Expert Report

Independent Planning Commission

Public Hearing – Vickery Extension Project

February 2019

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Executive Summary

1. Anthropogenic climate change is real and poses serious risks for the wellbeing of humans and our societies. These risks rise rapidly and nonlinearly with the rise in global average surface temperature.

2. Recognising that the risks to human wellbeing of unchecked climate change are too high to accept, governments around the world have agreed to limit warming to 1.5-2.0°C (the 2015 Paris accord).

3. The carbon budget approach is the most robust way to determine the rate of emissions reductions required to meet the goals of the Paris accord. This approach limits the cumulative amount of additional CO_2 emissions that can be allowed consistent with the Paris accord.

4. To meet a 2°C carbon budget, a very rapid phase-out of all fossil fuel usage by 2050 at the latest, or preferably earlier, is required. The 1.5°C carbon budget is smaller, requiring an even more rapid phase-out of fossil fuel usage.

5. This means that the majority of the world's existing fossil fuel reserves must be left in the ground, unburned. Furthermore, no new fossil fuel developments, or extensions to existing fossil fuel mines or wells, can be allowed.

Introduction

6. I have prepared this report in response to an expert brief provided to me by EDO NSW acting on behalf of Lock the Gate, dated 8 February 2019. I have reviewed Division 2 of Part 31 and the Expert Witness Code of Conduct under the *Uniform Civil Procedure Rules 2005* and I agree to be bound by their terms.

Anthropogenic climate change and its impacts

7. Anthropogenic (human-driven) climate change refers to the changes in the climate system caused by human activities, primarily the emission of greenhouse gases into the atmosphere. The most important of these gases is carbon dioxide (CO_2), with about 90% of CO_2 emissions arising from fossil fuel (coal, oil, gas) combustion and the remainder from land-use change (Le Quéré et al. 2017).

8. Greenhouse gases change the climate by trapping outgoing heat (long-wave radiation) from the Earth's surface and retaining it in the lower atmosphere and at the surface, thus increasing the energy of the climate system and raising its average temperature (Intergovernmental Panel on Climate Change (IPCC) 2013).

9. Currently global average surface temperature is about 1°C higher than pre-industrial levels and 2015, 2016, 2017 and 2018 have been the four hottest years on record (Bureau of Meteorology (BoM) 2019).

10. The rate of climate change is alarming. The rise in atmospheric CO_2 concentration is up to 10 times faster than the most rapid changes in the geological record (Lüthi et al. 2008). Since 1970 global average surface temperature has been rising at a rate of 1.7°C per century, compared to a 7,000-year background rate of change of about 0.01°C per century (NOAA 2016; Marcott et al. 2013).

11. Many other features of the climate system, in addition to global average surface temperature, are changing as a result of anthropogenic greenhouse gas emissions (IPCC 2013). These include changes in the basic circulation patterns of the atmosphere and the ocean, increasing intensity and frequency of many extreme weather events, increasing acidity of the oceans, rising sea levels and consequent increases in coastal flooding, and intensification of the hydrological cycle.

12. The impacts of climate change are already being felt around the world. As reported by the IPCC (2013), the most authoritative assessment body on the science of climate change, some of the most important impacts are:
    a) Warmer and/or fewer cold days and nights over most land areas.
    b) Warmer and/or more frequent hot days and nights over most land areas.
    c) Increases in the frequency and/or duration of heat waves in many regions.
    d) Increase in the frequency, intensity and/or amount of heavy precipitation (more land areas with increases than with decreases).
    e) Increases in intensity and/or duration of drought in many regions since 1970.
    f) Increases in intense tropical cyclone activity in the North Atlantic since 1970.
    g) Increased incidence and/or magnitude of extreme high sea levels.

13. The impacts of climate change are also being felt in many ways across Australia, especially in the form of changes in extreme weather events (CSIRO and BoM 2015).

14. The evidence for the influence of climate change on worsening extreme weather include:
    a) The fact that all extreme weather events are now occurring in an atmosphere that is warmer and wetter than it was 70 years ago (Trenberth 2012);
    b) Long-term data records show observed changes in the nature of extreme weather; and
    c) Climate models run with and without the additional greenhouse gases in the atmosphere from human emissions show the increase in likelihood that a specific extreme weather event would have occurred because of climate change.

15. The most important of these climate-related impacts are (CSIRO and BoM 2015):
    a) Australia’s average surface temperature has increased by 0.9°C from 1910 to 2014, and is now 1.14°C above the long-term average (BoM 2019).

b) Many heat-related records were broken in the summer of 2012-2013, and again in the two most recent summers. 2013 was Australia's hottest year on record. Record-breaking heat continues. January 2019 was Australia's hottest January on record, with heatwaves unprecedented in their scale and duration (World Meteorological Organization (WMO) 2019).

c) Heat waves have increased in duration, frequency and intensity in many parts of the country.

d) Cool-season rainfall has declined in southeast and southwest Australia and wet-season rainfall has increased in northern Australia.

e) Heavy daily rainfall has accounted for an increased proportion of total annual rainfall over an increasing fraction of the Australian continent since the 1970s.

f) Extreme fire weather days have increased at 24 out of 38 monitoring sites from 1973-2010 due to warmer and drier conditions.

g) For 1966-2009 the average rate of relative sea-level rise along the Australian coast was approximately 1.4 millimetres per year.

16. Southeast Australia has experienced many of the impacts that have been observed around Australia as a whole (CSIRO and BoM 2015). In particular, these include:

    a) Changes in heatwaves, such as more frequent occurrence, increasing number of heatwave days and the hottest day of a heatwave becoming even hotter.

    b) Increases in the Forest Fire Danger Index have occurred mostly in the southeast region of the continent.

    c) Strong drying trends in cool-season rainfall since 1990.

    d) Three-fold increase in coastal flooding in the Sydney region through the 20th century.

17. The central slopes region of NSW has also experienced many impacts of climate change. These include:

a) Heatwaves have worsened in the following ways: (i) the number of heatwave days is increasing; (ii) the duration of the longest heatwave is increasing; and (iii) the hottest day of a heatwave is becoming hotter (Perkins and Alexander 2013).

b) In terms of bushfire weather, in the central slopes region of NSW there has been a significant increase in the McArthur Forest Fire Danger Index (FFDI) from 1973 to 2013 (CSIRO and BoM 2015; Clarke et al. 2013).

c) Observations show mixed changes in rainfall patterns for the region. For the northern wet season (October to April), rainfall has been above average for the 1997-2013 period. For the southern cool season (April to September – the main growing season for the agricultural sector), rainfall has generally been average, with some sub-regions recording above-average rainfall (CSIRO and BoM 2015).

Projections of future climate change

18. Future climate change will be driven in the near-term (several decades into the future) by the further amount of greenhouse gas emissions emitted by human activities, and in the longer term by both human emissions and feedbacks in the climate system (e.g., melting of permafrost, collapse of the Amazon rainforest) that could emit significant additional amounts of greenhouse gases to the atmosphere.

19. The projections for future changes in Australia's climate include (CSIRO and BoM 2016):
    a) Temperatures will continue to increase, with more hot days and fewer cool days.
    b) Oceans around Australia will warm further and acidification will continue.
    c) Tropical cyclones are projected to decrease in number but increase in intensity.
    d) Extreme rainfall events are likely to be more intense.
    e) Harsher fire weather is projected for southern and eastern Australia.
    f) Further decreases in winter rainfall for southern continental Australia, with an increase in droughts.

20. Projected changes in the climate of NSW central slopes region include (https://www.climatechangeinaustralia.gov.au/en/, based on CSIRO and BoM 2015):
    a) Average temperatures will continue to increase in all seasons, and increases will be greater than average in inland regions (*very high confidence*).
    b) More hot days and warm spells are projected with *very high confidence*. Fewer frosts are projected with *high confidence*.

c) Natural variability will predominate over climate change trends in the near term but decreases in winter rainfall are projected later in the century with *medium confidence*. Other changes are possible but unclear.

d) Increased intensity of extreme rainfall events is projected, with *high confidence*.

e) A harsher fire-weather climate in the future (*high confidence*).

21. Globally, climate change projections for the rest of the 21st century range from:

a) A low emissions scenario (phasing out fossil fuels by the 2040-2050 period), which leads to a rise in global average surface temperature of 1.5-2.0°C above pre-industrial levels; to

b) A high emissions scenario, which leads to a temperature rise of 4°C or greater by 2100 (Collins et al. 2013).

22. Current global emissions are now over 10 billion tonnes of carbon (emitted as CO_2) per annum, and have risen steadily since the mid-20th century, when emissions were about 3 Gt C (billion tonnes of carbon, emitted as CO_2) per year (Le Quéré et al. (2018; Figure 3). If the trend of rising emissions is continued, it would put the world on an emissions pathway between the IPCC RCP6.0 and RCP8.5 scenarios[1] (Collins et al. 2013, based on extrapolation of observed emissions trend in Le Quéré C et al. (2017); consistent with analysis in Climate Action Tracker (2018). Based on scenarios of changes in radiative forcing (i.e., the effect of (i) the atmospheric concentration of greenhouse gases and aerosols and (ii) the reflectivity of the Earth's surface on the Earth's surface energy balance – the difference between incoming solar energy and outgoing heat energy), climate models can simulate the resulting changes to the climate system).

23. Model-based projections of the level of climate change consistent with this emissions trajectory would lead to a global average surface temperature rise of 3-4°C by 2100. Thus, the world is currently on a pathway much closer to 21b) than to 21a) above.

24. The IPCC has summarised the risks to humanity of various levels of climate change through the so-called 'burning embers' diagram (IPCC 2014), Figure 1 below:

[1] "RCP" is Representative Concentration Pathway, which is a scenario for the concentration of greenhouses in the atmosphere. The numbers refer to the 'radiative forcing' for each scenario, in watts per square metre.

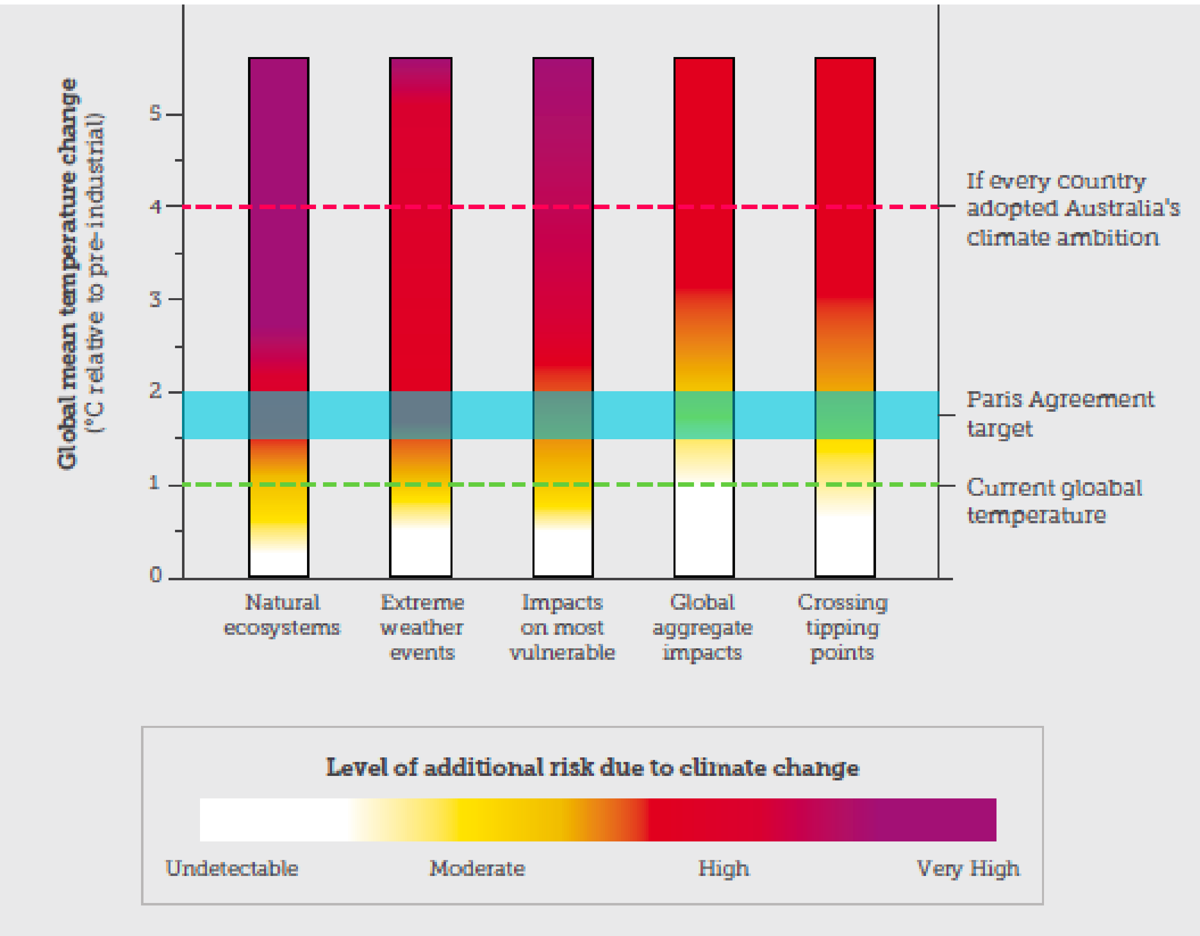

Figure 1: The IPCC 'burning embers' diagram – the reasons for concern about the impacts of climate change with increasing temperature. Adapted from IPCC (2014).

25. Figure 1 shows clearly that the impacts and risks of climate change increase nonlinearly with the increase in global average surface temperature, and connects these risks to levels of climate change using global average temperature as the indicator.

26. Figure 1 shows several levels of temperature:

a) The current observed level, ca. 1°C above pre-industrial levels;

b) The 1.5-2°C target range for the Paris accord; and

c) The level of temperature increase by 2100 (ca. 3-4°C above pre-industrial) that would be reached if every country adopted Australia's level of ambition in terms of targets and policies (Climate Action Tracker (CAT) 2018[2]). In its country analysis dated 30 April 2018, CAT identifies that Australia's emissions are set to far exceed its Paris accord Nationally Determined Contributions (NDC) target for 2030 (itself a target

[2] The Climate Action Tracker is an independent scientific analysis produced by three research organisations tracking climate action since 2009: www.climateactiontracker.org

which, if followed by all other countries would lead to global warming of over 2°C and up to 3°C). Further, CAT assesses that, if all other countries were to follow Australia's current policy settings, warming could reach over 3°C and up to 4°C.

27. The synthesis of information represented by Figure 1 shows that:
    a) Australia is not doing nearly enough to meet its obligations under the Paris accord, which it signed; and
    b) That if every country followed Australia's level of action, the world would be on a trajectory to reach a 3-4°C temperature rise by 2100 and would thus face extremely damaging levels of climate change impacts (point 26c) above and Figure 1).

28. At today's level of climate change – about 1°C above pre-industrial – many impacts are already occurring. For example, many natural ecosystems are already being severely damaged.

29. In Australia alone, the Great Barrier Reef suffered consecutive mass bleaching events in 2016 and 2017 driven by unusually high surface water temperatures as a result of climate change (Hughes et al. 2017); a large area of Tasmania's World Heritage forests was decimated by bushfires driven by unusually dry conditions with high temperatures (Prof D. Bowman, personal comm.); and a mass die-off of mangroves in the Gulf of Carpentaria which was driven by exceptionally high sea temperatures (Duke et al. 2016). Also at a 1°C temperature rise, extreme weather events are worsening in most parts of the world and severe impacts are already hitting the most vulnerable groups of people and countries (IPCC 2013; IPCC 2014).

30. The Paris accord range of 1.5-2.0°C is by no means 'safe'. As shown in Figure 1, at this level of climate change, the following risks/impacts would be expected:
    a) Risks to natural ecosystems would be high; this refers to a rapidly rising risk of extinction for vulnerable species as well as increasing damage to ecosystems, such as bleaching of coral reefs and damage to forests by fires and insect attacks.
    b) Extreme weather events would be far worse than today; for Australia this means far more severe heatwaves, more frequent and intense bushfires, an increase in extreme rainfall, and more frequent and damaging coastal flooding.

c) The risk of widespread impacts on the most vulnerable would rise from moderate towards high; this includes the population of less developed countries who have low resilience and adaptive capacity as well as the most vulnerable people in wealthy countries – children, older people and disadvantaged people.
d) The aggregated impacts of climate change around the world would increase political tensions and instabilities and take its toll on the global economy; as the most vulnerable countries and groups of people suffer increasing impacts, the risk of conflict and migration increases significantly, creating security threats in other parts of the world (UK MoD (Ministry of Defence) 2010; The White House 2015).
e) Some important tipping points, such as the Greenland ice sheet, would be at risk of being crossed, driving an unstoppable rise in sea level of up to 7 metres (Kintisch 2017). The summertime Arctic sea ice would almost surely disappear, accelerating warming in the northern high latitudes and disrupting atmospheric circulation patterns (e.g., the jet stream) (Figure 1; Schellnhuber et al. 2016).

31. A 4°C temperature rise would likely lead to a world that would hardly be recognisable today (IPCC 2014; Figure 1). There is a high to very high risk that:
a) Most of the world's ecosystems would be heavily damaged or destroyed;
b) Extreme weather events would be far more severe and frequent than today;
c) The most vulnerable people would increase greatly in number and, as large areas of the world become uninhabitable, migration and conflict would escalate;
d) The aggregated impacts around the world would significantly damage the entire global economy; and
e) A cascade of intrinsic tipping points in the climate system could drive ongoing strong warming even as humanity finally took action to reduce its emissions (Figure 1; Steffen et al. 2018).

32. A ca. 4°C temperature rise would result if all countries adopted Australia's current climate ambition and policy settings (CAT 2018).

Global and Australian targets for stabilising the climate system

33. In 2015, countries around the world carefully assessed the risks of allowing climate change to continue on a high emissions scenario (cf. Figure 1 and "Projections of future climate change" above) and agreed in the Paris accord on a new international framework for tackling climate change. The accord aims to "*…limit global average temperature rise to well below 2 ℃ and to pursue efforts to limit warming to 1.5 ℃*". The Paris accord is near-universal, with 197 countries signing the agreement.

34. Australia is a signatory to the Paris accord and so has committed to do its part in keeping the global average temperature rise to the 1.5-2.0°C range. Yet Australia's national greenhouse gas emission reduction target of a 26-28% reduction by 2030 compared to a 2005 baseline (United Nations Framework Convention on Climate Change (UNFCCC) 2015) is, based on an expert analysis by Australia's Climate Change Authority (CCA 2015), inadequate to meet Australia's Paris accord obligations.

35. The Climate Change Authority calculated that the appropriate target for Australia, consistent with its Paris accord obligations, would be a 45-65% reduction in emissions by 2030 from 2005 levels (CCA 2015).

36. Australia is not on track to meet its 2030 target, based on a linear emission reduction pathway between 2018 and 2030. Australia's emissions have actually risen over the past three years so Australia is trending in the wrong direction (Australian Government 2018), much less reducing emissions in order to meet the rate required. In fact, if the rest of the world adopted Australia's targets and policy settings, global average temperature would be headed for up to 4°C by the end of the century (CAT 2018), with all of the high-risk consequences outlined above.

37. This leads to the question of how does one scientifically determine what is an adequate rate of emission reductions to meet the Paris accord targets. A commonly used approach based on the well-proven relationship between the cumulative anthropogenic emissions of greenhouse gases and the increase in global average surface temperature (Collins et al. 2013) – the one adopted by the Climate Change Authority in 2015 (CCA 2015) – is the carbon budget approach.

The global carbon budget approach to climate stabilisation

38. The ‘carbon budget’ approach is a conceptually simple, yet scientifically robust, approach to estimating the level of greenhouse gas emission reductions required to meet a desired temperature target, for example, the Paris accord 1.5°C or 2°C targets (Collins et al. 2013).

39. The approach is based on the approximately linear relationship between:
    a) The cumulative amount of carbon dioxide (CO_2) emitted from all human sources since the beginning of industrialisation (often taken as 1870); and
    b) The increase in global average surface temperature (Figure 2; IPCC 2013).

40. Once the carbon budget has been ‘spent’ (emitted), then emissions need to be net zero[3] to avoid exceeding the temperature target.

[3] “Net zero emissions” means the magnitude of carbon dioxide emissions to the atmosphere is matched by the magnitude of carbon dioxide removal from the atmosphere by, for example, “carbon capture and storage – CCS” technologies, sometimes called “Negative Emission Technologies”. At present these technologies are in the early development stage, and none are technologically or commercially viable yet.

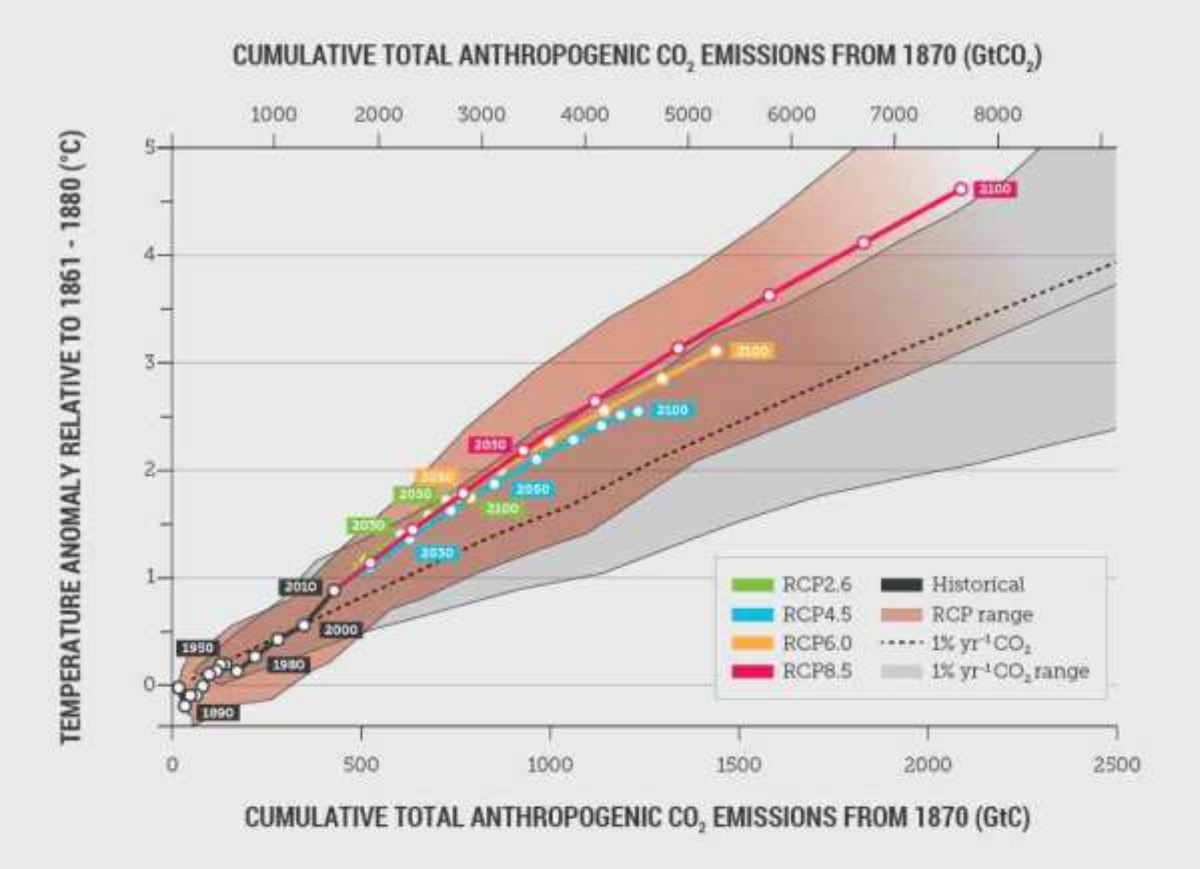

Figure 2: Global mean surface temperature increase as a function of cumulative global CO_2 emissions. The black line is global historical emissions and the coloured lines are climate model projections for various levels of human emissions. The coloured plume represents the spread of results across the models. From IPCC (2013).

41. There are several key areas of uncertainty that influence the carbon budget required to meet a temperature target:

a) **<u>Probability of meeting the target</u>**. Higher probabilities of meeting a given temperature target (e.g., 2°C) require a more stringent carbon budget. Thus, there is a critical trade-off: relaxing the carbon budget to make it more feasible to meet means that there is a lower probability of achieving the desired temperature target.

b) **<u>Accounting for other greenhouse gases</u>**. Non-CO_2 gases (e.g., methane (CH_4) and nitrous oxide (N_2O)), which are important contributors to warming, are assumed to be reduced to zero at the same rate as CO_2 is reduced to zero. If non-CO_2 gases are not reduced, or reduced more slowly than CO_2, then the CO_2 budget is reduced accordingly. Most of the CH_4 and N_2O emissions arise from the agricultural sector, where emission reductions are generally considered to be more difficult and expensive to achieve than for the electricity generation sector. Thus, carbon budgets are often configured on the basis that reduction of CO_2 emissions from the electricity and transport sectors is more technologically feasible and less expensive than for the non-CO_2 gases, and therefore CO_2 emissions should be reduced even further to compensate for the continued emission of non-CO_2 gases.

c) **Accounting for feedbacks in the climate system**. Some carbon cycle feedbacks, such as permafrost melting or abrupt shift of the Amazon rainforest to a savanna, are not accounted for in the carbon budget approach. Including estimates for these would reduce the budget further (Ciais et al. 2013; Steffen et al. 2018). These are likely to be very significant. Quantitative estimates suggest that at a 2°C temperature rise (the upper Paris accord target), about 110 Gt C (billion tonnes of carbon, emitted as CO_2) of additional emissions to the atmosphere (about 11 years worth of human emissions at current rates) would be emitted (Steffen et al. 2018). These estimated feedbacks would cut the remaining carbon budget in half (see Table 1 below).

42. Applying the carbon budget for a 2°C target demonstrates how it can be used. The IPCC estimates that for a greater than 66% probability of limiting global average temperature rise to no more than 2°C, cumulative human emissions since 1870 must be less than 1,000 Gt C (emitted as CO_2) (IPCC 2013). If non-CO_2 greenhouse gases are not reduced at the same rate, the carbon budget must be reduced by up to a further 210 Gt C to 790 Gt C (see 42b) above). From 1870 through 2018 cumulative human emissions have been about 585 Gt C (Collins et al. 2013; Le Quéré C et al.2018). The remaining budget then becomes 205 Gt C.

43. The current rate of human emissions of CO_2 is about 10 Gt C per year (Le Quéré et al. 2018), so at these present rates of emissions, the carbon budget would be consumed in about two decades (at about 2040).

44. I summarise this analysis in tabular form below:

Table 1: Carbon budget for a 66% probability of restricting temperature rise to no more than 2°C

Budget Item/Process	**Gt C**
Base budget based on IPCC (2013)	1,000
Accounting for non-CO_2 greenhouse gases	-210
Historical emissions through 2018	-585
Remaining budget to net zero emissions	**205**

45. The conclusion is that the world has 20-21 years of emissions (at current rates) remaining before the world's economy must reach net zero emissions (205 Gt C divided by 10 Gt C per year = 20.5 years).

46. Applying this budget to emission reduction trajectories emphasises the need to peak emissions by 2020 at the latest, followed by a steep reduction curve thereafter (the area under the curves created by emission reduction trajectories is equal to the cumulative emissions of CO_2, which can then be directly compared to a remaining carbon budget – see Figure 3 below).

47. The recent IPCC Special Report on the 1.5°C Paris target (IPCC 2018) has estimated carbon budgets required to meet that more stringent target. The remaining budget for a 66% probability of meeting the 1.5°C target is 155 Gt C, or about 15 years of emissions at current rates. Reducing the budget to allow for carbon feedbacks reduces the budget to about 8-9 years at present emission rates (Steffen et al. 2018).

Implication of carbon budget approach for the rate of emission reductions

48. The carbon budget approach has strong implications for the trajectory of emission reductions towards their eventual phasing out. Figure 3 shows the importance for the rate of emissions reductions of the peaking year (the year in which global emissions peak before starting their downward trajectory). The area under all of the curves on the graph are the same; they are equivalent to the cumulative carbon budget estimated by Figueres

et al. 2017 (cf. Figure 3), either 600 Gt CO_2 or 800 Gt CO_2[4]. To allow comparison to the carbon budget above, expressed as Gt C, these CO_2 budgets become 144 and 198 Gt C (or, 134 and 188 Gt C, taking 2018 emissions into account), the more generous budget comparing well with the budget estimated above (205 Gt C, Table 1), and the smaller budget comparable to the 1.5°C carbon budget.

49. Figure 3 demonstrates the absolute importance of peaking global emissions as soon as possible, and then reducing emissions strongly thereafter. Although global CO_2 emissions flat-lined for the 2014-2016 period, they rose again in 2017 and rose even more strongly in 2018 (Le Quere et al. 2018). This implies that 2020 is probably the earliest that emissions can peak, and it is important that they do. Delaying the peak just five further years would create a subsequent emission reduction trajectory that would be impossible to follow economically or technologically (Figueres et al. 2017).

50. The clear message from any carbon budget analysis, under any reasonable set of assumptions regarding probabilities of actually meeting the budget and the sensitivity of the climate system to the level of greenhouse gases in the atmosphere, is that fossil fuel combustion must be phased out quickly, at the rate of the curves shown in Figure 3.

51. Most of the world's existing fossil fuel reserves[5] – coal, oil and gas – must be left in the ground, unburned, if the Paris accord climate targets are to be met. I say that because the exploitation, and burning, of fossil fuel reserves leads to an **increase in** CO_2 emissions when meeting the Paris accord climate targets requires a rapid and deep **decrease** in CO_2 emissions.

52. An obvious conclusion that follows from this fact is that: No **new** fossil fuel development is consistent with meeting the Paris accord climate targets. That is, paragraphs 49-52 above demonstrate clearly that to meet the Paris accord, emissions must be reduced rapidly and deeply (cf Figure 3 below), and to do this requires the rapid phase-out of

[4] The 600 Gt CO_2 budget is the midpoint of a wider range of budgets that represents different ways of calculating the budget for the Paris target range (1.5-2.0°C). The 800 Gt CO_2 budget reduces the probability of meeting the 600 Gt CO_2 budget (Figueres et al. 2017).

[5] "Reserves" are defined by McGlade & Ekins (see below) as a subset of "resources" that are recoverable under current economic conditions and have specific probability of being produced. "Resources" are the remaining ultimately recoverable deposits of fossil fuels that are recoverable over all time with both current and future technologies, irrespective of economic conditions. Thus, "resources are all of the fossil fuels that are known to exist, and "reserves" are the subset of resources that are economically and technologically viable to exploit now.

existing fossil fuel mines/wells. It is an obvious conclusion that no new fossil fuel developments can therefore be allowed.

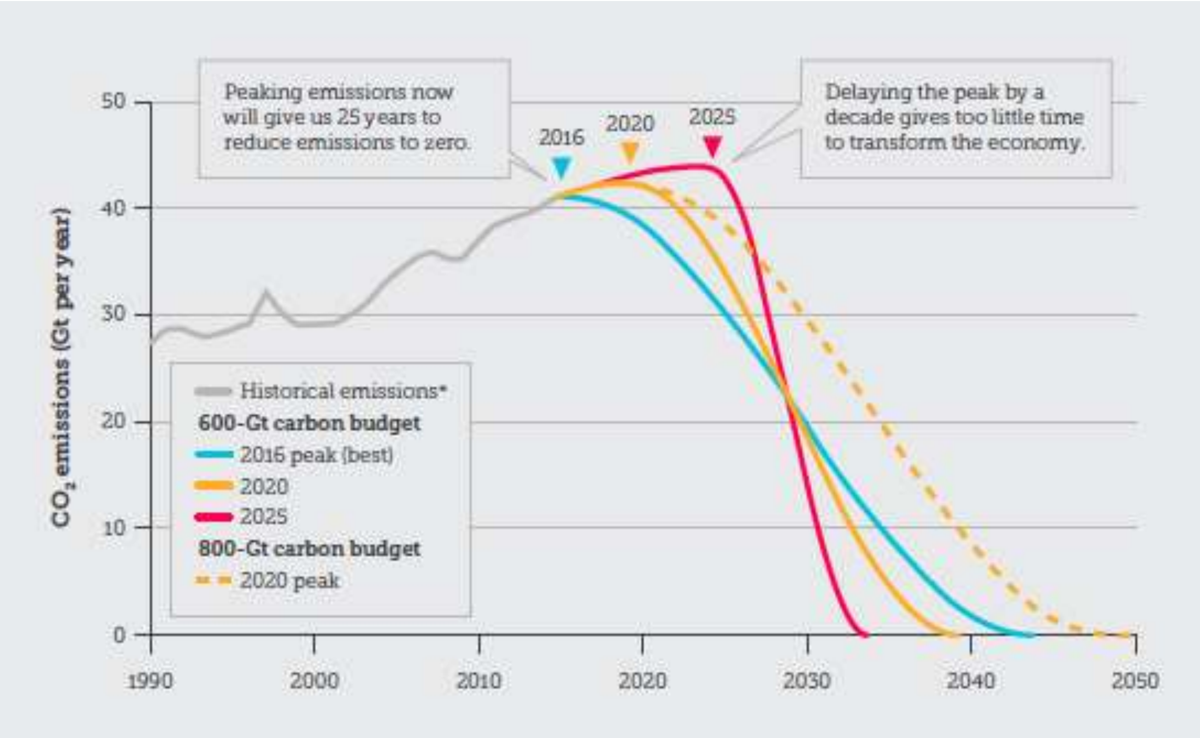

Figure 3. Emission reduction trajectories for meeting the Paris accord target(s). Delaying peak emissions to 2025 is too late for any achievable emission reduction trajectory. Note that the budgets in Gt CO_2; converting them to Gt C would give budgets of 164 Gt C and 218 Gt C, respectively. Budgets are from 2016; converting them to budgets from the end of 2018 would yield 134 Gt C and 188 Gt C, respectively. Source: Figueres et al. 2017

Applying the carbon budget approach to Australia and the Vickery Extension Project

53. An economic analysis of a generous global carbon budget highlights the implications of meeting the Paris accord climate targets for the Australian fossil fuel sector (McGlade and Ekins 2015). Based on a 50% probability of meeting the 2°C temperature target, the global budget for the 2011-2050 period was estimated by the authors at 300 Gt C, somewhat higher than the budget in Table 1. The study showed that if all of the world's existing fossil fuel reserves were burned, about 780 Gt C would be emitted as CO_2, about 2.5 times greater than the allowable budget. Globally, 62% of the world's existing fossil fuel reserves need to be left in the ground, unburned, to remain within the carbon budget.

54. Meeting the carbon budget consistent with the Paris accord climate targets therefore means that not only must currently operating mines and gas wells be closed before their economic lifetime is completed (obvious from point 54 above – 780 is much larger than the assumed budget of 300), but also that no approved (but not yet operating) and no proposed fossil fuel projects, based on existing reserves, can be implemented. This analysis applies to the Vickery Extension Project.

55. McGlade and Ekins (2015) then applied an economic analysis to the three types of fossil fuels – coal, oil and gas – and to the various regions of the world that are major producers of fossil fuels. Based on their analysis, 88% of global coal reserves are unburnable for any purpose (it is the CO_2 emissions that matter for the carbon budget approach, not the purpose for which the fossil fuel is burnt). The regional analysis yielded even more stringent conditions for Australia's fossil fuel industry (Australia is the only major fossil fuel producer in the OECD Pacific region; other countries in the region are only minor producers of fossil fuels). Over 90% of Australia's existing coal reserves cannot be burned to be consistent with the Paris accord 2°C target, and certainly not with the more stringent Paris accord 1.5°C target.

56. The conclusions from this – or any other analysis based on a carbon budget – are:

- **Australia's existing fossil fuel industries must be phased out as quickly as possible, with most of the Australian fossil fuel reserves (and nearly all of Australia's coal reserves) left in the ground.**

- **Development of new fossil fuel reserves, no matter how small, is incompatible with any carbon budget assuming a 50% or better chance of the budget meeting the temperature target (see paragraph 42a): that is, a very generous budget) and with Australia's commitments to the Paris accord.**

- **Based on this analysis, approval of the development of the Vickery Extension Project is inconsistent with the carbon budget approach to climate stabilisation.**

The fallacy of the "my emissions are too small to matter" or "some other coal resource will be developed if this one isn't" arguments

57. A common argument made for proceeding with new fossil fuel developments is that the resulting emissions are so small compared to the total global emissions (currently about 10 billion tonnes of carbon per annum) that they do not matter. The argument is made at the national level in terms of Australia's national emissions being such a small fraction (ca. 1.2%) of the global total that they don't matter (i.e., "even if we reduce our emissions, it won't have a major effect on the climate").

58. A second common argument is that if a proposed new coal development is not allowed to proceed, another new coal resource, either in Australia or overseas, will be developed to take its place. A supporting argument is that the development of new coal resources is required to meet society's basic energy needs (i.e., electricity).

59. These arguments are, in my opinion, fundamentally flawed. The first argument (paragraph 58) is flawed because it ignores the fact that global greenhouse gas emissions are made up of millions, and probably hundreds of millions, of individual emissions around the globe. All emissions are important because cumulatively they constitute the global total of greenhouse gas emissions, which are destabilising the global climate system at a rapid rate. Just as many emitters are contributing to the problem, so many emission reduction activities are required to solve the problem.

60. A useful analogy for this first argument is the total tax revenue that a government agency collects each year to support the activities of the government. While there are certainly some large taxpayers (just as there are some large carbon emitters), there are also millions of Australians who pay a small amount of tax each year, compared to the total revenue. Each of these taxpayers could make the argument to the government agency that their amount of tax compared to the total revenue collected is so small that it does not matter. The government agency would very likely not accept that argument, and nor should decision makers, in my view, accept the argument that some activity's greenhouse gas emissions are so small that they do not matter.

61. The second argument (paragraph 59) is flawed because it assumes that there is now, and will continue to be, a demand for new coal resources beyond those that already exist. Observations of global coal production show that this assumption is not valid. Global coal production peaked in 2013/2014 and has been in a steady decline since then (Our World in Data 2018). In fact, coal production is dropping in all regions of the world – North America, Europe & Eurasia, Africa, South & Central America, the Middle East and Asia-Pacific (which includes Australia). The trend towards decreasing coal production is very likely to continue, or even accelerate, as the world experiences more severe impacts of climate change over the coming decades and the economic and social advantages of renewable energy technologies become even more apparent than they are today.

62. The recent judgment in *Gloucester Resources Limited v Minister for Planning* on the Rocky Hill coal mine also recognised the flaws in the arguments in paragraphs 58 and 59 above.

[redacted]

Professor Will Steffen

9 February 2019

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