

4 Not on Track to Hold Global Warming to 1.5°C

4.1 The World

119) This section analyses whether or not the world is on track to hold global warming to 1.5°C, using several different measures.

4.1.1 Paris Agreement pledges and the IPCC conditions to meet 1.5°C

120) The UNFCCC Paris Agreement¹⁰⁸ commits signatories to “keeping a global temperature rise this century *well below* 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C [emphasis added].” Signatory nations have made separate Nationally Determined Contributions (NDCs) as a step to meet these goals.

121) In late 2019, it was estimated that the 2019 NDCs, if achieved, would result in global warming by 2100 of 2.9°C—3.4°C relative to pre-industrial levels, increasing thereafter.¹⁰⁹

122) After many countries updated their NDCs in 2020, an update by Climate Action Tracker,¹¹⁰ estimates warming between 2.1°C and 3.3°C could result from current commitments — if honoured — still falling far short of the Paris Agreement targets, though slightly improved (see Fig. 11).

123) Aggravating this state of affairs, most nations are not on-track to meet their current commitments, which if not corrected immediately, would result in even more warming. In fact, based on current policies as opposed to pledges, Climate Action Tracker estimates that warming could go as high as 3.9°C (see Fig. 11).¹¹¹

¹⁰⁸ UN (2015), Paris Agreement, Accessed from https://unfccc.int/sites/default/files/english_paris_agreement.pdf

¹⁰⁹ WMO 2019, United in Science, Report prepared for the UN Climate Action Summit 2019, <https://wedocs.unep.org/bitstream/handle/20.500.11822/30023/climsci.pdf>

¹¹⁰ Climate Action Tracker (2020), <https://climateactiontracker.org/> Accessed 22 Jan 2021.

¹¹¹ Climate Action Tracker (2020), <https://climateactiontracker.org/> accessed 22 Jan 2021.

124) In its early 2021 analysis,¹¹² the UNFCCC notes that even after consideration of the 48 new or updated NDCs submitted by 31 December 2020, the total GHG emissions of the Parties to the Paris Agreement is expected to be only 2.1% lower in 2030 than in 2017, falling “far short” of pathways consistent with holding global warming to 1.5°C.

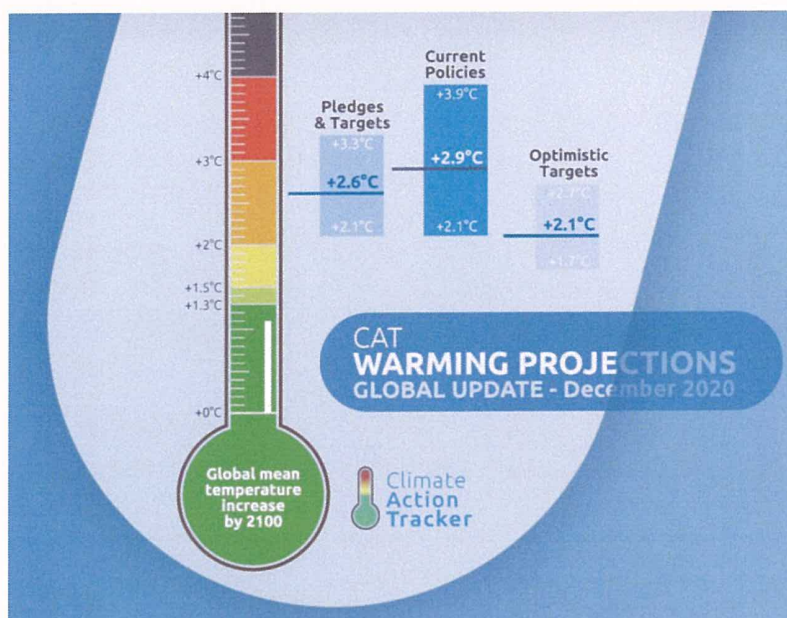


Fig. 11: Global warming projections based on pledges and policies of global nations. (Climate Action Tracker, Dec 2020 analysis).

125) In its report “Global Warming of 1.5°C”¹¹³, the IPCC studied emissions pathways that *could* hold global average temperature at 1.5°C above pre-industrial levels (taken to be during the period 1850-1900). **Successful 1.5°C pathways not only reached net zero around 2050, but by 2030 also reduced net CO₂ emissions by about 45% compared to 2010 levels.** Furthermore, the **successful 1.5°C pathways studied in the SR1.5 report also involved deep reductions in the methane and black carbon** (small particulate carbon analogous to soot) — **specifically a reduction of at least 35% by 2050 on 2010 levels.**¹¹⁴ **These three targets must be achieved in parallel** in order to ‘pass’ what this report will call the ‘IPCC SR1.5 three-part test’ for holding global warming to 1.5°C.

¹¹² UNFCCC (2021) Synthesis Report: Nationally determined contributions under the Paris Agreement, Accessed at: <https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-determined-contributions-ndcs/ndc-synthesis-report>

¹¹³ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/> SPM p(12)

¹¹⁴ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/> SPM p(12)

- 126) As described in Section 3.2, human emissions of greenhouse gases continue to rise from all fossil fuel sources (Fig. 3), leading to increasing levels of greenhouse gases in the atmosphere (Fig. 1). There is **no indication that the world is on track to reach net zero emissions by 2050.**
- 127) As net global anthropogenic CO₂ emissions in 2010 (from all sources, including land use) totalled about 34.8 Gt CO₂ (WRI 2020),¹¹⁵ a 45% reduction would require the world to be emitting no more than about 19 Gt CO₂ by 2030. At the moment, net global CO₂ emissions are rising, albeit with a small drop of about 7% in 2020 due to COVID-19.¹¹⁶ Thus, **the world is not on track to reduce CO₂ emissions by 45% of 2010 levels by 2030.**
- 128) As global methane emissions are rising, and since 2012 have been, in fact, tracking the warmest scenarios assessed by the IPCC,¹¹⁷ **the world is not on track to reduce methane emissions at least 35% on 2010 levels by 2050.**
- 129) Consequently, using the IPCC SR1.5 three-part test as the measure, **the world is not on track to holding average global warming to 1.5°C above pre-industrial levels.**

4.1.2 The World's 'Carbon Budget'

- 130) In order to stabilise the climate at a certain average global temperature, human greenhouse gas emissions must at some point drop to net zero. The maximum temperature reached is determined by cumulative net global anthropogenic CO₂ emissions up until the time of net zero CO₂, and by the level of non-CO₂ radiative forcing in the decades just prior.
- 131) **The 'carbon budget approach' is a conceptually simple and scientifically sound method to estimate the speed and magnitude by which emission reductions must occur**

¹¹⁵ World Resources Institute (WRI) (2020) Climate Watch Historical GHG Emissions 2020. Available online at: <https://www.climatewatchdata.org/ghg-emissions>

¹¹⁶ Friedlingstein, P et al. (2020) Global Carbon Budget 2019, Earth Syst. Sci. Data, 12, 3269-3340, <https://doi.org/10.5194/essd-12-3269-2020> Table 6 on p3292.

¹¹⁷ Saunio, M. et al. (2020) The Global Methane Budget 2000 – 2017, Earth System Sci. Data, 12, 1561, <https://doi.org/10.5194/essd-12-1561-2020>

in order to meet a desired warming target,¹¹⁸ focussing on CO₂ as the primary greenhouse gas. This approach is used by the IPCC,^{119,120} and was adopted by the Climate Change Authority to form its 2014 recommendations¹²¹ for Australia.

132) The manner in which CO₂ moves through the land, ocean and atmosphere is complex, but the full effect of these processes yields an **approximately linear relationship** (see Fig. 12, taken from the IPCC SR1.5)¹²² **between:**

- a) The 'carbon budget': that is, the cumulative amount of carbon¹²³ emitted from human actions since the beginning of industrialisation (often taken to be about 1870), and
- b) The increase in average global surface temperature since that time.

133) The **budget is not annual, but cumulative: for all time—past, present and future. Once the carbon budget has been 'spent' (emitted as greenhouse gases), emissions must be held to net zero**¹²⁴ from that point onward to avoid exceeding the target temperature. Carbon emissions budgets are generally calculated in either billions of tonnes of carbon (GtC) or billions of tonnes of CO₂ (Gt CO₂). 1Gt CO₂ contains 0.273 GtC.

134) Several assumptions influence the size of the global carbon budget for a given warming target. Key among them are:

¹¹⁸ Collins, M. et al. (2013) Long-term climate change: Projections, commitments and irreversibility, in Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by Stocker et al. Cambridge University Press, pp. 1029-1136.

¹¹⁹ Collins, M. et al. (2013) Long-term climate change: Projections, commitments and irreversibility, in Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by Stocker et al. Cambridge University Press, pp. 1029-1136.

¹²⁰ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/> SPM p(12)

¹²¹ CCA (Climate Change Authority) (2014) Reducing Australia's Greenhouse Gas Emissions: Targets and Progress Review—Final Report, <https://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3>

¹²² IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/> Figure 2.3.

¹²³ NB: Carbon budget numbers presented here are measured in the weight of carbon emissions, not carbon dioxide. CO₂ weighs more than the carbon it contains. CO₂-e, carbon dioxide equivalent, counts greenhouse gases whose effects have already been tallied in the budget.

¹²⁴ NB: The term 'net zero' used here means that CO₂ emissions *into* the atmosphere are matched in magnitude by CO₂ removal *from* the atmosphere. Carbon capture and storage and many other 'Negative Emission Technologies' are not yet viable at scale.

- a) What is considered an 'acceptable' probability of meeting the target,
- b) The date period used for 'pre-industrial,'
- c) The accounting of other greenhouse gases (particularly CH₄ and N₂O),
- d) Whether or not 'temporary overshoot' of the desired warming target is allowed, and
- e) If, and how, carbon feedbacks in the climate system are accounted. Carbon feedback occurs when warming causes the Earth to release some of its own sequestered CO₂.

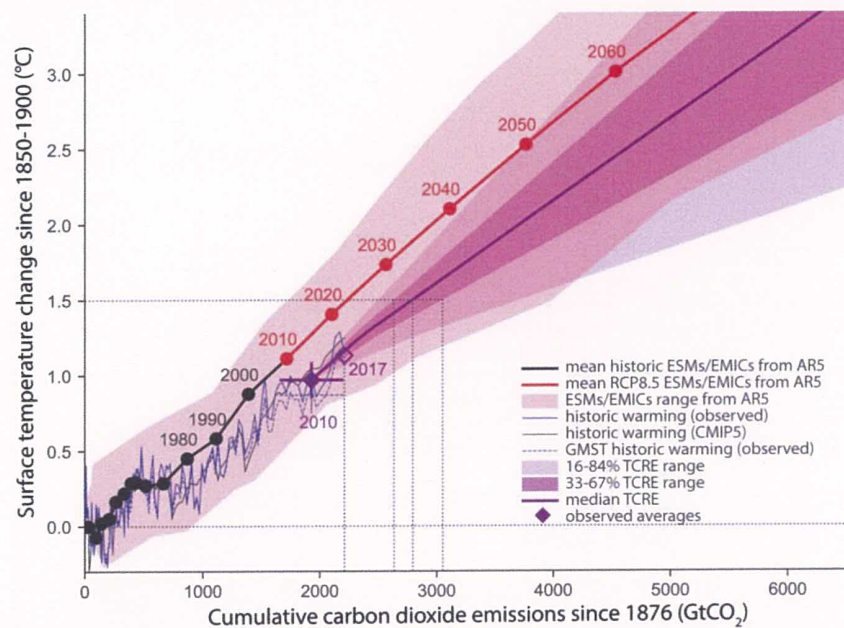


Fig. 12: Relationship between warming (vertical) and total carbon dioxide emitted (horizontal).

135) Here, a conservative, precautionary application of these assumptions is used to determine a carbon budget for a 1.5°C scenario. The approach is precautionary in that: no temperature overshoot is allowed, feedbacks are included, the period 1850-1900 is taken as the 'pre-industrial' era, the effects of other greenhouse gases are included, and at least a 50% probability of staying below the 1.5°C target is required. Furthermore, untested massive new carbon capture and storage ventures are not relied upon to offset continuing emissions. In this sense, it is similar to the 'P1' pathway presented in the IPCC SR1.5 report,¹²⁵ which had its focus on a 1.5°C warming limit.

¹²⁵ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

136) The goal is to ascertain the **remaining amount of carbon** (in the form of CO₂) **that humans can still release** into the atmosphere **without exceeding average global warming of 1.5°C**. This remaining 1.5°C carbon budget, the amount humans have ‘left to spend,’ is **much less than the total carbon budget, for three reasons**.

- a) First, substantial historical emissions from pre-industrial times through 2020 have already been emitted, and must be subtracted from the total budget, to arrive at the amount remaining.
- b) Second, implicit in simple budget estimates is the assumption that future non-CO₂ emissions will be reduced to zero at the same rate that CO₂ is diminished. This will be difficult to achieve, since about half of the anthropogenic CH₄ and N₂O emissions arise from the agricultural sector, where emission reductions are generally considered to be more difficult and expensive than in other sectors, especially with growing population.
- c) Third, some carbon cycle feedbacks, such as the abrupt shift of the Amazon rainforest to a savanna, are not accounted for in some carbon budget approaches, and require the budget to be reduced further.^{126,127} These feedback processes are underway.

137) In its special 1.5°C report,¹²⁸ the IPCC updated its carbon budget analysis from that presented in earlier work.¹²⁹ Estimates of climate sensitivity, pre-industrial temperature levels and treatment of aerosol emissions, which lead to a net cooling effect, were revised. Carbon budgets for a 50% chance and for a stricter 66% chance of holding warming to 1.5°C were presented.

138) Subsequently, a study taking into account non-linearity (deviation from a straight line in Fig. 12) in the carbon budget-warming relationship and including most carbon

¹²⁶ Ciais P et al. (2013) Carbon and Other Biogeochemical Cycles, in Climate Change 2013: The Physical Science Basis, Fifth Assessment Report of the IPCC, edited by Stocker TF, et al., Cambridge University Press, pp. 465–570, doi:10.1017/CBO9781107415324.015.

¹²⁷ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Appendix <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

¹²⁸ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

¹²⁹ Ciais P et al. (2013) Carbon and Other Biogeochemical Cycles, in Climate Change 2013: The Physical Science Basis, Fifth Assessment Report of the IPCC, edited by Stocker TF, et al., Cambridge University Press, pp. 465–570, doi:10.1017/CBO9781107415324.015.

feedbacks¹³⁰ from interacting climate models, indicated that the SR1.5 carbon budgets may need to be revised upward, i.e., more carbon may be able to be emitted for the same warming outcome.

- 139) The results for **remaining global carbon budgets presented in Table 1** are based on these recent analyses (see footnoted references in the table) **for staying within a 1.5°C warming threshold, using the precautionary assumptions noted above.**

Table 1: Updated, 'precautionary' carbon budget to limit global warming to 1.5°C, rounded to the nearest 5 Gt CO₂

Budget Item	Global (Gt CO ₂) for 1.5°C (>66% chance)	Global (Gt CO ₂) for 1.5°C (>50% chance)
Base Budget (beginning 1 Jan 2018 (IPCC SR1.5)). ¹³¹ Historical emissions pre-2018 have already been deducted.	420	580
Historical emissions for 2018 through 2020. Taken as 11.5 GtC for years 2018 & 2019, and estimated at 10.6 GtC for 2020, ¹³² and converted to Gt CO ₂	-125	-125
Additional non-CO ₂ greenhouse gases allowance (Precautionary estimate to allow for missed CH ₄ agricultural reduction. ¹³³)	-35	-35
Correction due to non-linearity and some carbon feedbacks (see Nicholls et al. 2020) ¹³⁴ .	+70	+70
Carbon feedbacks not included ^{135,136} in Nicholls et al. 2020.	-120	-120
Remaining Budget to Net Zero Emissions	210	370

¹³⁰ Nicholls, ZRJ et al. (2020) Implications of non-linearities between cumulative CO₂ emissions and CO₂-induced warming for assessing the remaining carbon budget, Environ. Res. Letter, 15, 074017, <https://doi.org/10.1088/1748-9326/ab83af>

¹³¹ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/> Table 2.2 on p107.

¹³² Friedlingstein, P et al. (2020) Global Carbon Budget 2019, Earth Syst. Sci. Data, 12, 3269-3340, <https://doi.org/10.5194/essd-12-3269-2020> Table 6 on p3292.

¹³³ The IPCC SR1.5 no overshoot 'P1' pathway assumes CH₄ emissions from agriculture decline by 33% on 2010 levels by 2050. If this does not occur, e.g., due, to increased population, this lost CH₄ reduction will need to come from the CO₂ budget.

¹³⁴ Nicholls, ZRJ et al. (2020) Implications of non-linearities between cumulative CO₂ emissions and CO₂-induced warming for assessing the remaining carbon budget, Environ. Res. Letter, 15, 074017, <https://doi.org/10.1088/1748-9326/ab83af>

¹³⁵ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Supplementary material. <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

¹³⁶ Will Steffen, private communication (2020). Carbon feedbacks not accounted for in the models used by Nicholls et al. (2020) are: ocean bacterial respiration, and Amazon and boreal forest dieback. Here, feedbacks are reduced by half to estimate the effect at 1.5°C, not 2°C as in Steffen et al (2018).

- 140) Large uncertainties are attached to some of the quantities in Table 1 that could push numbers higher or lower, but given that **current global emissions are about 40 GtCO₂ (11 GtC) annually**,¹³⁷ the results in Table 2 show that for **at least a 50% chance of holding warming to 1.5°C, the world's carbon budget could be expended in five to nine years at current emission rates**. The odds of holding warming to 1.5°C would then drop below 50%, odds worse than the flip of a coin.
- 141) **If world CO₂ emissions were to drop linearly starting in 2021 until net carbon emissions were reached**, these precautionary 1.5°C carbon budgets could stretch out twice as long, but **net zero would still need to be reached by about 2035**. A linear drop of this magnitude is challenging, as it would require reductions similar to that caused by COVID-19 restrictions every year to net zero.
- 142) It is worth noting that, due to natural fluctuations, the world may soon experience years in which the global average temperature exceeds 1.5°C of warming. Work led by the UK Met Office shows **there is a 20% chance that the world will see global average 1.5°C warming (at least temporarily) in the next 5 years**.¹³⁸ While this possibility is primarily related to natural fluctuations, it is conceivable, given feedbacks in the Earth system, that such fluctuations may lead to an additional permanent increase in the long-term average temperature.

4.1.3 Largest Driver of Missing the 1.5°C target: The Fossil Fuel Production Gap

- 143) A recent economic analysis **based on only a 50% chance of achieving 2°C** concluded that **a third of oil reserves**,¹³⁹ **half of gas reserves and over 80% of coal reserves** (as defined in 2015) **should remain unused** from in the period from 2010 to 2050 **in order to meet a warming target of 2°C**, above Paris Agreement goals.¹⁴⁰

¹³⁷ Friedlingstein, P et al. (2020) Global Carbon Budget 2019, *Earth Syst. Sci. Data*, 12, 3269-3340, <https://doi.org/10.5194/essd-12-3269-2020>

¹³⁸ WMO 2020, Global Annual to Decadal Climate Update. Accessed at: <https://hadleyserver.metoffice.gov.uk/wmolc/>

¹³⁹ Here, 'reserves' is taken to mean a subset of known resources that are defined to be recoverable under current economic conditions and have a specific probability of being produced.

¹⁴⁰ McGlade C and Ekins P (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2°C. *Nature* 517: 187-190.

144) Underscoring this point are more recent reports^{141,142} that analyse the gap between different nations' expectations for the production of fossil fuels and the Paris warming target range that the same nations support. The analysis shows that **governments are planning to produce about 50% more fossil fuels by 2030 than would be consistent with a 2°C pathway and 120% more than would be consistent with a 1.5°C pathway.**

145) The disconnect between the intention to produce more fossil fuels and the commitment to reduce emissions has been called the 'Production Gap', as shown in Fig. 13 below, taken from the latest SEI report.¹⁴³

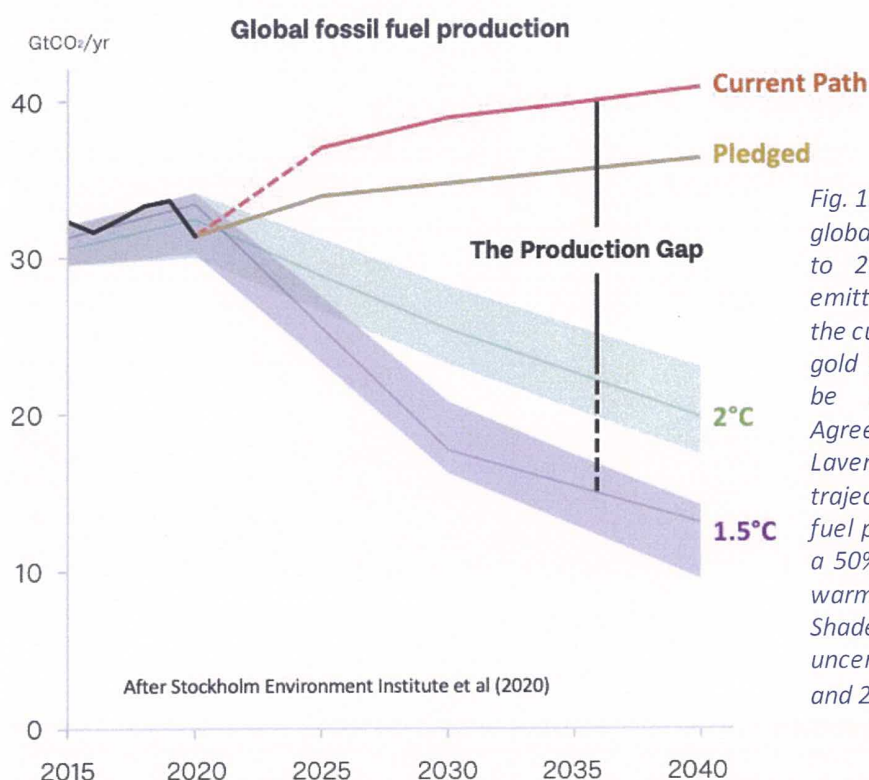


Fig. 13: Possible trajectories of global CO₂ emissions from 2015 to 2040 in units of GtCO₂ emitted in each year. In red is the current trajectory, whilst the gold line indicates what would be achieved if all Paris Agreement pledges were met. Lavender and turquoise trajectories reflect world fossil fuel production consistent with a 50% (66%) chance of holding warming to 1.5°C (2.0°C). Shaded regions indicate uncertainty ranges for the 1.5°C and 2.0°C trajectories.

146) At 2030, this gap between the world's current path in fossil fuel production and what is required for a trajectory consistent with warming of 1.5°C is about 20 Gt CO₂ (about 5.5

¹⁴¹ SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP. (2019). The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C. <http://productiongap.org/>

¹⁴² SEI, IISD, ODI, E3G, and UNEP. (2020). The Production Gap Report: 2020 Special Report. <https://productiongap.org/2020report/>

¹⁴³ SEI, IISD, ODI, E3G, and UNEP. (2020). The Production Gap Report: 2020 Special Report. <https://productiongap.org/2020report/>

Gt C) every year. **In other words, it is primarily the “overproduction” of fossil fuels that is preventing the world from being on-track to meeting a global warming limit of 1.5°C.**

147) Redressing this fossil fuel production gap cannot be met by *adding* fossil fuel development, even that which may have already planned. Instead, new fossil fuel development and expansion must cease, and ageing facilities brought to rapid close if global warming is to be halted at 1.5°C or even 2.0°C above pre-industrial times.

148) Trajectories for gas may decline slower than oil or coal to achieve the overall trajectories shown in Fig. 18, but **gas must still decline around 2020 (under a 1.5°C pathway) or around 2030 (under a 2°C pathway).**¹⁴⁴ The more time that elapses without executing this decline, the faster the decline must be to reach the desired temperature target. That is, the longer we wait, the more difficult the transition becomes.

149) As a consequence, *increasing* gas development to “replace” an equivalent amount of coal (in energy content) is not a viable approach to holding warming to well-below 2°C, let alone 1.5°C, even in the near term to 2030.

150) Furthermore, to the extent that coal or oil do not follow their 1.5°C or 2.0°C trajectories, gas will need to decline even faster. Note that what is required is reduction of the *production* of each of these fossil fuels to meet the Paris Agreement goal; ***the location* in which these fuels are combusted is of no consequence to future climate change, only the *amount* of emissions released as a result.**

151) **On each of the measures presented in Sections 4.1.1, 4.1.2, and 4.1.3, it is clear that the world is not on track to holding average global warming to 1.5°C above pre-industrial levels.**

¹⁴⁴ SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP. (2019). The Production Gap: The discrepancy between countries’ planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C. <http://productiongap.org/>

4.2 Australia

- 152) This section analyses whether or not Australia is on track to hold global warming to 1.5°C, using several different tests, which use different considerations to determine the magnitude of Australia's responsibility to reduce emissions to an overall trajectory compatible with the global 1.5°C goal.
- 153) **Australia is a signatory to the Paris Agreement**,¹⁴⁵ committed to "keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C."
- 154) Individual signatory nations have made separate Nationally Determined Contributions (NDCs) to meet the Paris goals. As a nation, **Australia's NDC is to reduce its emissions by 26%–28% (on 2005 levels) by 2030.**¹⁴⁶ Australia did not update its NDC targets in 2020, whereas many other nations did so.
- 155) **Australia's 2030 target has been rated "Insufficient"** (by Climate Action Tracker)¹⁴⁷ **to hold global warming to below 2°C, let alone 1.5°C.** If all governments were to adopt and fulfill targets like those Australia, global warming would exceed 2.0°C and could climb as high as 3.0°C. **Australia's current *emissions policy trajectory*, that is, taking into account its current policy plans, has also been rated "Insufficient."**¹⁴⁸
- 156) Expert analysis by Australia's Climate Change Authority (2014)¹⁴⁹ also judged Australia's 2030 target inadequate to meet the nation's obligations under the Paris Agreement.

¹⁴⁵ UN (2015), Paris Agreement, downloaded from

https://unfccc.int/sites/default/files/english_paris_agreement.pdf

¹⁴⁶ Commonwealth of Australia, Australia's 2030 Emissions Reduction Target Fact Sheet,

https://pmc.gov.au/sites/default/files/publications/fact_sheet-aus_2030_climate_change_target.pdf

¹⁴⁷ Climate Action Tracker (2020), <https://climateactiontracker.org/countries/australia/>

¹⁴⁸ Climate Action Tracker (2020), <https://climateactiontracker.org/countries/australia/>

¹⁴⁹ CCA (Climate Change Authority) (2014) Reducing Australia's Greenhouse Gas Emissions: Targets and Progress Review—Final Report, <https://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3>

- 157) **Moreover, Australia is not on track to meet its 2030 Paris NDC commitment.** The Government's own 2020 projections¹⁵⁰ anticipate emissions to be 478 MtCO₂-e in 2030, a reduction of 23% on 2005 levels (622 MtCO₂-e),¹⁵¹ insufficient to meet Australia's NDC of 26%–28% (on 2005 levels) by 2030.
- 158) On the basis of these Government's projections¹⁵², between 18 Mt CO₂-e (the 26% target requires 460 Mt CO₂-e by 2030) and 30 Mt CO₂-e (the 28% target requires 448 Mt CO₂-e by 2030) of **additional emissions reduction** must be found over the period 2021 to 2030, or **about 2 to 3 Mt CO₂-e new reductions every year** over this period to meet its own 2030 NDC, in addition to maintaining the reductions it already projects.
- 159) **Thus, on a Paris Agreement NDC measure, neither Australia's actual or planned emission trajectory is in line with holding global warming to 1.5°C.**
- 160) One can also 'downscale' the other global measures described in Section 4.1 to assess, on a smaller national scale, whether or not Australia's emissions and production trajectories are compatible with the 1.5°C goal. These are:
- a) the IPCC SR1.5¹⁵³ three-part test of simultaneously meeting net zero emissions by 2050, a 45% reduction of CO₂ emissions on 2010 levels by 2030, and a 35% reduction on 2010 levels of methane emissions by 2050,
 - b) whether Australia is staying within its 'share' of the remaining precautionary 1.5°C carbon budget (see Table 2), and
 - c) whether Australia is closing the fossil fuel production 1.5°C gap fast enough.

¹⁵⁰ Australian Government (2020) Australia's emissions projections 2020, available from <https://www.environment.gov.au/climate-change/publications/emissions-projections-2020>

¹⁵¹ National Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <http://ageis.climatechange.gov.au/>

¹⁵² Australian Government (2020) Australia's emissions projections 2020, available from <https://www.environment.gov.au/climate-change/publications/emissions-projections-2020>

¹⁵³ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

IPCC SR1.5 three-part test

- 161) Every state and territory in Australia has set a net zero emissions target of 2050 or earlier,¹⁵⁴ resulting in a *de facto* national target at this level. However, the **Commonwealth of Australia has not made a net zero commitment and thus fails this piece of the IPCC SR1.5°C test.**
- 162) In order to reach net zero by 2050 on a steady, linear path, Australian emissions would need to peak around 2020, and then decrease by about 3.3% of their 2020 level (510 Mt CO₂-e)¹⁵⁵ every year, year-on-year until 2050. This is an annual reduction of about 17 Mt CO₂-e (equivalent to about 4.7 MtC) every year. For comparison, the decrease in CO₂ emissions in 2020 due to COVID-19 is about 7% on 2019 levels.^{156,157} Every year action is delayed, emissions must drop more quickly to achieve net zero by 2050.
- 163) In 2010, Australia's annual CO₂ (only) emissions totalled about 432 Mt CO₂. Since then, emissions have declined, and then flattened to a value of 384 Mt CO₂ in 2018 (the most recent date for which data are available)¹⁵⁸, representing a reduction of about 11% over 8 years. **Another 34% drop (on 2010 levels) over the subsequent 12 years from then to 2030 would be necessary for Australia's CO₂ pathway to be broadly consistent with a 1.5°C pathway, requiring at least a doubling in the annual rate of reduction of CO₂ emissions.** Given this challenge and the Australian Government's current plans and projections, **Australia is not on track to cutting CO₂ emissions by 45% (on 2010 levels) by 2030.**

¹⁵⁴ PV Magazine (2020) NT sets net-zero climate target, joining other states and territories in 'de facto national net-zero target', Accessed at: <https://www.pv-magazine-australia.com/2020/07/10/nt-sets-net-zero-climate-target-joining-other-states-and-territories-in-de-facto-national-net-zero-target/>

¹⁵⁵ Australian Government (2020) Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2020, accessed from <https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-updates>

¹⁵⁶ Le Quéré, M. et al. (2020) Temporary reduction in daily CO₂ emissions during the COVID-19 forced confinement. *Nature Climate Change*, 10, 647 <https://doi.org/10.1038/s41558-020-0797-x>

¹⁵⁷ Friedlingstein, P et al. (2020) Global Carbon Budget 2019, *Earth Syst. Sci. Data*, 12, 3269-3340, <https://doi.org/10.5194/essd-12-3269-2020> Table 6 on p3292.

¹⁵⁸ National Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <http://ageis.climatechange.gov.au/>

164) In 2010, Australia's methane emissions were 4.69 Mt CH₄. Since then, they have remained nearly constant, at least out to 2018.¹⁵⁹ Thus, **by this IPCC methane measure, Australia's emissions are also not consistent with the IPCC SR1.5°C test.**

165) The overall **conclusion is that Australia fails the IPCC SR1.5 three-part test for holding warming to 1.5°C.**

Australia's 'share' of the remaining precautionary 1.5°C carbon budget

166) **The remaining carbon budgets presented in Table 2 for the whole globe can be translated into notional remaining carbon budgets for Australia and for NSW.** Arguments can be made as to how much a region can or should be allowed to emit, based on history, industrial base, international trade, or ethical considerations. Nature is blind to these distinctions. In this context, however, it is worth noting that Australia, the USA, and top-oil-producers such as Saudi Arabia, have the highest per capita emissions of greenhouse gases in the world (WMO 2019).¹⁶⁰

167) Regional carbon budgets can be formulated in any of a number of ways, each with its own advantages and disadvantages. Examples^{161,162,163,164} include:

- a) Remaining carbon budgets are divided equally on a per capita basis;
- b) Remaining carbon budgets are divided in proportion to current emissions;
- c) Responsibility for emissions reductions based on past emissions;

¹⁵⁹ National Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <http://ageis.climatechange.gov.au/>

¹⁶⁰ World Meteorological Organization (WMO) 2019, United in Science, Report prepared for the UN Climate Action Summit 2019,

<https://wedocs.unep.org/bitstream/handle/20.500.11822/30023/climsci.pdf>

¹⁶¹ Carbon Brief (2014) How to divide up carbon budgets fairly, Accessed at:

<https://www.carbonbrief.org/how-to-divide-up-carbon-budgets-fairly>

¹⁶² Climate Change Council (2018) What is a Carbon Budget? Accessed at:

https://www.environment.act.gov.au/_data/assets/pdf_file/0006/1297707/What-is-a-Carbon-Budget.pdf

¹⁶³ Rodriguez-Fernandez, L, et al. (2020) Allocation of Greenhouse Gas Emissions Using the Fairness Principle: A Multi-Country Analysis, and references cited therein. Sustainability, 12, 5839. Accessed at: <https://www.mdpi.com/2071-1050/12/14/5839>

¹⁶⁴ CCA (Climate Change Authority) (2014) Reducing Australia's Greenhouse Gas Emissions: Targets and Progress Review—Final Report, <https://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3>

- d) Remaining burden to reduce emissions based on fraction of world GDP;
- e) Per capita emissions set equal across the globe at some fixed point in future;
- f) Some combination of the above.

168) For this report, the remaining 1.5°C carbon budgets of Table 1 are simply apportioned equally among the world's population today (sometimes referred to as the 'Egalitarian' approach)¹⁶⁵, to arrive at notional 'population share' values for Australia and NSW. For this estimate, the relevant approximate populations^{166,167} are taken to be: 7.85 billion (world), 25.7 million (Australia), and 8.16 million (NSW). Note that the carbon budget numbers for Australia and NSW are in *millions* of tonnes of carbon dioxide (Mt CO₂), not *billions* of tonnes of carbon dioxide (Gt CO₂).

Table 2: Precautionary carbon budgets to limit global warming to 1.5°C apportioned by current population, and rounded to the nearest 5 Gt/Mt CO₂

Share based on current population for	1.5°C (>66% chance)	1.5°C (>50% chance)
World	210 Gt CO ₂	370 Gt CO ₂
Australia	690 Mt CO ₂	1215 Mt CO ₂
New South Wales	220 Mt CO ₂	385 Mt CO ₂

169) To put these local carbon budgets in perspective using the most recent National Greenhouse Gas Inventory¹⁶⁸ data (for Scope 1 direct emissions only), Australia emits about 380 million tonnes of CO₂ per year, while New South Wales emits 90 million tonnes of CO₂ annually. Thus, on current emission rates, the remaining 'population share' carbon budgets for Australia and NSW for a 66% chance of achieving 1.5°C will be expended in about 2 years, and even 'coin-flip' 1.5°C budgets will be exceeded in about 3 to 4 years.

¹⁶⁵ Rodriguez-Fernandez, L, et al. (2020) Allocation of Greenhouse Gas Emissions Using the Fairness Principle: A Multi-Country Analysis, and references cited therein. Sustainability, 12, 5839. Accessed at: <https://www.mdpi.com/2071-1050/12/14/5839>

¹⁶⁶ <https://www.worldometers.info/world-population/>

¹⁶⁷ <https://abs.gov.au/statistics/people/population/national-state-and-territory-population/jun-2020>

¹⁶⁸ National Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <http://ageis.climatechange.gov.au/>

- 170) If Australia were to reduce its CO₂ emissions on linear path starting now until net zero was reached, its share of the 66% (50%) chance 1.5°C budget could be stretched to about 4 years (6 years). This would require reaching net zero CO₂ emissions well before 2030, which is certainly not compatible with the current Australian emissions trajectory or planned targets and policies. **Australia is not staying within its 'population share' of a precautionary 1.5°C carbon budget, and thus fails this test.**
- 171) A carbon budget approach was used by the Government-established Australian Climate Authority (CCA) to arrive at its 2014¹⁶⁹ and 2015¹⁷⁰ recommendations for Australian GHG reduction targets, namely, a 40 – 60% reduction on 2000 levels by 2030, and a 25% reduction on 2000 levels by 2025, using CO₂-e (not CO₂ alone) as the measure of emissions. The CCA recommendations used a combination of current emissions and a future 'egalitarian' (per capita) approach to determine Australia's 'fair share' of a carbon budget designed to hold warming to 2°C (not 1.5°C) with at least a 66% chance. **Based on 2000 emissions of 544 Mt CO₂-e in 2000, these CCA-recommended targets translate to 408 MtCO₂-e in 2025, and between 218 and 326 MtCO₂-e in 2030.**
- 172) This contrasts sharply with the **Australian Government's current 2030 GHG target of 26 – 28% on 2005 levels**, which corresponds to between **448 and 460 MtCO₂-e in 2030, 35% to 111% weaker than recommended by the CCA in 2014.** It is important to stress that the 2014 CCA carbon budget analysis was based on at least a 66% chance of holding global to 2°C (not 1.5°C); the Government's current 2030 targets fail this weaker test.
- 173) A recent independent report¹⁷¹ has updated Australia's emissions targets, using the methodology used by the CCA in 2014. **The report concludes that in order to be consistent with holding warming to 1.5°C with just a 50% chance, Australia's 2030**

¹⁶⁹ CCA (Climate Change Authority) (2014) Reducing Australia's Greenhouse Gas Emissions: Targets and Progress Review—Final Report, <https://www.climatechangeauthority.gov.au/reviews/targets-and-progress-review-3>

¹⁷⁰ CCA (Climate Change Authority) (2015) Final Report on Australia's Future Emissions Reduction Targets, <https://www.climatechangeauthority.gov.au/sites/default/files/2020-07/Final-report-Australias-future-emissions-reduction-targets.pdf>

¹⁷¹ Hewson, J., Steffen, W., Hughes, L, and Meinshausen, M. (2021) Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 Emissions Reduction Targets, <https://www.climatecollege.unimelb.edu.au/files/site1/docs/%5Bmi7%3Ami7uid%5D/ClimateTargetsPanelReport.pdf>

emissions reduction target must be 74% below 2005 levels, with net-zero emissions reached by 2035. This required level of emissions reduction by 2030 is nearly three times that of Australia's Paris NDC.

- 174) In summary, Australia fails to meet the 2014 CCA-recommended targets for holding warming to 2.0°C, as well as updated 2021 recommendations based on similar methodology for a 1.5°C warming level.

Is Australia closing the fossil fuel production 1.5°C gap fast enough?

- 175) Yet another measure of whether Australian policies and current trajectory are consistent with reducing greenhouse emissions in a manner consistent with holding global warming to 1.5°C is provided by the Australia-focussed component of a six-part series of reports¹⁷² (CAT report) examining how countries can scale up climate action in four key sectors: electricity supply, transport, industry (including LNG production) and buildings.

- 176) The CAT report¹⁷³ lists reduction targets for each of these sectors for years 2030, 2040 and 2050 that begin with Australia's current emission profile and reduce it over time in a manner consistent with holding warming to 1.5°C. The result is shown in Fig. 14 as a combined pathway for Australia's emissions. (Fig. 14 here is Fig. 10 in CAT report.)

¹⁷² Climate Action Tracker (CAT) (2020) Scaling up Climate Action Australia, Accessed at: <https://climateactiontracker.org/publications/scalingup/>

¹⁷³ Climate Action Tracker (CAT) (2020) Scaling up Climate Action Australia, Accessed at: <https://climateactiontracker.org/publications/scalingup/>

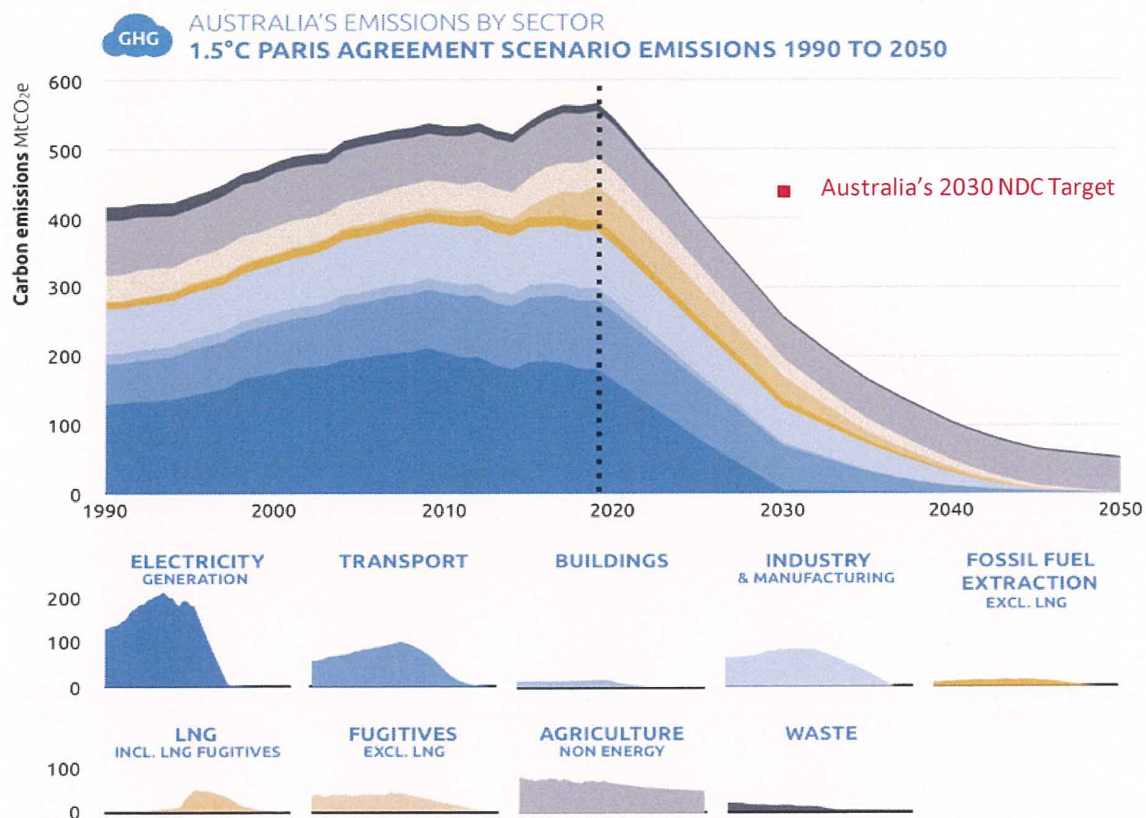


Fig. 14: A combined pathway for Australian sectoral emissions that is consistent with holding global warming to 1.5°C (according to CAT 2020). Negative emissions from land sector sinks are not shown, but could enable net zero in emissions 2050.

177) Australia's only stated policy goal¹⁷⁴ with regard to greenhouse gas emissions is to reduce its emissions by 26%–28% (on 2005 levels) by 2030, which translates to a 2030 target of 448–460 MtCO₂-e.¹⁷⁵ Examination of Fig. 14 (above) shows that Australia's stated policy range lies far above the combined sectoral pathway consistent with 1.5°C.

178) Australia's (and NSW's) effect on global warming and climate change goes far beyond its direct emissions (Scope 1) of greenhouse gases. Australia has a large indirect contribution to climate change through the emissions of countries that burn our nation's exported fossil fuels. These are called 'Scope 3' emissions.

¹⁷⁴ Commonwealth of Australia, Australia's 2030 Emissions Reduction Target Fact Sheet, https://www.pmc.gov.au/sites/default/files/publications/fact_sheet-aus_2030_climate_change_target.pdf

¹⁷⁵ Note: CO₂-e is a commonly used measure that combines the effects of different greenhouse gases into an "equivalent" amount of CO₂. Unless otherwise stated, it refers to the effects of GHGs over a 100-year time frame after they are emitted.

179) Although the *National Greenhouse and Energy Reporting Act 2007* (the NGER Act)¹⁷⁶ does not require reporting of Scope 3 emissions for Australian entities, all emissions arising directly or indirectly from an activity lead to global warming and climate change, regardless of where they are emitted. Thus, **from a scientific perspective, all emissions, including Scope 3 emissions** released when fossil fuels are combusted by any end user, **must be included** in decisions regarding new and existing regulations, approvals and policies. **To do otherwise is to assume that the fuel is never used for its intended purpose.**

180) World production of each of coal, oil and gas must drop sharply before 2030 for even a 50% chance of holding global warming to 1.5°C.¹⁷⁷ (See Fig. 15 below).

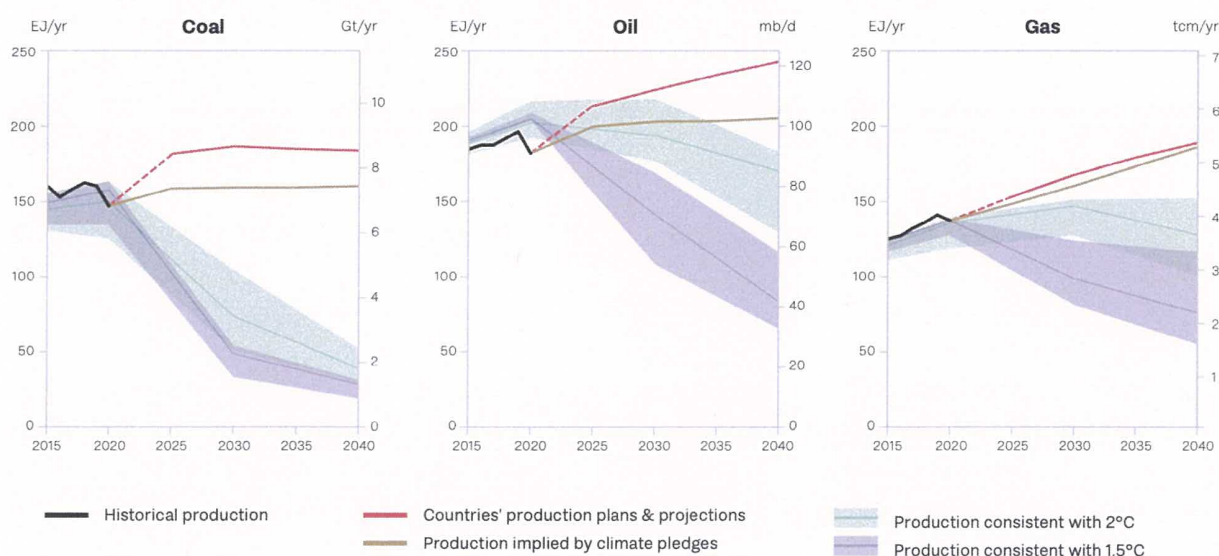


Fig. 15: Global emissions trajectories for coal, oil and gas production based on current production and projections (red) and as implied by climate pledges (gold). Also shown is a range of trajectories consistent with holding global warming to 2.0°C with a 66% chance (light green), and with holding global warming to 1.5°C with a 50% chance (lavender). From SEI et al. 2020.¹⁷⁸

¹⁷⁶ Accessed at: <https://www.legislation.gov.au/Details/C2019C00044>

¹⁷⁷SEI, IISD, ODI, E3G, and UNEP. (2020). The Production Gap Report: 2020 Special Report. <https://productiongap.org/2020report/>

¹⁷⁸SEI, IISD, ODI, E3G, and UNEP. (2020). The Production Gap Report: 2020 Special Report. <https://productiongap.org/2020report/>

- 181) **Australia is the world's leading exporter of coal¹⁷⁹ and the second largest producer and exporter of LNG.¹⁸⁰** Under government projections analysed in recent international reports,^{181,182} **Australia's extraction-based emissions from fossil fuel (coal and gas) production are expected to nearly double by 2030 compared to 2005 levels, despite Australia's stated Paris NDC target of a reduction in territorial GHG emissions of 26–28% over the same period.**
- 182) **Australia's share of global CO₂ emissions from domestic use of fossil fuels was about 1.4% in 2017. Accounting for fossil fuel emissions from Australia's exports, lifts Australia's global carbon footprint to about 5%, equivalent to the total Scope 1 emissions of Russia. If current government and industry projections for fossil fuel exports are realised, Australia could be responsible (through both domestic emissions and indirect Scope 3 emissions from exported coal and gas) for about 13% of Paris Agreement-compatible global CO₂ emissions in 2030.¹⁸³**
- 183) **Consequently, Australia is a major contributor to the Production Gap¹⁸⁴ between global intended fossil fuel production and the Paris agreed warming target range. In this sense, Australia is indirectly working against global warming held at 1.5°C, through the large Scope 3 emissions associated with its fossil fuel exports.**

¹⁷⁹ International Energy Agency (IEA 2019), World Energy Statistics and Balances (2018 Edition). Paris, France: International Energy Agency. doi:10.1787/42865fbc-en

¹⁸⁰ International Gas Union (IGU 2018), 2018 World LNG Report, International Gas Union.
<https://www.igu.org/news/2018-world-lng-report>

¹⁸¹ SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP. (2019). The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C. <http://productiongap.org/>

¹⁸² SEI, IISD, ODI, E3G, and UNEP. (2020). The Production Gap Report: 2020 Special Report.
<https://productiongap.org/2020report/>

¹⁸³ Parra, P.Y, Hare, B. Hutfilter, U.F., and Roming, N. (2019) Evaluating the significance of Australia's global fossil fuel carbon footprint, Climate Analytics, accessed from:
<https://climateanalytics.org/publications/2019/evaluating-the-significance-of-australias-global-fossil-fuel-carbon-footprint>

¹⁸⁴ SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP. (2019). The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C. <http://productiongap.org/>

4.3 New South Wales

184) In this section, the current emissions trajectory of New South Wales (NSW) is assessed against the “tests” of compatibility with holding global warming to 1.5°C that were applied to Australia as a whole in the previous section.

IPCC SR1.5 three-part test

185) NSW has set an aspirational goal of achieving net zero greenhouse gas emissions by 2050.¹⁸⁵ This ambition, *if achieved*, would be compatible with one piece of the ‘IPCC SR1.5 test’ of holding warming to a 1.5°C global temperature rise.

186) **In order to reach emissions neutrality by 2050** on a steady, linear path beginning now, NSW emissions would need its **emissions to peak in 2021 and then decrease by about 3.3% of their 2020 level** (estimated at 132 Mt CO₂-e)¹⁸⁶ **every year**, year-on-year until 2050. This would require a reduction of about 4.4 Mt CO₂-e new emissions reductions every year in the State.

187) **According to projections from the NSW Government,¹⁸⁷ emissions from the state are projected to stabilise around current values if no further action is taken.** (See Fig. 16).

¹⁸⁵ NSW Office of Environment and Heritage (2016) NSW Climate Change Policy Framework. Accessed from: <https://www.environment.nsw.gov.au/topics/climate-change/policy-framework>

¹⁸⁶ State Greenhouse Gas Inventory, maintained by the Australian Government’s Department of the Environment and Energy. Accessed at <https://ageis.climatechange.gov.au/SGGI.aspx>

¹⁸⁷ NSW Department of Planning, Industry and the Environment (2020) Net Zero Plan Stage 1: 2020 – 2030. Accessed at: <https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan>

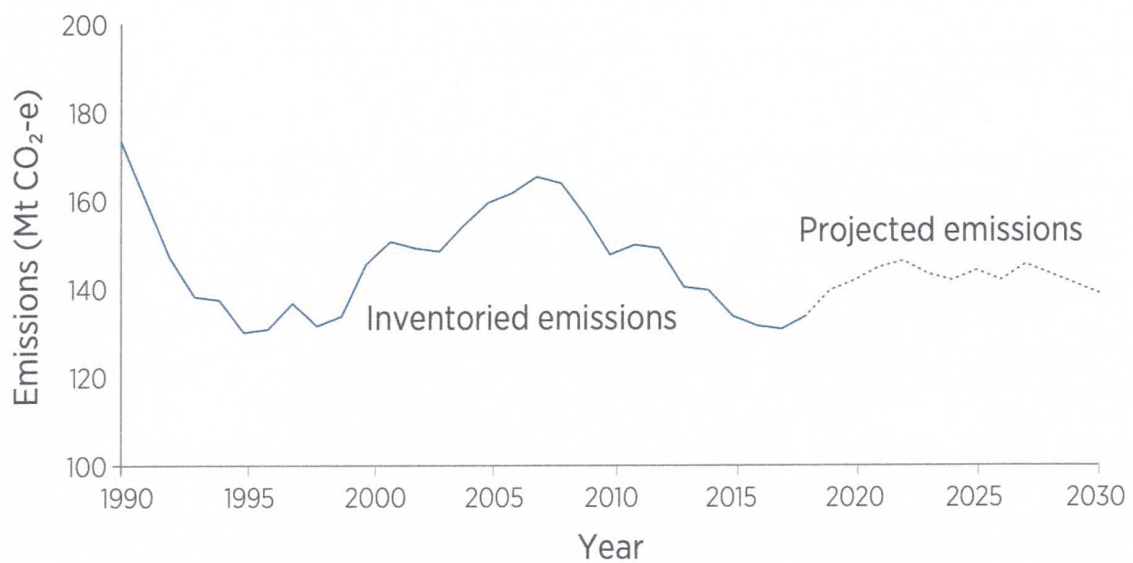


Fig. 16: Historical and projected emissions for New South Wales if no further action is taken.¹⁸⁸ Note that the vertical scale does not start at zero.

188) Recently, however, **New South Wales set an objective¹⁸⁹ of reducing its greenhouse gas emissions by 35% on 2005 levels by 2030**, as a first step to reaching net zero emissions by 2050. In 2005, NSW emissions were 159 Mt CO₂-e. If the State's 35% target is met, its emissions will be 103 Mt CO₂-e in 2030, corresponding to an average reduction of 1.9 Mt CO₂-e annually from 2020 to 2030. This reduction rate is **incompatible with the average annual rate of emissions reductions required to achieve net zero, namely 4.4 Mt CO₂-e by 2050**. In this sense, NSW does not pass a net zero by 2050 test, the first of the three parts of the SR1.5 IPCC 1.5°C test.

189) In 2010, NSW's CO₂ (only) emissions were about 100 Mt CO₂. Since then, CO₂ emissions have declined to 90 Mt CO₂ in 2018 (the most recent date for which they are available in the State Greenhouse Gas Inventory),¹⁹⁰ representing a reduction of about 10% over 8 years. **Another 35% drop (on 2010 levels) over the subsequent 12 years to 2030 would be necessary for NSW's CO₂ pathway to be broadly consistent with a 1.5°C pathway**, requiring more than a doubling in the reduction rate of State CO₂ emissions.

¹⁸⁸ NSW Department of Planning, Industry and the Environment (2020) Net Zero Plan Stage 1: 2020 – 2030. Accessed at: <https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan>

¹⁸⁹ NSW Department of Planning, Industry and the Environment (2020) Net Zero Plan Stage 1: 2020 – 2030. Accessed at: <https://www.environment.nsw.gov.au/topics/climate-change/net-zero-plan>

¹⁹⁰ State Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <https://ageis.climatechange.gov.au/SGGI.aspx>

- 190) If CO₂ emissions were to follow the *planned* trend for NSW CO₂-e emissions, namely a reduction of 35% on 2005 levels, they would drop from 110 Mt CO₂ (2005) to 71 Mt CO₂ (2030). In order to be in line with an IPCC 1.5°C pathway, however, CO₂ emissions need to drop 45% on 2010 levels, that is, to 55 Mt CO₂ in 2030. **NSW emissions are not in line to drop 45% on 2010 levels by 2030**, the second part of the IPCC SR1.5 three-part test.
- 191) In 2010, NSW's methane emissions were 1.45 Mt CH₄. Since 2010, they have dropped to 1.28 Mt CH₄ in 2018, the most recent date for which they are available in the State Greenhouse Gas Inventory,¹⁹¹ a reduction of about 0.021 Mt CH₄ annually over that period. If this annual reduction was to occur every year from 2018 until 2050, then NSW's 2050 methane emissions would be 0.6 Mt CH₄, a drop of 59% on 2010 levels. Thus, **NSW's current methane trajectory passes the third part of the IPCC SR1.5 three-part test.**
- 192) As each of the three parts of this IPCC SR1.5 test must be simultaneously satisfied for success, **NSW fails the composite IPCC SR1.5 three-part test to hold warming to 1.5°C.**

NSW's 'share' of the remaining precautionary 1.5°C carbon budget

- 193) The precautionary estimates from Table 2 for NSW's remaining carbon budget indicate that if NSW were to reduce its CO₂ emissions on a linear path starting now until net zero was reached, its 66% (50%) chance 1.5°C budget could be stretched to about 5 years (8 years). This would require reaching net zero CO₂ emissions well before 2030, which is not compatible with the current NSW emissions trajectory or planned targets and policies. **NSW is not staying within its 'population share' of a precautionary 1.5°C budget, and thus fails this test.**

¹⁹¹ State Greenhouse Gas Inventory, maintained by the Australian Government's Department of the Environment and Energy. Accessed at <https://ageis.climatechange.gov.au/SGGI.aspx>

Is NSW closing the fossil fuel production 1.5°C gap fast enough?

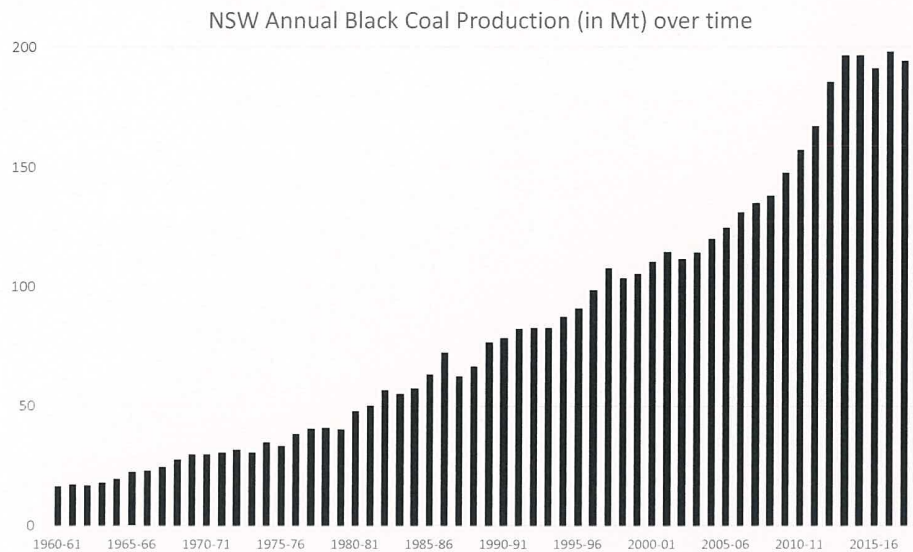


Fig. 17: NSW black coal production in millions of tonnes (Mt) from 1960-61 to 2018-19. From Table I of Australian Energy Statistics 2020.

- 194) Australian black coal production grew by 2% in 2018–19, a new peak. Production grew in both NSW (see Fig. 17) and QLD, which together produce almost all Australian black coal. Most of this coal (88%) is exported.¹⁹²
- 195) **New South Wales' energy (consumption) mix contains the largest share of coal, 42%, in Australia.** The Northern Territory uses no coal and the share in South Australia and Tasmania is below 10% per cent.¹⁹³
- 196) Cumulatively, over the past six decades, NSW has produced a little over 5 billion tonnes (Gt) of black coal.¹⁹⁴ Using a carbon content typical of high-grade coking coal, this is equivalent to about 15 Gt CO₂ due to combustion only at its final destination, or about 1.1% of the world's total CO₂ emissions from fossil fuels and cement production over this time,¹⁹⁵ despite NSW accounting for only 0.1% of the world's population.

¹⁹² Australian Government (2020) Australian Energy Statistics, including Table I, Dept of Industry, Science, Energy and Resources, September 2020. Accessed at:

<https://www.energy.gov.au/publications/australian-energy-update-2020>

¹⁹³ Australian Government (2020) Australian Energy Statistics, Table I, Dept of Industry, Science, Energy and Resources, September 2020. Accessed at:

<https://www.energy.gov.au/publications/australian-energy-update-2020>

¹⁹⁴ Australian Government (2020) Australian Energy Statistics, including Table I, Dept of Industry, Science, Energy and Resources, September 2020. Accessed at:

<https://www.energy.gov.au/publications/australian-energy-update-2020>

¹⁹⁵ Using data downloaded from <https://ourworldindata.org/co2-emissions>

- 197) From 2012 to 2019, the *annual* production of NSW black coal has been responsible, when combusted, for about 600 Mt CO₂ released into the atmosphere every year, over six times the state's entire Scope 1 annual CO₂ emissions.
- 198) As a result, NSW is a major contributor to the Production Gap¹⁹⁶ between global intended fossil fuel production and the Paris-agreed warming target range. In this sense, **NSW is indirectly working against global warming being held to 1.5°C (and even to 2.0°C), through the large Scope 3 emissions associated with its black coal exports.** Any new or expanded fossil fuel development in the State will aggravate this situation.
- 199) The size of this effect compared to NSW's own domestic emissions indicates that the State could have a major role in limiting climate change by quickly reducing its production of fossil fuels, particularly those which are exported.

4.4 Table Summary of Results

- 200) All tests of compatibility for holding global warming to 1.5°C used in Section 4 are summarised in Table 3 for the world as a whole, Australia, and New South Wales.

Table 3: Summary of compatibility measures for holding global warming to 1.5°C

Measure of Compatibility with 1.5°C	World	Australia	NSW
Paris Agreement NDCs	X	X	N/A
IPCC SR.15 Three-Part Test: Overall	X	X	X
Net Zero GHG by 2050 (ambition/action)	some ✓ / X	X / X	✓ / X
CO ₂ emissions drop 45% on 2010 levels by 2030	X	X	X
Methane emissions drop 35% on 2010 levels by 2050	X	X	✓
Closing Production Gap	X	X	X
Climate Action Tracker Country Sectoral Analysis	N/A	X	N/A
Climate Change Authority (CCA) 2014 recommendation	N/A	X	N/A
Updated 'CCA-method' 2021 recommendation	N/A	X	N/A

¹⁹⁶ SEI, IISD, ODI, Climate Analytics, CICERO, and UNEP. (2019). The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5°C or 2°C. <http://productiongap.org/>

5 Projections of Future Climate Change and its Effects

- 201) At its simplest level, **future climate change can be projected on the basis of different scenarios for future human GHG emission trajectories**. GHG targets are useful in estimating future climate change only to the extent that they are met and maintained.
- 202) Other drivers of future climate change include **the speed with which the planet responds to feedbacks in the Earth System**, and how these interact with one another, possibly cascading to create a planetary tipping point. This risk is discussed in Section 5.4.

5.1 World

- 203) Climate projections depend on the speed with which global emissions evolve. **As the previous section makes clear, the world is not on track to hold global warming to 1.5°C. If the trend of rising emissions is continued**, the world will be on a pathway similar to the scenarios¹⁹⁷ labelled RCP6.0 and RCP8.5 by the IPCC,¹⁹⁸ based on extrapolation of observed emissions trends,¹⁹⁹ and consistent with recent analyses.²⁰⁰ In this case, **global warming could be 3–4°C above pre-industrial times in just 80 years**.
- 204) **Climate impacts are hitting harder and sooner than previous scientific assessments have expected**. Over two decades, the IPCC has published a series of science-based risk assessments for people, ecosystems and economies worldwide. **A comparison of these “Reasons for Concern”** (see Fig. 18 based on WMO 2019)²⁰¹ **shows that the level of risk**

¹⁹⁷ NB: “RCP” is Representative Concentration Pathway, which is a scenario for the concentration of greenhouse gases in the atmosphere. The numbers refer to the ‘radiative forcing’ for a scenario, in Watts per square metre.

¹⁹⁸ Collins, M. et al. (2013) Long-term climate change: Projections, commitments and irreversibility, in Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by Stocker et al. Cambridge University Press, pp. 1029–1136.

¹⁹⁹ Le Quéré, C et al. (2018) Global Carbon Budget 2018, Earth Syst. Sci. Data, 10, 2141–2194, <https://doi.org/10.5194/essd-10-2141-2018>

²⁰⁰ Climate Action Tracker (2020) <https://climateactiontracker.org/global/cat-thermometer/>

²⁰¹ WMO 2019, United in Science, Report prepared for the UN Climate Action Summit 2019, <https://wedocs.unep.org/bitstream/handle/20.500.11822/30023/climsci.pdf>

has increased with each subsequent analysis from 2001 to 2018. (Areas marked in grey have not been formally assessed by the indicated IPCC report.)

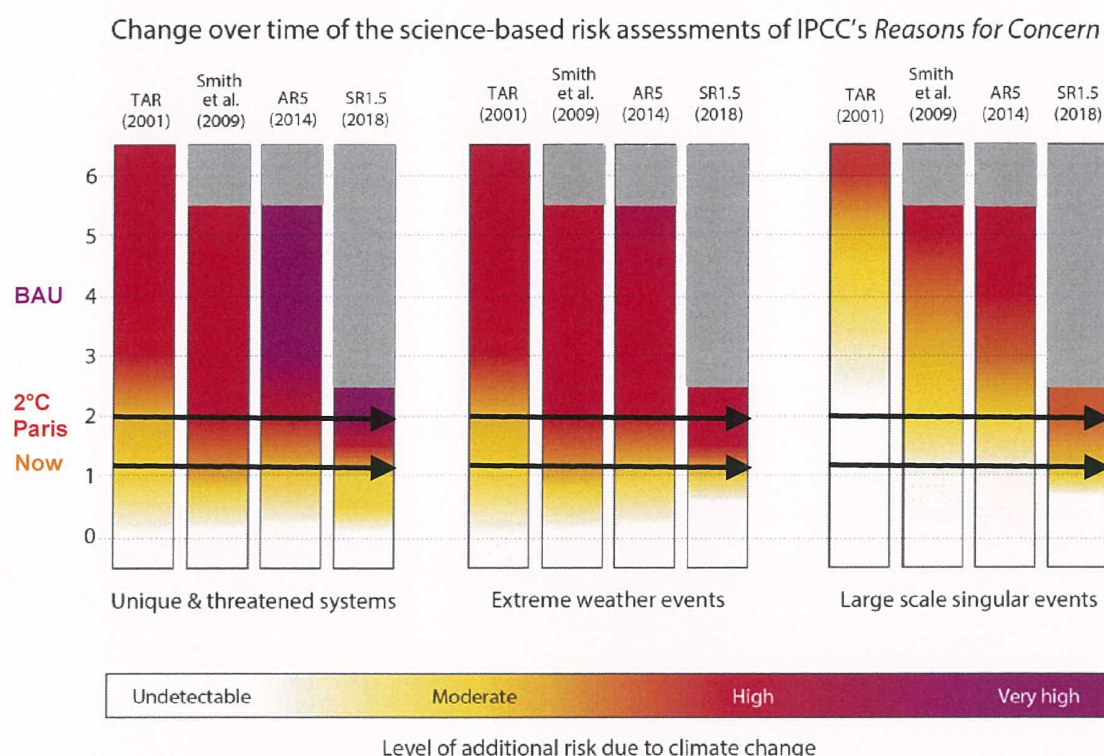


Fig. 18: As temperature above pre-industrial time climbs upward, climate risks increase (shown by deeper, dark colours). Indicated are the present (marked as "now" at 1.1°C), a 2°C scenario, and possible 'business as usual' at about 4°C. Results from more recent IPCC reports (arrows moving left to right) indicate higher risks than did earlier reports at the same temperature. Figure WMO 2019.

205) The conclusion is clear: **the more we know, the more we realise how dangerous even a small amount of warming can be.**

206) Already we know that **even the Paris Agreement range of 1.5°C to well below 2.0°C is not 'safe.'** Within this range of warming, ecosystems are at high to very high risk, there is a high risk of extreme global weather events, and a moderate risk of large-scale singular events that could lead to climatic tipping points, as Figure 18 shows.

207) **At 2°C warming, 99% of the world's coral reefs, including the Great Barrier Reef, are very likely to be eliminated, and crisis upon crisis will compound for the world's most vulnerable people²⁰².**

²⁰² IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

208) **At 3°C–4°C of warming** above pre-industrial temperatures (a consequence of continuing on our current path), today's world would be nearly unrecognisable, with high to very high risk that:²⁰³

- a) Most of the **world's ecosystems are heavily damaged** or destroyed;
- b) **Extreme weather events are far more severe and frequent** than today;
- c) **Large areas of the world become uninhabitable**. Migration and conflict escalate;
- d) Aggregated global impacts **significantly damage the entire global economy**; and
- e) A **moderately high risk** that a cascade of tipping points in the climate system drives the **Earth system into a state not seen for millions of years**, irrespective of humanity's late attempts to reduce emissions.²⁰⁴

5.2 Australia

209) The CSIRO and BOM²⁰⁵ report that **Australia will experience more extreme climate effects**, including:

- a) Further warming, with **more extremely hot days and fewer extremely cool days**.
- b) A **decrease in cool-season rainfall** across many regions of the south and east of Australia, with more time spent in drought.
- c) **A longer fire season for the south and east and an increase in the number of dangerous fire weather days**.
- d) **More intense short-duration heavy rainfall events** throughout the country.
- e) Fewer tropical cyclones, a greater proportion of which will be of high intensity.

²⁰³ IPCC (2014): Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Field et al. (eds.) Cambridge University Press, pp. 1-32.

²⁰⁴ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Appendix

<https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁰⁵ CSIRO/BOM (2020) State of the Climate 2020, Commonwealth of Australia.

<http://www.bom.gov.au/state-of-the-climate/>

- f) **More frequent, extensive, intense and longer-lasting marine heat waves**, increasing risk of frequent and severe bleaching of the Ningaloo and Great Barrier Reefs.
- g) **Oceans around Australia will continue to warm, rise and become more acidic.**
- h) **Ongoing sea level rise**, with recent research on ice sheet melting revealing that sea level rise could be higher than previously assessed.

Specifically, the CSIRO/BOM 2020 report states that:

- a) For most of the Australian coast, extreme sea levels that had a probability of occurring *once in a hundred years* are projected to become an *annual event* by the end of this century with lower emissions, and by mid-century for higher emissions.
- b) **The year 2019 was Australia's hottest year on record. That temperature is expected to be an average year in a world where the global mean temperature is 1.5 °C above the pre-industrial baseline period of 1850–1900.**
- c) **While the current decade is warmer than any other decade over the last century, it is also likely to be the coolest decade for the century ahead.**

210) Australian continental temperatures are observed to be about 1.4 times greater than global average temperatures. Thus, global warming between 1.5°C and 2°C above 1850-1900 levels translates into rises of 2.1°C and 2.8°C for Australia. (See Fig. 19).²⁰⁶

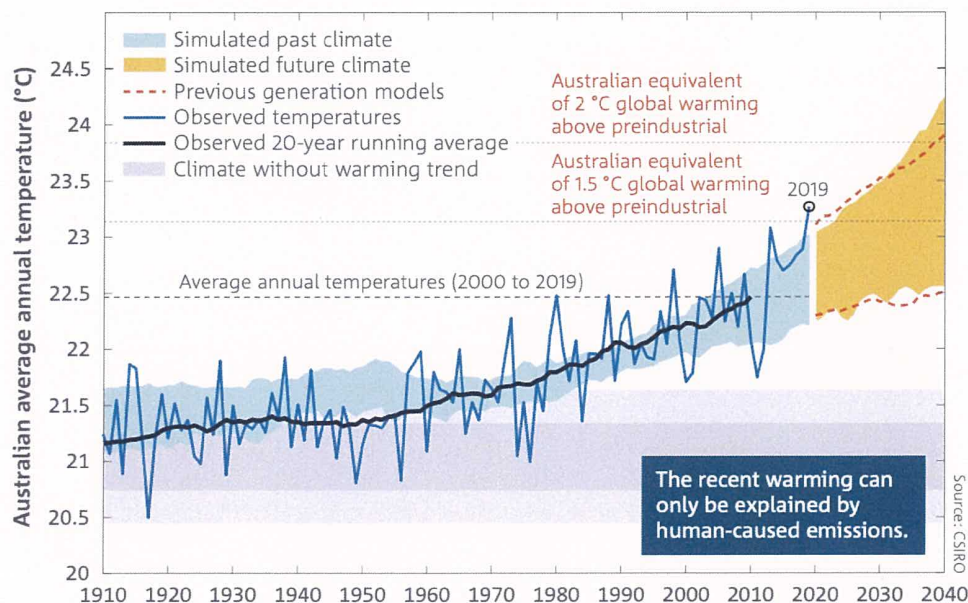


Fig. 19: Average Australian temperatures over time and projected into the future. Natural variation (without climate change) would give temperatures with the grey horizontal bands. Recent warming is due to human GHG emissions. Additional warming will cause greater average temperature changes in Australia than the global average, leaving Australia particularly exposed to more detrimental effects.

211) The intensity, frequency and duration of heatwave extremes are projected to increase in the future due to climate change.²⁰⁷ For example, for every degree °C of global temperature rise, Australians will see about 16 more heatwaves days, with the longest heatwave increasing in length by about 5 days. Already peak heatwaves that occurred only once per 30 years in pre-industrial (1861-1890) times in Australia, can now be expected every 5 years. At a global warming of 1.5°C, this frequency will nearly double to once every 2.7 years. In a world with 3°C of average warming, Australians will see such peak heatwaves nearly every year.²⁰⁸

²⁰⁶ CSIRO/BOM (2020) State of the Climate 2020, Commonwealth of Australia.
<http://www.bom.gov.au/state-of-the-climate/>

²⁰⁷ Perkins-Kirkpatrick, S. E. & Gibson, P. B. (2017) Changes in regional heatwave characteristics as a function of increasing global temperature. Sci. Rep. 7, 12256.

²⁰⁸ Perkins-Kirkpatrick, S.E. and Gibson, P.B. (2017) Changes in regional heatwave characteristics as a function of increasing global temperature. Nature Scientific Reports, 7: 12256. DOI:10.1038/s41598-017-12520-2

- 212) The risk of temperature extremes rises faster than the average global temperature rise. For example, the IPCC reports²⁰⁹ that **day-time temperature extremes that currently occur every 20 years will occur every 5 or fewer years by the middle of the century.**
- 213) **The situation may be worse than previously modelled if emissions are not quickly and dramatically reduced.** A study²¹⁰ of the future of Australia's climate using the most modern climate-coupled models (CMIP6) shows similar results to the previous generation (CMIP5), with one notable exception: **if emissions continue to grow unchecked, these newer results indicate that Australia could experience a warming of over 6°C in the average national temperature compared to pre-industrial times.** For comparison, Australia's climate has warmed on average by 1.44 ± 0.24 °C since national records began in 1910.²¹¹
- 214) The economic cost of climate change to Australia is estimated to have doubled since the 1970s,²¹² with about \$35 billion in losses reported in the 2010s. This is expected to rise if emissions are not curbed sharply. **Annual damages from extreme weather, along with sea-level rise and other impacts of climate change upon Australia, could exceed \$100 billion by 2038, and exceed \$1.89 trillion by 2050.**²¹³

²⁰⁹ IPCC (2012) Summary for policymakers. Managing the Risks Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I II IPCC 3–21.

<https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/>

²¹⁰ Grose, M.R. et al. (2020) Insights from CMIP6 for Australia's future climate. *Earth's Future*, 8, e2019EF001469. <https://doi.org/10.1029/2019EF001469>

²¹¹ BOM (2021), Annual Climate Statement 2020, accessed at: <http://www.bom.gov.au/climate/current/annual/aus/2020/>

²¹² Steffen, W. and Bradshaw, S. (2021) Hitting Home: The Compounding Costs of Climate Inaction, and references cited therein. Climate Council of Australia Ltd. Accessed at: <https://www.climatecouncil.org.au/resources/hitting-home-compounding-costs-climate-inaction>

²¹³ Kompas, T. cited in Silvester B. (2020) Trillions up in smoke: The staggering economic cost of climate change inaction. *New Daily*, 10 September 2020. <https://thenewdaily.com.au/news/national/2020/09/10/economic-cost-climate-change> based on the modelling framework set out in Kompas, T., Pham, V., Che, T. (2018) The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord. *Earth's Future* 6 <https://doi.org/10.1029/2018EF000922>

5.2.1 Australian fires in the future

- 215) Across southeast Australia, long fire-weather seasons occurred 10-25% more often in the period 1996-2013 compared to the previous 17 years,²¹⁴ consistent with annual cumulative FFDI increasing significantly in 16 out of 38 stations across Australia, and decreasing in none from 1973-2000.²¹⁵ The most significant changes were in the southeast mainland.
- 216) These trends are strengthening. **Since the mid-twentieth century, the clear trend is towards more dangerous forest fire weather in Australia, as well increasingly long fire seasons that start earlier.**^{216,217} **Furthermore, there has been a significant increase in the number of forest fires that are now developing into extreme pyroconvective events.**²¹⁸
- 217) 'Dry lightning' that occurs without significant rainfall is the primary source of natural ignition for bushfires.²¹⁹ Evidence indicates a trend in coastal southeast Australia for more frequent dry lightning events since 1979.²²⁰
- 218) **These are the effects, given full expression by Black Summer, that NSW is witnessing at about 1.1°C global warming.**

²¹⁴ Jolly, W.M. et al. (2015) Climate-induced variations in global wildfire danger from 1979 to 2013. *Nature Communications*, **6**, 7537, doi:10.1038/ncomms8537

²¹⁵ Clarke, H., Lucas, C. and Smith, P. (2013) Changes in Australian fire weather between 1973 and 2010. *Int. J. Climatology*. **33**: 931-944. DOI: 10.1002/joc.3480

²¹⁶ Harris, S. & Lucas, C. (2019) Understanding the variability of Australian fire weather between 1973 and 2017. *PLoS ONE* **14**, e0222328.

²¹⁷ Dowdy, A. J. (2018) Climatological variability of fire weather in Australia. *J. Appl. Meteorol. Climatol.* **57**, 221–234.

²¹⁸ Abram, N.J., et al. (2021) Connections of climate change and variability to large and extreme forest fires in southeast Australia, *Communications Earth & Environment* **2**:8, <https://doi.org/10.1038/s43247-020-00065-8>

²¹⁹ CSIRO/BOM (2020) State of the Climate 2020, Commonwealth of Australia. <http://www.bom.gov.au/state-of-the-climate/>

²²⁰ Dowdy, A. J. (2020) Climatology of thunderstorms, convective rainfall and dry lightning environments in Australia. *Clim. Dynam.* **54**, 3041–3052.

- 219) With the climate change that accompanies global warming, **key drivers of fire risk, particularly in southeast Australia, are becoming stronger.**^{221,222} The increased frequency and intensity of extreme heat caused by climate change magnifies fire weather risk. Climate change affects the dryness and amount of fuel, through changes in rainfall, air temperature and atmospheric moisture content that exacerbate landscape drying.
- 220) Based on the Keetch-Byram Drought Index (KBDI), which is an indicator of soil moisture deficit, one study²²³ finds that the climate conditions expected late this century (2070 – 2100) may result in high fire potential extending to seven months in Australia (August to February). **Extreme fire danger weather like that during the Black Summer bushfire season is projected to be four times more likely if global warming reaches 2°C, compared to conditions typical in 1900.**²²⁴
- 221) The frequency of the frontal systems associated with very severe fire risk is projected to double by the middle of this century due to climate change.²²⁵
- 222) **Average global temperatures in the latter half of this century, and the heat waves they induce, depend critically on human actions over the next twenty years.** Because Australia's average warming is about 1.4 times the global mean, average warming in Australia before the end of this century may reach 2.7°C (even for a rapid action SSP1-RCP2.6 sustainable pathway) to as high as 7°C (for a continued fossil fuel focused SSP5-RCP8.5 pathway) above pre-industrial levels.²²⁶

²²¹ Matthews, S., Sullivan, A. L., Watson, P., & Williams, R. J. (2012) Climate change, fuel and fire behaviour in a eucalypt forest. *Global Change Biology*, 18(10), 3212-3223. doi:10.1111/j.1365-2486.2012.02768.x

²²² Pitman, A. J., Narisma, G. T., & McAneney, J. (2007) The impact of climate change on the risk of forest and grassland fires in Australia. *Climatic Change*, 84(3), 383-401. doi:10.1007/s10584-007-9243-6

²²³ Liu, Y., J. Stanturf, and S. Goodrick (2010) Trends in global wildfire potential in a changing climate. *For. Ecol. Manage.*, **259**, 685–697, doi:10.1016/j. foreco.2009.09.002

²²⁴ Oldenborgh, G.J. et al. (2020) Attribution of the Australian bushfire risk to anthropogenic climate change, *Natural Hazards and Earth System Sciences Discussions*, Accessed at: <https://doi.org/10.5194/nhess-2020-69>

²²⁵ Hasson, A. E. A., Mills, G. A., Timbal, B., & Walsh, K. (2009). Assessing the impact of climate change on extreme fire weather events over southeastern Australia. *Climate Research*, 39(2), 159-172.

²²⁶ Grose, M. R. et al. (2020) Insights from CMIP6 for Australia's Future Climate. *Earth's Fut.* 8, e2019EF001469.

223) **Regional temperatures are key to fire development.** Modelling indicates that regional warming of around 4°C or more above pre-industrial is sufficient to allow megafires to occur in southeast Australia irrespective of whether drought occurs simultaneously.²²⁷ In other words, **if GHG emissions are not curbed sharply, Black Summer-like megafires may be a common Australia feature by late century even in years with plentiful rainfall.**

5.3 New South Wales

224) **New South Wales crosses five cluster regions**²²⁸ used to project more local future effects of climate change, namely **East Coast** (incl. Sydney), **Central Slopes** (incl. Dubbo), **Rangelands** (incl. Broken Hill), **Murray Basin** (incl. Wagga Wagga), and the **Southern Slopes**, (incl. Batemans Bay).²²⁹ (See Fig. 20 below).²³⁰

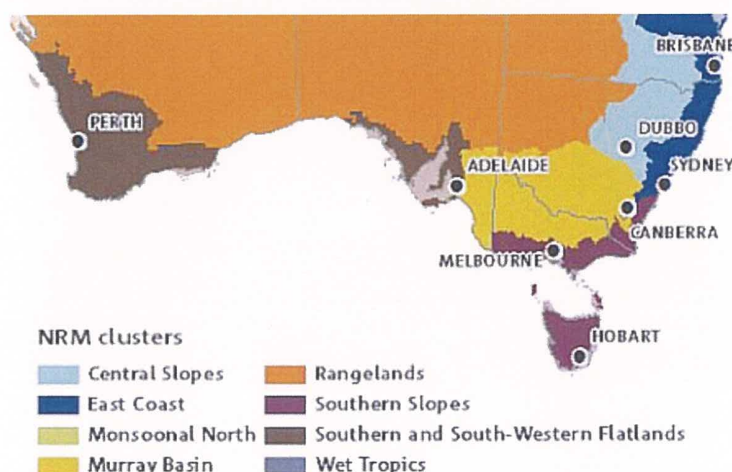


Fig 20: Colour-coded regional clusters used to project future climate.

²²⁷ Sanderson, B. M. & Fisher, R. A. (2020) A fiery wake-up call for climate science. Nat. Clim. Change. 10, 175–177

²²⁸ Climate Change in Australia: Projections for Australia's NRM Regions. Accessed at: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/>

²²⁹ Climate Change in Australia: Projections for Australia's NRM Regions. Regionalisation Schemes. Accessed at: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/about/modelling-choices-and-methodology/regionalisation-schemes/>

²³⁰ Climate Change in Australia: Projections for Australia's NRM Regions. Regionalisation Schemes. Accessed at: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/about/modelling-choices-and-methodology/regionalisation-schemes/>

225) Work²³¹ by the CSIRO and BoM projects future climate conditions by combining several global climate simulations with fine resolution “downscaled” data appropriate to local regions. **Highlights** are presented in Table 4 for the five NSW regional clusters.

Table 4: Future Climate Changes expected for New South Wales

NSW Cluster	Key Climate Changes
All NSW Regions	Temperatures increase in all seasons. Substantial increase in the temperature on hot days, the frequency of hot days, and the duration of warm spells. Fewer frosts. Less cool season rainfall. Increased intensity of extreme rainfall events.
East Coast (incl. Sydney)	Some areas could experience two to three times the average number of days above 35°C under intermediate emission scenarios by late century. Mean sea level rises and height of extreme sea-level events increases. Harsher fire weather climate.
Central Slopes (incl. Dubbo)	Harsher fire weather climate. By 2030, the annually averaged warming is projected to be 0.6 to 1.5 °C above the climate of 1986–2005.
Rangelands (incl. Broken Hill)	Less cool season rainfall in the south. Potential evapotranspiration is projected to increase in all seasons.
Murray Basin (incl. Wagga Wagga)	Increased time in drought. Harsher fire-weather climate. Evapotranspiration increases in all seasons.
Southern Slopes (incl. Batemans Bay)	Increased time in drought. Harsher fire-weather climate. Evapotranspiration increases in all seasons. Late in the century, warming of the coastal waters poses significant threat to the marine environment through biological changes in marine species.

226) **For NSW, run-off, that is the water available to feed dams and rivers, will decrease markedly with the multiple effects of climate change.** It is estimated²³² that **for every one degree (°C) of global warming, runoff will be reduced by 15%**, which matches what is currently being experienced. With current emissions trends leading to a possible *additional 2°C to 3°C* of temperature increase (for a total increase of 3°C to 4°C), the NSW region could be faced with water reductions of 45 – 60%, compared to mid last century.²³³ This has profound consequences for water availability for human and environmental use.

²³¹ Climate Change in Australia (2015): Projections for Australia’s NRM Regions. Accessed at: <https://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/>

²³² Reisinger, A., et al. (2014) Australasia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1371-1438.

²³³ ACT Climate Change Council (2020), Learning from Canberra’s Climate-Fuelled Summer of Crisis, accessed at: https://www.environment.act.gov.au/data/assets/pdf_file/0003/1611471/learning-from-canberras-climate-fuelled-summer-of-crisis.pdf

- 227) Specifically designed to study regions in Australia, the **NSW/ACT Regional Climate Modelling (NARCLiM)**²³⁴ project uses downscaled climate data over 50km regions of Australia to measure climate changes from the 'recent past' (1990–2009), to what might be expected in the 'near' (2020–2039) and 'far future' (2060–2079). The future projections **use a high-emissions scenario (SRES A2)**.²³⁵ Current emissions are tracking along this scenario; whether they do in future will depend most critically on the extent to which fossil fuels contribute to the world's future energy mix.
- 228) When reading these projections, it is instructive to note that an Australian born today will spend childhood and teen years in the 'near future', and middle age in the 'far future'. The NARCLiM study²³⁶ found that **under a high-emissions scenario:**
- a) **Daytime temperature extremes are projected to increase by up to 3.5°C** in the far future, depending on season and location.
 - b) Heatwave frequency, number and duration will increase significantly in the near and far future. **All capital cities will experience at minimum a tripling of heatwave days each year by the far future compared to the recent past.** For example, the number of heatwave days in Sydney each year will increase from 5.5 days in the recent past to 23 days in the far future.
 - c) **Implications for mortality are severe**, with projected future climates leading to increases in mortality due to high temperatures in all examined capital cities.
 - d) Moderate to severe drought conditions are expected in the far future in the southwest and southeast of Australia during spring.
 - e) **The number of days at or above 30°C in the major Australian wheat growing regions (such as NSW) will increase substantially**, particularly during spring when wheat is

²³⁴ Herold, N. (2018) Australian climate extremes in the 21st century according to a regional climate model ensemble: Implications for health and agriculture, *Weather and Climate Extremes*, 20, 54–68, <https://doi.org/10.1016/j.wace.2018.01.001>

²³⁵ According to NARCLiM, "The projected warming for SRES A2 for the 2090 to 2099 period, relative to 1980 to 1999, is given by IPCC AR4 as 2.0°C to 5.9°C, with a best estimate of 3.4°C."

²³⁶ Herold, N. (2018) Australian climate extremes in the 21st century according to a regional climate model ensemble: Implications for health and agriculture, *Weather and Climate Extremes*, 20, 54–68, <https://doi.org/10.1016/j.wace.2018.01.001>

most vulnerable to temperature. Projected decreases in precipitation would **decrease the likelihood of meeting historical production levels.**

5.3.1 Impact on NSW if the 1.5°C warming target is not met

229) Due to the combination of climate variability and long-term warming, 2019 was Australia's hottest year on record. **Even in a world in which the global mean temperature is 1.5°C (above pre-industrial times in 1850–1900) such a year would be considered 'average.'**²³⁷

230) Some NSW forests are near, or may have already crossed, local tipping points that would irretrievably alter those ecosystems, perhaps turning what was forest into dry grassland.²³⁸ Sharp reductions in GHG emissions, such as those required to hold warming to 1.5°C, are required to decrease this very high risk.

231) Warming of 2.0°C would be substantively different to that of 1.5°C above pre-industrial temperatures. In addition to the increased risks faced globally, the IPCC²³⁹ has listed **Australia as a region where the change in risk in moving from 1.5°C of global warming to 2°C is particularly high with regard to:**

- a) Water stress and drought,
- b) Shifts in biomes in major ecosystems, including rainforests,
- c) Changes in ecosystems related to the production of food,
- d) Deteriorating air quality,
- e) Declines in coastal tourism,
- f) Loss of coral reefs, sea grass and mangroves,
- g) Disruption of marine food webs, loss of fin fish, ecology of marine species,

²³⁷ CSIRO/BOM (2020), State of the Climate 2020, Commonwealth of Australia.

<http://www.bom.gov.au/state-of-the-climate>

²³⁸ Steffen, W. and Bradshaw, S. (2021) Hitting Home: The Compounding Costs of Climate Inaction, and references cited therein. Climate Council of Australia Ltd. Accessed at:

<https://www.climatecouncil.org.au/resources/hitting-home-compounding-costs-climate-inaction>

²³⁹ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

- h) Heat related mortality and morbidity, and
 - i) Ozone-related mortality.
- 232) With the possible exception of points f) and g) above, in my opinion, NSW is likely to be at increased risks equal to or larger than that of Australia as a whole, should global warming rise to 2°C rather than 1.5°C above pre-industrial temperatures.
- 233) Recent research²⁴⁰ has found that the 2019/20 bushfires that devastated NSW and surrounding areas were at least 30% more likely because of climatic changes caused by humans. **If global temperatures rise to the 2°C, the extreme fire weather conditions of Black Summer will be at least four times more common than in 1900.**
- 234) Events such as the **'Angry Summer' of 2013 and the high temperatures associated with the drought of 2006 in southeast Australia, including NSW, would be 20-25% more likely to happen in any given year if global warming is allowed to rise to 2°C rather than 1.5°C.**²⁴¹
- 235) The difference in global warming between 1.5°C and 2.0°C greatly increases the frequency of extreme temperatures over many regions. For southern Australia, a median of 4–8 extra heatwave days per year is projected for every additional degree of warming.²⁴² **Consequently, in a world with 1.5°C of warming, NSW can expect about 2–4 more heatwave days than currently, and 4-8 more with 2°C of global warming. Should global warming reach 3°C or more, as indicated by current policy settings in Australia and elsewhere in the world, NSW will incur one or two more weeks in heatwave every year in addition to what it now endures.**²⁴³

²⁴⁰ Oldenborgh, G.J. et al. (2020) Attribution of the Australian bushfire risk to anthropogenic climate change, in Natural Hazards and Earth System Sciences, 1-46. Accessed at: <https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2020-69/>

²⁴¹ King, A.D., Karoly, D.J., and Henley, B.J. (2017) Australian climate extremes at 1.5 °C and 2 °C of global warming, Nature Climate Change, 7, p 412-418.

²⁴² Perkins-Kirkpatrick, S.E. and Gibson, P.B. (2017) Changes in regional heatwave characteristics as a function of increasing global temperature. Nature Scientific Reports, 7: 12256. DOI:10.1038/s41598-017-12520-2

²⁴³ Perkins-Kirkpatrick, S.E. and Gibson, P.B. (2017) Changes in regional heatwave characteristics as a function of increasing global temperature. Nature Scientific Reports, 7: 12256. DOI:10.1038/s41598-017-12520-2

- 236) Runoff is reduced by 15% for every one degree (°C) of global warming.²⁴⁴ **This means that at 2°C of global warming, runoff would generally be expected to be 15% less than the already depressed values seen in NSW at the current 1.1°C of global warming.** A study focused on specific major river basins²⁴⁵ found that for the Murray-Darling Basin most of this additional loss at 2°C comes from exceeding the 1.5°C global target. With current emissions trends leading to a possible additional warming of 2°C to 3°C **(for a total increase of 3°C to 4°C), NSW could be faced with water reductions of 45 – 60%, compared to mid last century.**²⁴⁶
- 237) The non-linear complexity of Earth’s climate system is such that the most extreme of extreme temperature events do not scale simply with an additional amount of warming. One study from 2017 (before Black Summer) **concluded that major Australian cities, such as Sydney or Melbourne, could therefore incur maximum summer temperatures of 50°C under 2°C of global mean warming.**²⁴⁷ Penrith recorded 48.9°C (whilst many other sites in metropolitan Sydney exceeded 47°C) on 4 January 2020, at a time when global warming stands at only 1.1°C. This raises the possibility that **current models may be underestimating the extreme heat that NSW will feel at 1.5°C, let alone, at 2°C of global warming.**
- 238) **The impacts on NSW will be widespread, deleterious and costly if the global 1.5°C target is not met; even half of a degree of global warming makes a difference.**

²⁴⁴ Reisinger, A., R.L. Kitching, F. Chiew, L. Hughes, P.C.D. Newton, S.S. Schuster, A. Tait, and P. Whetton (2014) Australasia. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1371-1438.

²⁴⁵ Betts, R.A. et al. (2018) Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376(2119), 20160452, doi:10.1098/rsta.2016.0452.

²⁴⁶ ACT Climate Change Council (2020), Learning from Canberra’s Climate-Fuelled Summer of Crisis, accessed at: https://www.environment.act.gov.au/data/assets/pdf_file/0003/1611471/learning-from-canberras-climate-fuelled-summer-of-crisis.pdf

²⁴⁷ Lewis, S. C., King, A. D., & Mitchell, D. M. (2017). Australia’s unprecedented future temperature extremes under Paris limits to warming. *Geophysical Research Letters*, 44, 9947–9956. <https://doi.org/10.1002/2017GL074612>

5.4 The greatest climate risk of all: crossing Earth system tipping points

- 239) The stability of the Earth system is influenced by feedbacks between the climate system and carbon-regulating processes such as frozen permafrost soils or carbon uptake by forests. Many biosphere feedback processes are losing strength, increasing the **risk that self-reinforcing mechanisms will counter efforts to mitigate further climate change, and instead accelerate it.**²⁴⁸
- 240) **Tipping points**²⁴⁹ in the Earth System refer to thresholds that, if crossed, would lead to far-reaching, and, in some cases, abrupt and/or irreversible changes in subsystems. Examples²⁵⁰ range from the release of CH₄ from ocean methane hydrates, which is likely to take place slowly over millennia, to the total loss of Arctic sea ice in summer, which according to the most recent studies that include complex ice melt may occur in just fifteen years' time, around 2035,²⁵¹ if GHG emissions go unchecked.
- 241) The **most devastating risk of continued global warming is that some of Earth's subsystems** (e.g., Arctic sea ice, ocean circulation, the Amazon rainforest, or coral reefs) **will become unstable and 'tip' irreversibly into new states that accelerate the effects of climate change.** Some of these subsystems are already showing signs of becoming unstable, with 'tipping points' that could lie on our current trajectory of global warming rising to 2°C, 3°C or 4°C above pre-industrial temperatures.^{252,253}
- 242) **Continued warming increases the risk** that crossing tipping points will cause subsystems of the Earth to rapidly collapse, one initiating another, to create a **cascade of**

²⁴⁸ WMO 2019, United in Science, Report prepared for the UN Climate Action Summit 2019, <https://wedocs.unep.org/bitstream/handle/20.500.11822/30023/climsci.pdf>

²⁴⁹ Schellnhuber HJ, Rahmstorf S, Winkelmann R (2016) Why the right climate target was agreed in Paris. *Nature Climate Change*, 6:649-653

²⁵⁰ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Appendix <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁵¹ Guarino, M-V. et al. (2020) Sea-ice-free Arctic during the Last Interglacial supports fast future loss, in *Nature Climate Change*, 10, 928-932, <https://doi.org/10.1038/s41558-020-0865-2>

²⁵² Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Appendix, accessed at: <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁵³ Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K, Steffen, W. & Schellnhuber, H.J. (2019) *Nature*, vol 575, pp 592 – 595.

transformations that result in what has been dubbed a “Hothouse Earth.”²⁵⁴ In this future, average temperatures will rise to match those not seen since the beginning of the Stone Age, millions of years ago, with devastating consequences. If such a cascade in a domino effect were to occur, the result would be an unrecognisable landscape for current ecosystems and human civilisation.

- 243) It is uncertain precisely where this ‘Hothouse’ threshold lies, but it could be as close as a few decades away, that is, at or just beyond 2°C of warming.²⁵⁵ Very recent research indicates that tipping point risks are now much higher than earlier estimates, with over half of previously identified tipping elements now “active,” that is, observational data show they are moving in the direction that could cause irreversible change.²⁵⁶

²⁵⁴ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. (USA) doi:10.1073/pnas.1810141115 and associated Appendix <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁵⁵ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. (USA) doi:10.1073/pnas.1810141115 and associated Appendix <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁵⁶ Lenton, T.M. et al. (2019) Climate tipping points — too risky to bet against. Nature, 2019; 575 (7784): 592. Accessed at: <https://www.nature.com/articles/d41586-019-03595-0>

6 The Greatest Threat to the Environment and People of NSW

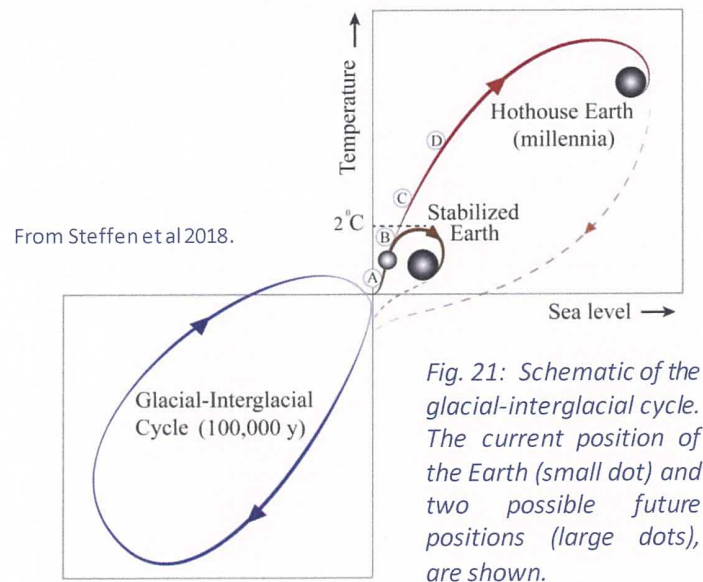
- 244) Unabated climate change poses an enormous threat to the environment and peoples of the world, Australia and NSW, in particular, for several reasons that, when taken together, are unique to climate change. Unabated anthropogenic climate change is:
- a) **Fundamental** – affecting basic aspects of the physical Earth system, and the ecosystems that depend on it,
 - b) **Global** – greenhouse gases emitted anywhere in the world affect the whole globe,
 - c) **Comprehensively Dangerous** – with the potential to disrupt or destroy nearly every ecosystem,
 - d) **Rapid** – occurring at a speed that precludes many organisms and even whole ecosystems from adapting,
 - e) **Inertial** – with a delayed response to emissions that “locks in” some measure of climate change that is greater than that currently experienced,
 - f) **Compounding** – the effects of climate change do not occur independently, but can occur simultaneously, greatly increasing the negative consequences of extreme events,
 - g) **Irreversible** – feedbacks in the Earth System may cause the crossing of tipping points, with the potential to irreversibly change ecosystems and processes in the Earth system, including the possibility of cascading to an unimaginably hostile one.

6.1.1 Climate change is fundamental to the environment

- 245) Over the last million or so years, the Earth system has travelled on bounded **pathways that connect glacial periods to warmer interglacial periods**. These pathways are not identical, but cycle about every 100,000 years.²⁵⁷ (See Fig. 21 below.)

²⁵⁷ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. (USA) doi:10.1073/pnas.1810141115 and references therein
<https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

246) The climate changes profoundly during each transition, reshaping the Earth's physical system and the life it supports. Sea levels can change by 100m, the fraction of the Earth's surface covered with ice dramatically changes, and different species dominate the biosphere, on land and in the ocean. Yet these **hugely different versions of Earth are separated by only 4-6°C of average global temperature.**



6.1.2 Climate change is global

247) Due to the interconnectivity of the Earth's systems, greenhouse gases emitted anywhere are distributed throughout the atmosphere, where they contribute to the warming of the planet as a whole. Thus, **the location, or the identity of the emitter, is of no consequence to the ultimate warming effect.** Australian emissions contribute to climate change impacts everywhere on Earth, and emissions from any location on Earth influence the effects that Australia feels from climate change. **Humans bear collective responsibility for anthropogenic climate change.**

248) A very large number of small, individual human sources of greenhouse gases combine to form the collective global risk of climate change. **If every source of emissions that is a 'small fraction of the whole were to be ignored,' the problem would persist.**

6.1.3 Anthropogenic change is comprehensively dangerous

249) **Australia has been rated fourth highest in the G20 for economic losses per unit of GDP incurred from extreme weather events over the last 20 years (1999-2018).**²⁵⁸

250) **Current levels of greenhouse gases are already dangerous:** ecosystems are degrading and catastrophes due to extreme weather are occurring that can be directly attributed to climate change. Section 5 above (see e.g., Fig. 18) and recent IPCC reports^{259,260} outline the comprehensive nature of the damage already being done by anthropogenic climate change across the whole of Earth's environmental systems, as well as that likely to occur in future if greenhouse gas emissions remain unchecked. **Nearly every system on Earth will be affected if global warming increases to 3°C – 4°C.**

6.1.4 Anthropogenic climate change is rapid

251) The dramatic changes that accompany the switch from a glacial to an interglacial period occur over tens of thousands of years with total temperature changes of about 5°C. **Yet in just 200 years humans have raised the average global temperature to more than 20% of the glacial-interglacial gap**, so that the Earth is now nearing the upper envelope of interglacial conditions over the past 1.2 million years.²⁶¹

252) **The speed of this change makes it difficult, or in some cases, impossible for some species and ecosystems to adapt. At 2°C of warming, 13% of the Earth's surface will undergo complete ecosystem transformations.**²⁶² **A study of 105,000 species found that even at 1.5°C of warming, 6% of insects, 8% of plants, and 4% of vertebrates are likely to**

²⁵⁸ Climate Transparency Report (2020) International Climate Transparency Partnership, accessed at: <https://www.climate-transparency.org/g20-climate-performance/the-climate-transparency-report-2020>

²⁵⁹ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

²⁶⁰ IPCC (2014): Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Field et al. (eds.) Cambridge University Press, pp. 1-32.

²⁶¹ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and references therein <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁶² IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

lose over half of their climatically-determined geographic. These percentages *double* for 2°C of warming.²⁶³

- 253) A recent meta-analysis²⁶⁴ of 27 studies concerning a total of 976 species found that **47% of local extinctions reported across the globe during last century could be attributed to climate change.**

6.1.5 Climate change has delayed effects

- 254) **The full climatic effects of greenhouse gases (especially CO₂) are not felt until long after the time of emission.** This means that a few tenths of a degree of additional warming above the present 1.1°C are already locked as inertia in the Earth system responds to greenhouse gases that have already emitted.²⁶⁵

- 255) This, together with natural variability, means that **even with rapid reductions of about 5% per year (relative to the year previous) beginning in 2021, a drop in global average temperatures may not be reliably measured until about 2050.**²⁶⁶ This is an example of how global emission decisions made in the period 1990 to 2020 have a delayed effect. **What *would* be observable sooner is the decline in atmospheric CO₂ should emissions drop rapidly.**

- 256) The amount of climate change expected in the next decade is similar under all plausible global emissions scenarios. However, by the mid-21st century, higher ongoing emissions of greenhouse gases will lead to greater warming and associated impacts, while reducing emissions will lead to less warming and fewer impacts.²⁶⁷ **The lag between the full effects**

²⁶³ Warren, R., J. Price, E. Graham, N. Forstenhaeusler, and J. VanDerWal (2018): The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5°C rather than 2°C. *Science*, 360(6390), 791–795, doi:10.1126/science.aar3646.

²⁶⁴ Wiens, J.J., 2016: Climate-Related Local Extinctions Are Already Widespread among Plant and Animal Species. *PLOS Biology*, 14(12), e2001104, doi:10.1371/journal.pbio.2001104.

²⁶⁵ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. See their Fig. 1.5. Accessed at: <http://ipcc.ch/report/sr15/>

²⁶⁶ Samset, BH, Fuglestad, JS and Lund, MT (2020) Delayed emergence of a global temperature response after emission mitigation. *Nature Communications*, 11, 3261, <https://doi.org/10.1038/s41467-020-17001-1> (and references therein)

²⁶⁷ CSIRO/BOM (2020) State of the Climate 2020, Commonwealth of Australia. <http://www.bom.gov.au/state-of-the-climate/>

of emissions and the global warming they cause means that what we do this year, has consequences for every year hereafter into the foreseeable future.

6.1.6 Climate change is compounding

257) **The effects of climate change often compound one another**, acting to amplify deleterious effects. This includes instances where **multiple destructive events or elements occur at the same time or in close succession, exacerbating one another such that the overall impact is worse than if each had occurred in isolation.**²⁶⁸

258) For example, tropical storms are damaging not only due to high winds, but also due to accompanying storm surge caused by rising sea levels and a warming, wetter atmosphere. This then can cause coastal erosion and flooding with different, and longer lasting consequences.

259) Another example is the drivers of interannual climate variability over southeast Australia, which do not operate independently of each other. This increases the chance of compounding effects on fire risk in NSW.²⁶⁹ Further, pre-existing drought conditions and heatwaves often occur simultaneously with high fire danger days. This 'triple whammy' effect has severe implications not only for the landscape and the ecosystems it supports, but also for humans working outside, on the land, and combating fires.

6.1.7 Climate change can be irreversible

260) **The nature of tipping points is that they are irreversible on timescales associated with natural variability in the Earth System.** Anthropogenic greenhouse gas emissions are now pushing the Earth System rapidly away from the glacial-interglacial cycle of stability (Fig. 21) toward new, hotter climatic conditions and a profoundly different biosphere.

²⁶⁸ Steffen, W. and Bradshaw, S. (2021) Hitting Home: The Compounding Costs of Climate Inaction, and references cited therein. Climate Council of Australia Ltd. Accessed at:

<https://www.climatecouncil.org.au/resources/hitting-home-compounding-costs-climate-inaction>

²⁶⁹ Abram, N.J., et al. (2021) Connections of climate change and variability to large and extreme forest fires in southeast Australia, Communications Earth & Environment 2:8,

<https://doi.org/10.1038/s43247-020-00065-8>

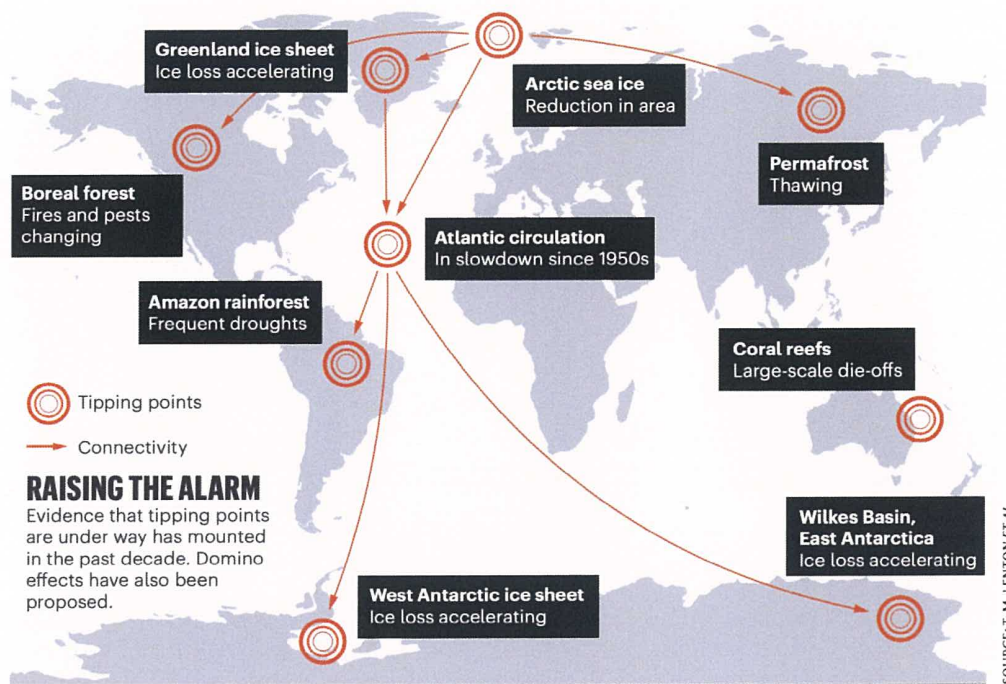


Fig. 22: Tipping elements on the move (from Lenton et al. 2019).

- 261) Over half of the local tipping elements identified a decade ago²⁷⁰ are already beginning to move,²⁷¹ including coral reefs in Australia (See Fig. 22).
- 262) If emissions are unabated, these elements, and others, will tip, with cascading effects that could accelerate irreversible changes elsewhere in the Earth system, leading to a devastating 'Hothouse Earth' persisting for millennia.²⁷²
- 263) On the basis of the foregoing, it is reasonable to state that unabated climate change is the greatest threat to the environment and people of New South Wales. NSW is not immune to any of these characteristics of climate change. Future risks specific to the state are sketched in Section 5.3.

²⁷⁰ Lenton, T.M. et al. (2008) Tipping elements in the Earth's climate system. In PNAS, 105(6), p1786-1793. Accessed from: <https://www.pnas.org/content/105/6/1786>

²⁷¹ Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K, Steffen, W. & Schellnhuber, H.J. (2019) Nature, vol 575, pp 592 – 595.

²⁷² Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. (USA) doi:10.1073/pnas.1810141115 and associated Appendix <https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

7 Assessing NSW EPA Objectives, Guidelines and Policies

264) The NSW Environment Protection Agency (NSW EPA) Tender Bundle was examined and used in this report to address the sixth area of Amended Areas of Expert Evidence as outlined in the Annex A1 of Justice Moore’s order of 26 October 2020, namely whether or not (and why) the objectives, guidelines and policies of the NSW EPA:

- a) Regulate or reduce direct and indirect sources of greenhouse gas emissions in a manner consistent with global temperature rise limited to 1.5°C from pre-industrial levels, and
- b) Are fit for purpose in protecting or mitigating against the threat posed by climate change to the quality of the environment and the people of New South Wales.

265) This report interprets “*consistent with global temperature rise limited to 1.5°C from pre-industrial levels*” to mean an emission trajectory for NSW that uses the same widely-used targets (as a percentage) for a global emission trajectory assessed to result in limiting global warming to 1.5°C above pre-industrial temperatures with little or no overshoot.²⁷³ In particular, the IPCC SR1.5 three-part test (see point 125) and the Closing the Production Gap test (see point 143) and Fig. 13) apply.

266) The EPA Tender Bundle offered for my consideration included 300 papers, many of which had multiple components, totalling 399 individual documents. (See Appendix D.) These documents were used to address the question posed in point 264) regarding NSW EPA objectives, guidelines and policies with respect to greenhouse gases and fit for purpose in mitigating the threat of climate change. For clarity, it is noted that the Tender Bundle documents included all those included in Annex A of EPA’s Response dated 5 June 2020.

267) Although documents #122 and #123 in the Tender Bundle are identical in content (with slightly different document titles), they are treated as separate documents for counting purposes.

²⁷³ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

- 268) **It is important to note that the documents had a variety of authoring agencies,** including the Australian Government, the NSW Government, the NSW EPA or its predecessors, CSIRO, Greater Sydney Commission, and Ballina Shire.
- 269) **The documents provided in the Tender Bundle cover a very large number of environmental issues,** including *inter alia*: air pollutants, tyre waste, vibration, pesticides, dry cleaning chemicals, dust, litter, ground and water contaminants, mine rehabilitation, radiation protection, noise, vehicle emissions, private native forestry, air emissions from coal fired power stations, composting, liabilities from coal seam gas activities, recycling, and plastic microbeads.

7.1 Methodology for Assessment

- 270) **Given the sheer volume and scope of the material under scrutiny, documents were first searched for key words that would indicate possible relevance to the question posed in point 264).** These key words were: greenhouse, methane (CH₄), carbon dioxide (CO₂), nitrous oxide (N₂O), chlorofluorocarbon (CFC), landfill gas, carbon emission(s), Paris and Kyoto. (The words “emission” and “climate” were found to be too general to be an effective discriminant, given that the NSW EPA documents address emissions other than greenhouse gases, and climate, without reference to climate change.) This search reduced the full set to a subset of 127 documents. (Namely, those documents with a “Y” in column H of table in Appendix D.)
- 271) **This subset was then examined to determine which documents sought to regulate or reduce direct and indirect sources of greenhouse gases, either directly or indirectly.** Using a quite broad interpretation that included measures that may indirectly reduce GHG though without this as a stated aim, this criterion reduced the number of documents to a smaller subset of 55 documents. (Namely, those documents with a “Y” in column I of table in Appendix D.)
- 272) **When these 55 documents were examined in more detail, 15 were judged to have the reduction of greenhouse gas emissions as a major goal or outcome (namely those coloured yellow or light blue in column I of Appendix D), and of those 15 documents, 14 mentioned a *specific, quantifiable* emissions reduction or global warming goal (namely,**

those coloured light blue in column I of Appendix D). Vague aspirations (e.g., “reduce”, “minimise” or “contribute to”) were not included in latter this group.

7.2 Consistency with limiting global warming to 1.5°C above pre-industrial levels

273) In order to address part a) of the question posed in point 264), **these 14 documents** (listed in Table 5 below) **were assessed to ascertain whether their specific policy goal was consistent with a global temperature rise of no more than 1.5 degrees Celsius from pre-industrial levels.**

Table 5: NSW EPA Tender Bundle Documents deemed relevant to this export report

Doc #	Document Title, Publication Date, Authoring Agency	Notes	Specific GHG emissions or global temperature goal	Relevance to point 264)
5	<i>Action for Air</i> , 2009, NSW Dept of Environment, Climate Change and Water	Primary goals are meeting national standards for CO ₂ , NO ₂ , SO ₂ , Pb, ozone, PM ₁₀ , and reducing exposure to air pollutants in NSW. Roadmap/plan.	NSW state plan to achieve a 60% reduction in GHG by 2050 (p2).	Superseded by document #173.
32	<i>Cleaning up our Act: The Future for Waste and Resource Recovery in NSW</i> , 2020, NSW Government	Issues Paper for policy yet to be finalised.	Target of reaching net zero emissions in NSW for organic waste by 2030.	Issues paper for policy yet to be developed. Applies to less than 2.4% of NSW annual emissions. Consistent with holding warming to 1.5°C above pre-industrial levels for this component only.
67	<i>Environmental Guidelines: Solid waste landfills</i> , 2016, State of NSW Environmental Protection Agency	Applies only to the interior of buildings on or near landfill sites in NSW. Guidelines.	CH ₄ must be less than 1% by volume in the interior of buildings (p35).	Does not pertain to atmospheric CH ₄ concentrations relevant to climate change.
87	<i>Government resource efficiency policy</i> , 2019, State of NSW Office of Environment and Heritage	Several undertakings including those related to energy efficiency. Those most directly tied to GHG reductions are listed at right.	Purchase 6% green power (p9). At least 10% hybrid or electric vehicles in new fleet acquisitions (p9).	Policy document applies to NSW Government operations only, which may account for about 3% of NSW total emissions. Not compatible with sectoral declines consistent with holding warming to 1.5°C above pre-industrial levels (CAT 2020).
88	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – connection people and supporting</i>	Lays out a planning vision for Greater Sydney.	Aspirational goal of assisting NSW to net zero emissions by 2050 (p170).	Applies to Sydney only as aspirational goal only, not greater NSW. Necessary, but not sufficient, to be consistent with holding global

	<i>district Plans, 2018, NSW Greater Sydney Commission</i>			warming to 1.5°C above pre-industrial levels.
88a	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – Western Sydney District Plan, 2018, NSW Greater Sydney Commission</i>	As above.	As above.	As above.
88b	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – Central Sydney District Plan, 2018, NSW Greater Sydney Commission</i>	As above.	As above.	As above.
88c	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – Eastern Sydney District Plan, 2018, NSW Greater Sydney Commission</i>	As above.	As above.	As above.
88d	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – North District Plan, 2018, NSW Greater Sydney Commission</i>	As above.	As above.	As above.
88e	<i>Greater Sydney Regional Plan - A Metropolis of Three Cities – South District Plan, 2018, NSW Greater Sydney Commission</i>	As above.	As above.	As above.
138a	<i>Ballina Shire Local Strategic Planning Statement 2020-2040, 2019, Ballina Shire Council</i>		Calls upon the State and Federal Governments to legislate programs to drive emergency action to reduce greenhouse gas emissions and meet the lower of the Paris Agreements (<i>sic</i>) or a maximum 1.5 degree warming (p63).	Applies to the planning and goals of the Ballina Shire Council, not the policies, guidelines or objectives of the NSW EPA.

165	<i>Net Zero Plan Stage 1: 2020 – 2030, 2020, State of NSW Dept of Planning, Industry and Environment</i>	NSW Government plan to deliver net zero GHG emissions by 2050 via actions in period 2020-2030 in the first state. Subsequent plans are expected for the following two decades.	By 2030, NSW to obtain a 35% emissions reduction on 2005 levels (p2).	Stated 2030 emission reduction goal is not ambitious enough to be consistent with holding global warming to 1.5°C above pre-industrial levels.
172	<i>NSW Cleaner Vehicles and Fuels Strategy, 2008, DECCW</i>	NSW Government's 25-year Action Plan for air quality management for Sydney, the Illawarra and the Lower Hunter with photochemical smog and fine particles its "two main air pollutants of concern."	Stated goal to reduce GHG in NSW Government fleet by 20%. (p26)	Specific emissions target applies to NSW Government fleet only, with no timeline for completion. Not clear if target was met, and now appears to be superseded by document #87.
173	<i>NSW Climate Change Policy Framework, 2016, NSW Government</i>	"NSW Government endorses the Paris Agreement and will take action that is consistent with the level of effort to achieve Australia's commitments to the Paris Agreement." (p4)	Framework for policy development in NSW. Commits NSW to aspirational goal of net zero emissions by 2050.	Necessary, but not sufficient, to be consistent with holding global warming to 1.5°C above pre-industrial levels.

- 274) **Of these 14 documents**, three can be dismissed straightaway for the purposes of this report, namely, **documents #5, #67 and #138a**, for the following reasons. Document #5 is superseded by #173. Document #67 pertains only to the concentration of methane inside some buildings, not the atmospheric concentration of methane, which is the relevant measure for climate change. Document #138a pertains to Ballina Shire plans, not EPA plans, policies or guidelines. Although it refers to limiting global warming to 1.5°C above pre-industrial levels, it calls on state and federal levels of government to respond to this challenge.
- 275) **Document #32** is an issues paper for policy yet to be finalised that states an aim for NSW to have net zero emission for its organic waste by 2030. If acted upon, this objective would be consistent with holding global warming to 1.5°C for the organic waste sector. All waste contributes about 2.4% to NSW annual emissions;²⁷⁴ the organic component of this waste would therefore contribute less.
- 276) **Policy Document #87** introduces some targets — for state government activities only — with the stated aim of reducing operating costs and leading by example in efficient resource use. Although the total amount of emissions estimated from NSW Government activities is not given, the document does state that “NSW Government agencies own and operate facilities and infrastructure that use about 1800 gigawatt hours (GWh) of electricity each year or around 2.7% of NSW electricity sales.”²⁷⁵ If other emissions scale similarly, we might assume that NSW government emissions account for about 3% of NSW emissions.
- 277) Specific, quantifiable targets related to GHG emissions in document #87 include that NSW Government activities be powered by 6% green power and that 10% of *new* fleet

²⁷⁴ NSW Department of Planning, Industry and Environment. Cleaning Up Our Act: The Future for Waste and Resource Recovery in NSW. Issues Paper March 2020.

²⁷⁵ NSW and Office of Environment and Heritage (2019). NSW Government Resource Efficiency Policy: For a resource productive public sector with less impact on the environment

acquisitions to be electric or hybrid cars. The CAT report²⁷⁶ for Australia indicates that to be compatible with 1.5°C global warming, electricity emissions must decrease by 97% on a 2005 baseline (or 96.7% on 2019 baseline) and transport emissions by 20% on a 2005 baseline (or 36% on 2019 baseline). On this measure, these targets for NSW Government activities fall far short of compatibility with 1.5°C.

278) **Document #172** is a strategic plan written in 2008 to improve air quality in some parts of NSW. It includes the ambition to reduce GHG emissions of the NSW Government fleet by 20%, but does not indicate the time frame for doing so. If achieved, this target would have been close to the transport sector guideline for compatibility with 1.5C of warming from the CAT report (see point 277)) excluding growth in the fleet since that time. However, it only applies to Government fleet emissions, and this 2008 strategic plan appears to be superseded by document #87.

279) The remaining **documents (#88, #88a, #88b, #88c, #88d, #88e, #165 and #173)** reference NSW's aspirational goal of net zero (state) greenhouse gas emissions by 2050. As discussed in detail in Section 4 (see point 160)a), net zero emissions by 2050 is widely considered to be necessary, but not sufficient to hold global warming to 1.5°C. Steep CO₂ emission reductions of about 45% by 2030 and reduction policies for methane and black carbon are also required.²⁷⁷ Absent policies and efforts to govern the necessarily rapid decline of greenhouse gases by 2030 and interim periods thereafter, a stated reference to an aspiration goal of net zero by 2050, even if achieved, is not sufficient to be compatible with holding global warming to 1.5°C.

280) It must be noted, **however, that document #165 goes further than any of the others in the NSW EPA Tender Bundle, by setting out actions with the intent to explicitly reduce NSW emissions by 35% (on 2005 levels) by 2030, and thus must be assessed separately.** It is beyond the scope of this report to ascertain whether the actions set out in this document would achieve the stated goal. Rather, it is noted that an emission reduction of 35% by 2030 (on 2005 levels) is incompatible with the 2030 target of 45% (on 2010)

²⁷⁶ Climate Action Tracker (CAT) (2020) Scaling up Climate Action Australia, and in particular the reports' Table 3. Accessed at: <https://climateactiontracker.org/publications/scalingup/>

²⁷⁷ IPCC SR1.5 (2018) Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C. Accessed at: <http://ipcc.ch/report/sr15/>

levels necessary to be consistent with a 1.5°C pathway. Specifically, the emissions target of 71 Mt CO₂ is considerably higher than the 1.5°C-consistent 2030 target of 55 Mt CO₂ for New South Wales (see point 190).

- 281) **In conclusion, taken as an omnibus, the documents in the NSW EPA Tender Bundle do not regulate or reduce direct and indirect sources of greenhouse gas emissions in a manner consistent with global temperature rise being limited to 1.5°C from pre-industrial levels.**

7.3 *Fit for purpose*

- 282) In assessing the documents submitted in the NSW EPA Tender Bundle, **this report interprets 'fit for purpose'** in protecting or mitigating against the threat posed by climate change to the quality of the environment and the people of New South Wales in part b) of point 264) to mean that:

- a) taken as a collection, the documents presented in the NSW EPA Tender Bundle define, and activate through policy, restrictions on activities in the State that directly or indirectly release greenhouse gases that act as pollutants responsible for climate change, and further, that
- b) these restrictions are consistent with keeping a global temperature rise *well below* 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C. Here, 'consistent with' is taken to mean restricting activities in NSW in a manner similar with the restrictions that must be taken globally to achieve these warming limits. In particular, the IPCC SR1.5 three-part test (see point 125) and the Closing the Production Gap test (see point 143) and Fig. 13) apply.

- 283) The language in point 282)a) has been chosen to include activities in the State that indirectly release greenhouses gas (e.g., Scope 3 emissions from combusting of fossil fuels by end users outside the State) because these emissions contribute to the climate change that affects the environment and people of NSW and because they could be subject to NSW objectives, guidelines and policies. From a climate perspective, NSW is the only jurisdiction that that can definitely stop these emissions from occurring.

- 284) The language in point 282)b) has been chosen not (only) because it aligns with the UN Paris Agreement (Article 2, clause 1a)), but because it aligns with what is both feasible and scientifically demonstrated to provide the best safeguard against high risks of damage to environment and human well-being, particularly those associated with extreme weather events, ecosystem loss, food productivity and mega bushfires. Importantly, it recognises tipping points²⁷⁸ in the Earth system, some of which may lie just beyond 2°C of warming.²⁷⁹
- 285) The phrase “this century,” which appears in the Paris Agreement, does not figure in the meaning described in point 282)b) because anthropogenic emissions must rapidly decline by 2030 and reach net zero by about mid-century in order to meet the stated global warming goal.
- 286) Finally, the definition of ‘*fit for purpose*’ used in this report is aligned with the Precautionary Principle and the Intergenerational Equity Principle, both of which are guiding principles under the *Protection of the Environment Administration Act 1991* (NSW).²⁸⁰
- 287) Current NSW EPA documents (e.g., documents #1, #6 and #8 in the Tender Bundle) clearly indicate that greenhouse gases are a pollutant, whether or not they are actually regulated as such by the State or by the NSW EPA.
- 288) Given this context, it is the judgement of this report that the objectives, guidelines and policies submitted by the NSW EPA in its Tender Bundle are not fit for purpose in protecting or mitigating against the threat posed by climate change to the quality of the environment and the people of New South Wales, for the following reasons:
- a) Most of the documents in the Tender Bundle are not directly associated with reducing greenhouse gases that cause anthropogenic climate change. (See Section 7.1 and Appendix D).

²⁷⁸ Schellnhuber HJ, Rahmstorf S, Winkelmann R (2016) Why the right climate target was agreed in Paris. *Nature Climate Change*, 6:649-653

²⁷⁹ Steffen W et al. (2018) Trajectories of the Earth System in the Anthropocene. *Proc. Natl. Acad. Sci. (USA)* doi:10.1073/pnas.1810141115 and associated Appendix
<https://www.pnas.org/content/pnas/115/33/8252.full.pdf>

²⁸⁰ Protection of the Environment Administration Act 1991, No. 60, NSW Government, Part 3, Section 6, accessed here: <https://www.legislation.nsw.gov.au/#/view/act/1991/60/part3/sec6>

- b) The current and planned (using current policy measures as outlined in Documents #165 and #173) emissions trajectory of NSW is not consistent with well-below 2°C nor with efforts to hold to 1.5°C.
- c) The EPA's Strategic Plan 2017-21 (Document #77) does not mention climate, climate change or greenhouse gases.
- d) The only policies contained in the NSW EPA Tender Bundle with specific, quantifiable targets for GHG reductions apply to a small fraction of NSW's total emissions, namely those attributable to NSW Government operations or organic waste.
- e) The major source of GHG emissions in NSW is not addressed: namely that from fossil fuel industries, particularly coal and coal seam gas production and combustion. Important documents related to these activities do not seek to reduce GHG emissions from these major sources. Examples include: Document #145 (Safeguarding future environmental liabilities from Coal Seam Gas Activities in NSW, 2020) and Document #236 (Review of Coal Fired Power Stations Air Emissions and Monitoring, 2018).
- f) Taken as an omnibus, documents in the Tender Bundle do not appear to acknowledge that decisions that allow growth in GHG emissions must be matched with even stronger reduction targets in other sectors/areas in order to meet overall emissions targets. This most specifically applies to Documents #165 and #173.
- g) Policies related to GHG (Documents in Table 5) do not appear to take into account principles that are said to be applicable in assessing the impacts of some projects with respect to pollutants,²⁸¹ namely, cumulative impacts (when a cumulative effect is more dangerous than sum of individual effects), threshold effects (effects that occur once a critical boundary is exceeded), and irreversibility, despite the fact climate change brought about by greenhouse gas emissions displays both of these characteristics, as discussed in Section 6.
- h) There is no consideration in the omnibus of Tender Bundle documents of activities in NSW that worsen climate change through their Scope 3 emissions. These emissions

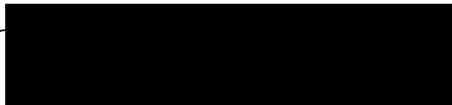
²⁸¹ See, e.g., Document #101, NSW Government (2015) Guidelines for the economic assessment of mining and coal seam gas proposals, 2015)

work directly against holding warming to well-below 2°C, let alone aiming for 1.5°C, by widening, rather than closing the fossil fuel Production Gap, particularly when they are expanded or new developments.

- i) Taken as an omnibus, the documents in the Tender Bundle do not acknowledge that from a Precautionary Principle point-of-view, current levels of GHG emissions are *already* dangerous.
- j) Taken as an omnibus, the documents in the Tender Bundle do not acknowledge that given current and future GHG emissions 'lock in' extra warming, so that there is no possibility for true 'remediation' to future generations for the climate damages they will experience from current policy settings. This point is directly relevant to the Intergenerational Equity Principle.

289) **In conclusion, it is the judgement of this report that that the objectives, guidelines and policies identified by the NSW EPA are not fit for purpose in protecting or mitigating against the threat posed by climate change to the quality of the environment and the people of New South Wales.**

Respectfully submitted on 5 March 2021,

A black rectangular box redacting the signature of Professor Penny D Sackett.

Professor Penny D Sackett