown by Melbourne's 'thunderstorm asthma' event in November 2016 that was responsible for nine deaths and over 8,500 hospitalisations (ABC 2017).

Security: Perhaps the most under-appreciated yet potentially devastating risk of climate change is the threat to global security. Our current globalised society has been built and optimised to the patterns of water availability and temperature that have existed in the relatively stable climate of the last several thousand years. That climate is being destabilised at an alarming rate, acting as a threat multiplier that can exacerbate existing tensions and points of conflict. The Middle East is a good example. The severe drying of the Mediterranean, with a strong link to climate change (Hoerling et al. 2011), has likely contributed to the ongoing crisis in Syria, as well as to the food-energy crisis of 2008 (Homer-Dixon et al. 2015). In a worst-case scenario, climate change could throw the world into chaos, conflict and misery for decades, dwarfing the current concerns over migration and terrorism. According to Brigadier-General (ret) King of the US Army: Climate change is "like getting embroiled in a war that lasts 100 years.... There is no exit strategy" (Climate Council 2015).

Economy: Bushfires are amongst the costliest of extreme weather events (Table 3), with the damages of the 2009 Black Saturday fires in Victoria estimated to be about $4 billion in total (Teague et al. 2010), with $1.3 billion in insured losses (ICA 2013). Drought can also have large economic impacts. The drought-driven decrease in agricultural production between 2002 and 2003 resulted in a 1% reduction in the nation's Gross Domestic Product and a 28.5% drop in the gross value-added for the industry (ABS 2004). Intense storms such as Category 4 and 5 tropical cyclones often pack a big economic punch. Cyclone Yasi, for example, caused over $2 billion in damages to the tourism and agricultural industries in Queensland (QRA and World Bank 2011).

Increased coastal flooding from rising sea level has the potential to drive profound economic damages. About $226 billion in commercial, industrial, transport and residential assets around the Australian coastline are potentially exposed to flooding and erosion with a 1.1 m rise in sea level (DCCEE 2011), a rise that looks more and more plausible the more we learn about instabilities in the Antarctic ice sheets (DeConto and Pollard 2016). Globally, by 2050 the costs of coastal flooding could rise to $US 1 trillion per year (Hallegatte et al. 2013), and by 2100 the economic losses from coastal flooding are estimated to be 0.3-9.3% of global GDP per year (Hinkel et al. 2014), the high-end projection being a scenario for global economic collapse.

Rural communities: Often lacking the emergency and health services of urban Australia, rural communities are especially vulnerable to the impacts of climate change. Increasing drought conditions exacerbate mental health problems and increase suicide rates, particularly among male farmers (Alston 2012). The extreme rainfall of 2010/2011 resulted in 78% of Queensland being declared a disaster area. Many rural communities were isolated for long periods of time, cutting off health and other services. Bushfires also pose a significant threat to rural Australia. The Black Saturday fires that roared through rural Victoria on 7 February 2009 left 174 people dead and 414 injured, as well as destroying 2,029 homes (PoV 2010; Figure 15).

Tourism: Climate change poses a large threat to much of Australia's tourism industry by damaging the natural assets on which it is based. The most economically serious threat is to GBR-based tourism, which is worth $6.4 billion annually to Australia's economy and supports 64,000 direct and indirect jobs (Deloitte Access Economics 2017). Other major nature-based tourism areas at risk include Uluru, where extreme heat is projected to increase (CSIRO and BoM 2015), and Kakadu, where salt-water intrusion from sea-level rise will affect the extensive freshwater wetlands (Finlayson et al. 2009).

Figure 15: Destruction in the Kinglake region from the Black Saturday bushfires in February 2009.

Natural ecosystems: Ecosystems and wildlife across the continent are feeling the heat from climate change. Flying foxes are particularly susceptible to extreme heat, with more than 45,000 flying foxes killed on just one extremely hot day in southeast Queensland in 2014 (Welbergen et al. 2014). Extreme heat has also taken its toll on birds. A severe heatwave in Western Australia in January 2009 caused the deaths of thousands of birds, mainly zebra finches and budgerigars (McKechnie et al. 2012). A year later over 200 endangered Carnaby's Black Cockatoos were killed by extreme heat (Saunders et al. 2011). In the hot summer of 2016 over 20 fires, many of them occurring in areas that had never previously experienced fire, affected ecosystems across many regions of Tasmania, including the killing of trees such as king billy and pencil pines, some over 1,500 years old (The Sydney Morning Herald 2016).

However, there are no other impacts on natural ecosystems that can compare with the climate change-driven devastation on the Great Barrier Reef (GBR) in 2016 and 2017 (Figure 16). The back-to-back coral bleaching events are unprecedented, with the record-breaking ocean temperatures of 2016 driving 67% coral mortality in the 1,000 km-long northern section of the reef (CoECSS 2016). Just a year later, another deadly heatwave struck the GBR, this time driving severe bleaching on the central section (GBRMPA 2017; Climate Council 2017i). Unless emission reduction efforts are ramped up quickly towards meeting the Paris targets, the future of the GBR looks grim (Hughes et al. 2017).

Figure 16 (a): When healthy coral is stressed from extreme ocean temperatures, it becomes bleached. Corals can recover from an isolated bleaching event, but when the bleaching is too frequent or too severe, the corals die **(b)**.

5.3 Medium to Long-term Risks

The impacts that we are experiencing now at a ~1°C rise in average temperature are the forerunners of rapidly escalating risks as the temperature rises towards 2°C and beyond. An overview of these risks – worsening extreme weather, damage to natural ecosystems, disproportionate impacts on the poor and vulnerable – is given by the 'burning embers diagram' of the Intergovernmental Panel on Climate Change (IPCC). The series reveals a striking trend – as the science of climate impacts advances, severe impacts are now expected at more modest increases in temperature (Box 3). Importantly, the burning embers approach dispels the myth that a 2°C rise in global average temperature is a 'safe' level of climate change.

Another common problem is the failure to understand that climate impacts increase much faster than temperature increases. The impacts of climate change don't just increase in proportion to the rise in global average temperature. New studies warn that a warming of 2°C in Australia could lead to extreme temperatures of 3.2°C above those experienced now at ~1°C above pre-industrial levels. In reality, we are likely to experience a nearly three-fold acceleration of extremes compared to changes in average temperatures. This could lead, for example, to record high temperatures of 50°C in Sydney or Melbourne by 2040-2050 under just a 2°C rise in average temperature (Lewis et al. 2017).

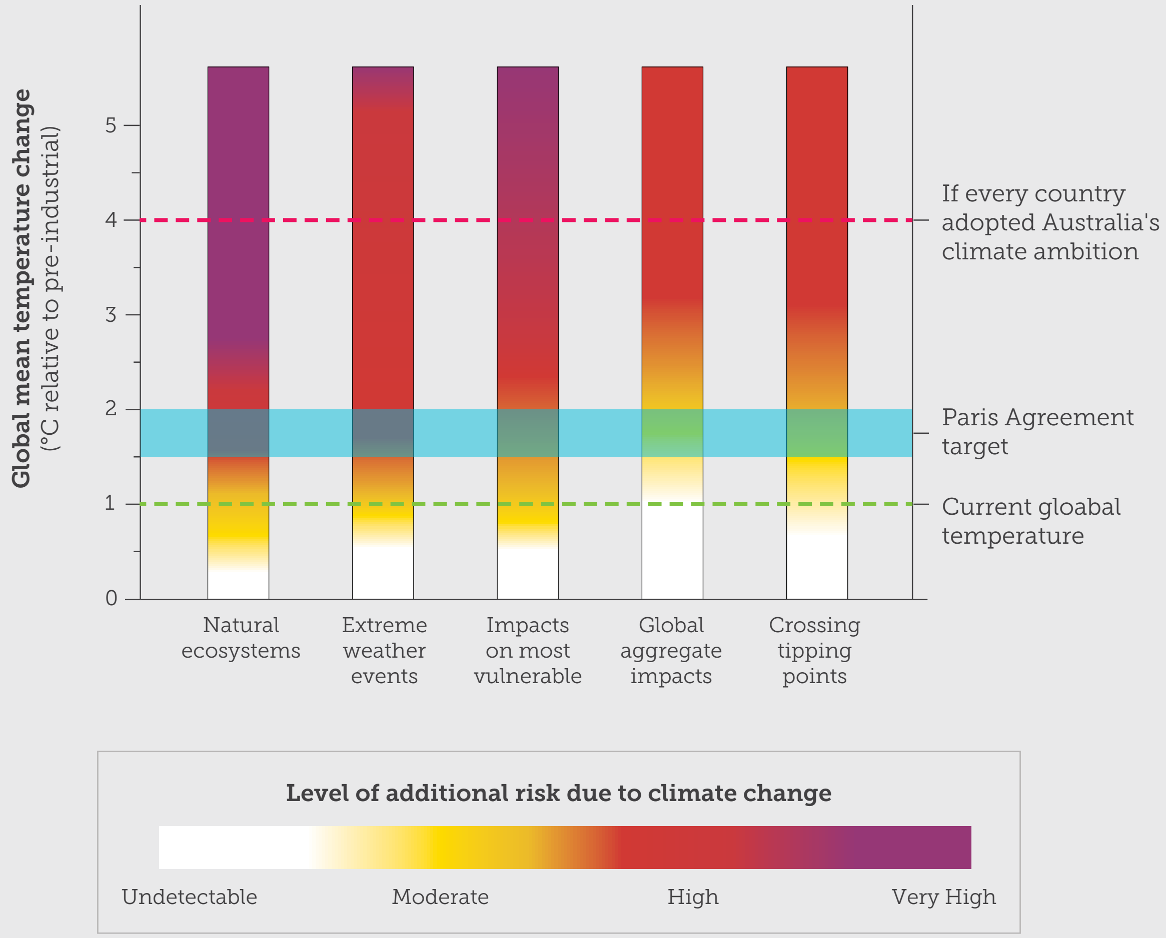
Modest rises in global average temperature could also lead to the crossing of 'tipping points' in ecosystems or parts of the physical climate system, where surprisingly rapid and often irreversible changes can occur with a small increase in temperature (Lenton et al. 2008; Figure 18). Examples include coral reefs, the Greenland ice sheet, Siberian permafrost and North Atlantic Ocean circulation (Figure 18). We are already witnessing the crossing of a tipping point here in Australia – extended periods of increases of 1 or 2°C in water temperature over the Great Barrier Reef have changed bleaching from sporadic and isolated to massive, widespread and with high rates of mortality (Hughes et al. 2017). Several other tipping points, in addition to coral reefs, are vulnerable to tipping within the Paris range of temperature rise (Schellnhuber et al. 2016).

BOX 3: THE 'BURNING EMBERS' ANALYSIS OF IMPACTS

The IPCC uses a synthesis of thousands of peer-reviewed scientific papers to assess the degree of risk at increasing levels of global average temperature. These risks are illustrated in Figure 17.

- There is a significant difference in the degree of risk between the 1.5°C and 2.0°C Paris targets, with higher risks of damage to natural ecosystems and more intense and/or frequent extreme weather events for the 2.0°C target.
- At a 2.0°C temperature rise, there is a high level of risk for 3 of the 5 categories – impacts on natural ecosystems, extreme weather events, and impacts on the most vulnerable. That is, a 2.0°C temperature rise is not a "safe" level of climate change.
- A 4.0°C temperature rise (business-as-usual) would lead to a vastly different world, with very high risks to many natural ecosystems and highly damaging impacts on the most vulnerable.

Figure 17: The IPCC "burning embers diagram" – the reasons for concern about the impacts of climate change with increasing global temperature (adapted from IPCC 2014).



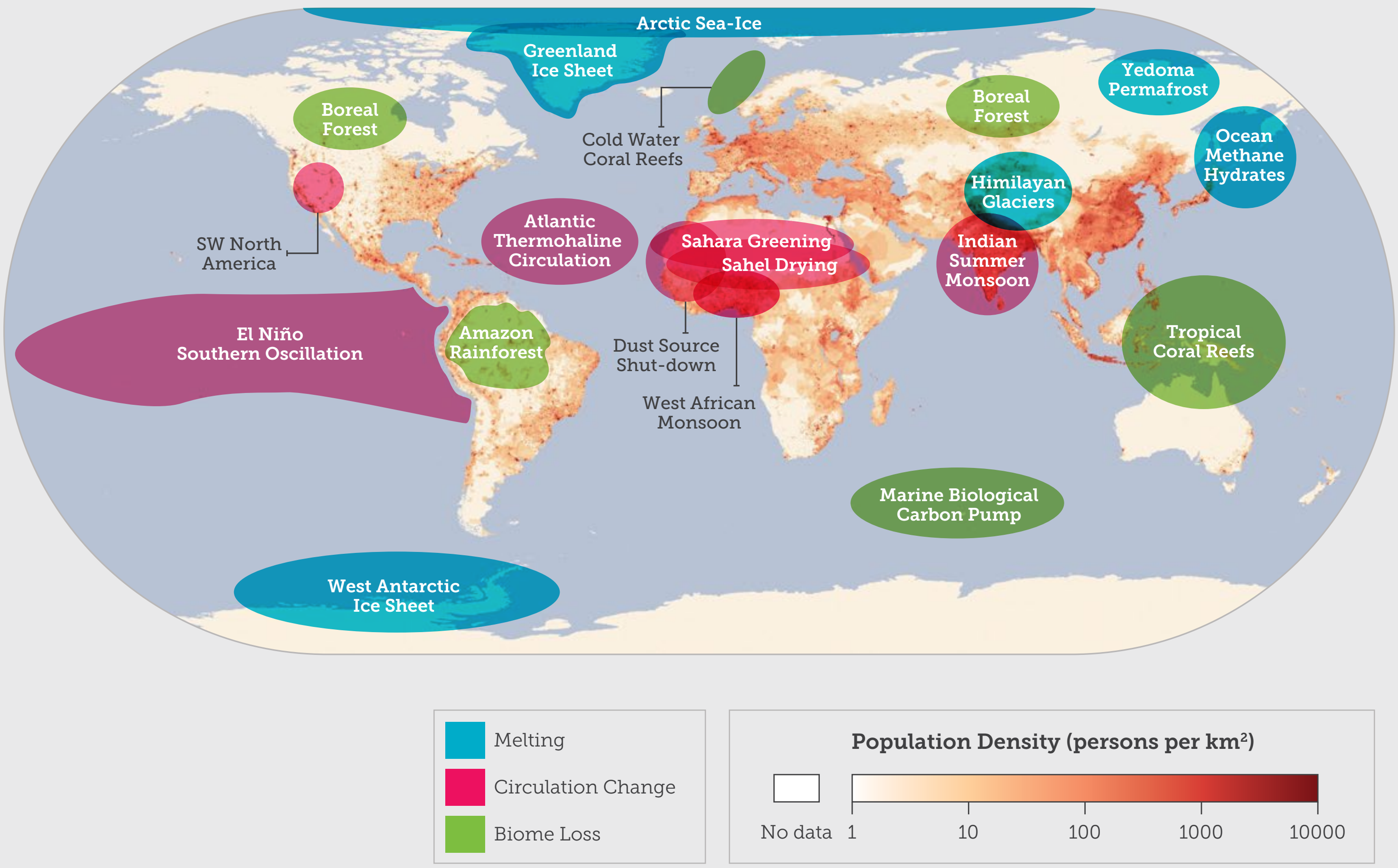


Figure 18: Map of where potential climate tipping points may occur around the world, overlain with global population density. Red indicates major changes in atmospheric and oceanic circulation; blue indicates the melting of ice sheets, glaciers and sea ice, and the thawing of frozen soils and sediments; and green indicates the loss of large terrestrial and marine biomes. As the map indicates, significant tipping points could occur in densely populated regions across the globe. **Source:** Adapted from Lenton et al. 2008.

A business-as-usual trajectory of emissions would take the Earth towards a 4°C rise, triggering most of these tipping elements and leading to a vastly different climate that would be very difficult for humans to prosper in. Collapse of global society could not be ruled out, and the Earth would likely experience its sixth great extinction event.

Tipping points do not act in isolation. Some of them trigger significant emissions of CO_2 and CH_4 to the atmosphere, above and beyond direct human emissions, which would accelerate global warming and increase the vulnerability of other tipping points.

'Tipping cascades' could result, which in a worst-case scenario could take the trajectory of the climate system out of human control and towards a 4°C warming or greater over coming centuries. There is thus a credible risk that a tipping cascade, initially triggered by human emissions that on their own could lead to only a 2°C temperature rise, or slightly more, could still eventually lead to a much hotter Earth, and to societal collapse and to a great extinction scenario.

The bottom line is clear. The more we learn about climate change, the riskier it looks.

Extreme temperatures will become even more extreme.

6. Putting the Pieces Together

More than three-quarters of the way through the Critical Decade, the climate change landscape looks vastly different than it did in 2011 when the forerunner of the Climate Council – the Climate Commission – published its first Critical Decade report.

Time is running out to avoid dangerous climate change.

The science of climate change has advanced enormously, and it is an unassailable fact that human emissions of greenhouse gases, primarily from burning fossil fuels, are driving rapidly increasing temperatures.

The risks of climate change are now coming into much sharper focus, and the evidence of its damaging impacts are there for all to see. With just a 1°C rise in global average temperature, the severity and frequency of many extreme weather events are increasing, the great polar ice sheets on Greenland and Antarctica are melting at increasing rates, and some of world's most treasured ecosystems, such as the Great Barrier Reef, are being battered towards extinction by intensifying heatwaves.

Despite the accelerating global action to tackle climate change, the task looks more challenging than previously thought.

Missing the 2°C Paris target and heading for a 3°C or 4°C world is looking much riskier the more we learn. Direct impacts from changing rainfall patterns, accelerating sea-level rise and worsening extreme weather will escalate the risks of starvation, massive migration and conflict as some agricultural zones collapse and coastal infrastructure is inundated. Worse yet, some tipping points in the climate system could be crossed at ~2°C, and more at higher temperatures, driving even more severe warming and taking the trajectory of the climate system out of human control.

These extremely serious risks, recognised by the world's leaders in 2015, informed the more ambitious Paris target "...to limit global average temperature rise to well below 2°C and to pursue efforts to limit warming to 1.5°C." The Paris climate agreement, however, is the most recent in a two-decade-long series of agreements and strategies, building on advances in climate science, that have attempted to slow climate change but with no demonstrable success yet.

Time is rapidly running out for humanity to avoid the extremely serious risks of a 2°C or warmer world. Analyses of the steps needed to meet the Paris target show that global emissions must have peaked by 2020. Even peaking emissions by 2016 would mean that the entire global economy would need to reach net zero emissions in only 25 years from now. Delaying peak emissions to 2025 would leave too little time to transform the economy; the world would be locked into a very dangerous future (Rockström et al. 2017; Figureres et al. 2017; Figure 19).

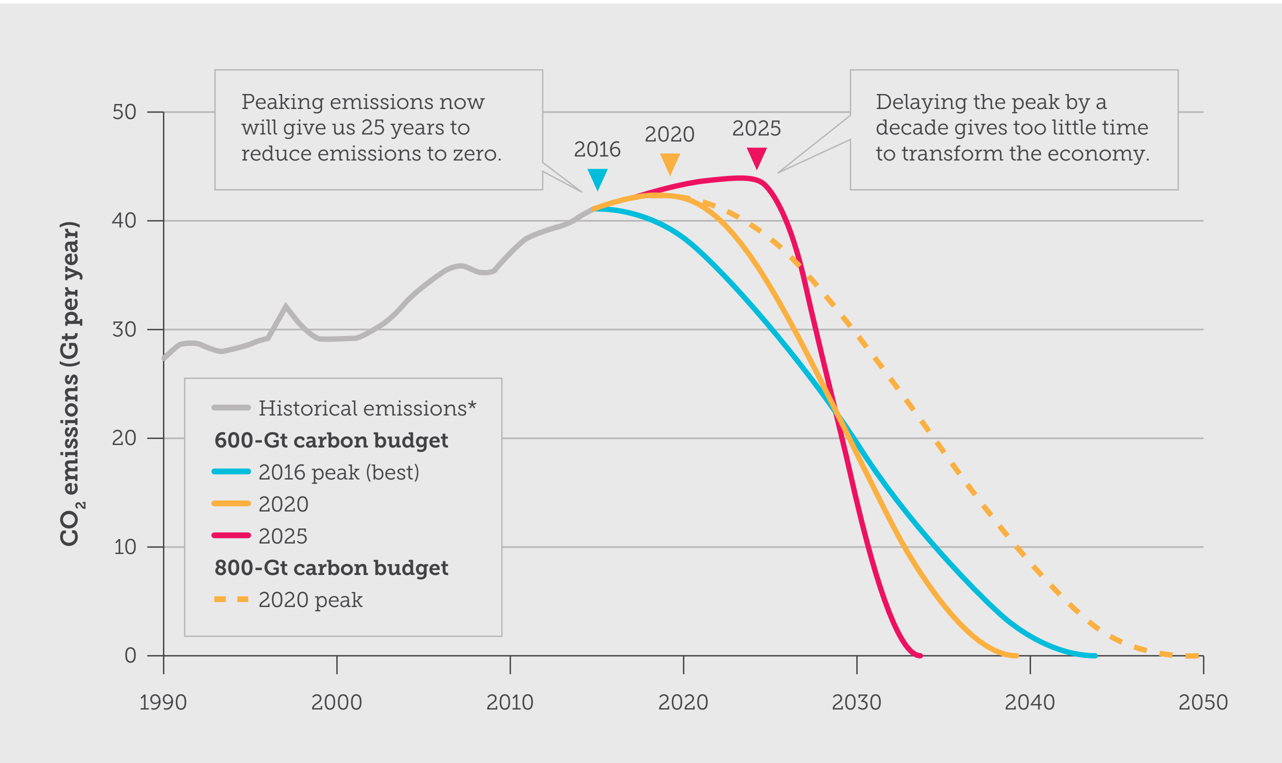


Figure 19: Emission reduction trajectories for meeting the Paris target(s). The year of peak emissions has an enormous effect on the steepness of the subsequent trajectory. Delaying peak emissions to 2025 is too late for any achievable emission reduction trajectory. **Source:** Figueres et al. 2017.

Reducing emissions delivers strong economic and social benefits.

This is indeed the critical point in the Critical Decade.

Decisions we make in the next two years could well determine whether or not our children and grandchildren will have a fighting chance for a bright future or will be scrambling to survive in a disintegrating and increasingly dangerous global society trying to cope with chaotic, rapidly changing climatic conditions that are unprecedented in the history of human existence. Emissions must be trending downwards by 2020 to give us a reasonable chance to avoid the worst scenarios.

Against this backdrop of escalating risks and extreme urgency for action, there are signs of hope on the horizon. The rapid rise of renewable energy around the world and the increase in energy efficiency in many economies are giving us a chance to limit temperature increase to 2°C or less. Emissions from the world's two biggest polluters – China and the United States – have dropped in the last year or two, and global emissions appear to have flat-lined even while economic development has continued.

Pathways for emission reduction show that such a rapid transformation of the global economy is not only achievable, but also yields large economic and social benefits (e.g. Rockström et al. 2017; Figueres et al. 2017). But we must decisively move onto these pathways now – not five or 10 years in the future. Yet, despite the overwhelming evidence for action, politics, ideologies and vested interests still stand in the way.

Nowhere is this tension between the need for urgent action and ideologically-driven denialism and inaction more evident than in Australia.

While the health of Australians suffers from worsening extreme weather and the world's most iconic marine ecosystem, the Great Barrier Reef, is hammered by climate change, some members of the Federal Government are pushing for 'clean coal', world-leading climate scientists are sacked, and science-based information is censored from a UNESCO report. Furthermore, fossil fuel businesses and advocates promote expansion of gas and coal production, ignoring the limits of the carbon budget.

Australia has no leadership, no national plan, no vision and no coherent policies.

Leadership at all levels of government is required to tackle climate change effectively.

After a decade of rancorous and divisive federal politics, we have no credible pathway for reducing emissions in our economy over the next two-three decades. In short, there is no leadership, no national plan, no vision, and no coherent policies.

Those who claim that the emission reduction task is so huge and difficult that it is impossible need to be reminded that "...impossible is not a fact, it's an attitude" (Figueres et al. 2017).

Fortunately, there are many Australians working at the sub-national level who are showing that "the impossible" is not only achievable, it is also desirable and is happening much faster than many thought possible.

Australia is a world leader in the uptake of household solar, and industrial-scale solar systems are being rolled out at an increasing rate. Wind energy is becoming a major source of electricity in Australia's populous southeast.

South Australia already generates nearly 50% of its electricity from renewables, and is moving forward on energy storage technologies, including the development of the world's largest lithium-ion battery. The Australian Capital Territory will be 100% renewable by 2020, and aims to reach net-zero emissions in its entire economy by 2050 at the latest. Such action at the state level shows that meeting the climate change challenge is not at all impossible, but with strong, 'can-do' leadership, the task of meeting the Paris targets can indeed be achieved.

The next few years – the last quarter of the Critical Decade – will be decisive. Can we overcome the obstacles to effective action on climate change and cross a political/social tipping point that puts Australia and the world firmly and irreversibly on a rapid path to net-zero emissions? The pathway may be bumpy, but it is becoming clearer and more achievable (Figueres et al. 2017):

"There will always be those who hide their heads in the sand and ignore the global risks of climate change. But there are many more of us committed to overcoming this inertia. Let us stay optimistic and act boldly together."

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