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Appendix

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Appendix: The *MJA–Lancet* Countdown on health and climate change: Australian policy inaction threatens lives

Introduction

This Appendix includes details of the data, methods, and caveats for each of the 41 indicators assessed in the Australian Countdown. It also includes additional figures and tables that further illustrate particular indicators. Finally, it includes, for each indicator, current thoughts regarding the potential future form of the indicator. This is provided in the context of this being the first Australian Countdown and the acknowledgement that its indicators, like those of the *Lancet* Countdown, will likely develop in future annual assessments.

Section 1: Climate change impacts, exposures, and vulnerability

Indicator	1.1. Health effects of temperature change
Data	1. Daily data on maximum temperature and minimum temperature were collected from Australian Bureau of Meteorology for three cities (Brisbane, Sydney, and Melbourne) during 1986 and 2017. 2. Historical data on daily non-accidental deaths in Brisbane, Sydney, and Melbourne were collected between 1988 and 2009 from Australian Bureau of Statistics (ABS).
Methods	1. To examine whether exposure to heat increases mortality risks or not, a Poisson regression model was used to estimate the city-specific association between summer daily mean temperature and mortality, while adjust potential confounders. A non-linear function was used for three days' moving average of temperature to assess the exposure-response curve. 2. Summer average temperature was calculated for each city for each year during 1986 and 2017. Temperature change was calculated relative to 1986–2008 from each city.
Caveats	We didn't assess the health impacts of temperature change in other seasons, e.g., winter, even though cold temperature also significantly affects mortality.
Indicator figure	Figure A1
Future form of indicator	Collect national data set for temperature and mortality, examine the association between temperature change in winter and the reduction in mortality, and calculate the net change in the temperature-related mortality.

Indicator	1.2. Health effects of heatwaves
Data	1. We collected daily data on maximum temperature and minimum temperature for three cities (Brisbane, Sydney, and Melbourne) during 1986 and 2017 from Australian Bureau of Meteorology. 2. Daily data on non-accidental deaths in Brisbane, Sydney, and Melbourne between 1988 and 2009 were collected from ABS.
Methods	1. To examine whether heatwaves increase mortality risks or not, we defined a heatwave as greater than the 95th percentile of minimum temperature for more than 3 days over the study period (1988-2009) for each city. A Poisson regression model was used to estimate the city-specific association between heatwaves and mortality, after adjustment for potential confounders. 2. To assess the change in heatwave days during 2000 and 2017, we defined a heatwave as greater than the 95th percentile of minimum temperature for more than 3 days over the study period (1988-2009) for each city. The change of heatwave length data (2000-2017) was calculated against the historical period of 1986–2008. The three cities' average change was also calculated.
Caveats	The heatwave definition used for this indicator differs from that used in Watts et al.[1] in that we used the 95th percentile and Watts et al. used the 99th percentile. A range of heatwave definitions are used within the scientific literature[2] and our selection of the 95th percentile is broadly within this range.
Future form of indicator	Collect national data set for assessing the association between heatwaves and non-accidental mortality.

Indicator	1.3. Change in labour capacity
Data	Data for this indicator are the same as those used for "Indicator 1.4 Change in labour capacity" in Watts et al.[3]
Methods	Methods for this indicator are the same as those used for Indicator "1.4 Change in labour capacity" in Watts et al.[3]

Caveats	Few studies quantify climate influence on Australia's labour capacity. Cited study limited by survey methodology. Assumes representativeness of sample /respondents, and extrapolated results. However, despite the inherent methodological flaws the ABS also uses this method to provide the nation's official summary statistics on labour.[4]
Future form of indicator	The future form of this indicator is the same as that for "Indicator 1.4 Change in labour capacity" in Watts et al.[3]

Indicator	1.4. Lethality of weather-related disasters
Data	This indicator summarises records from The Emergency Events Database (EM-DAT) at the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain, Belgium (http://www.emdat.be/). The records for all disasters in Australia between 1900 and 2018 were accessed on 16 April 2018 (last database update: 6 April 2018).
Methods	In the EM-DAT data used for analysis, a disaster is defined as either: (1) ten or more people killed; (2) 100 or more people affected; (3) a declaration of a state of emergency; or (4) a call for international assistance. EM-DAT classifies disasters in the following categories: • Drought: An extended period of unusually low precipitation that produces a shortage of water for people, animals and plants. • Flood: The overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than- normal levels along the coast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the rain fell (flash floods). • Storms: Including Tropical storms, Extra-tropical storms, and Convective storms. • Wildfire: An uncontrolled and non-prescribed combustion or burning of plants in a natural setting such as a forest, grassland, brush land or tundra, which consumes the natural fuels and spreads based on environmental conditions (e.g., wind, topography). Wildfires can be triggered by

	lightning or human actions. We summarised for each decade 1900-present the total deaths (the sum of confirmed deaths and missing persons), the total affected (the sum of those injured, homeless, and requiring immediate assistance) and number of individual disaster occurrences (Table A1). To compare the most recent decade to the 1990-99 baseline, we calculated the totals from 2008-2017 as shown in Table A2.
Caveats	The EM-DAT database definitions may not be appropriate when applied in high income countries such as Australia. For instance, a disaster is defined as ten or more people killed, but in Australia the disaster management systems are able to avert many deaths, so this may be too stringent. We also found discrepancies with other data sources. For example, Blanchi et al.[5] identified 825 deaths between 1901 and 2011 (compared to the 501 between 1900-2017 from EM-DAT), and so results shown are likely underestimated.
Future form of indicator	Future work should combine multiple data sources to mitigate the major limitations of the EM-DAT database.

Indicator	1.5. Trends in climate-sensitive diseases
Data	This indicator uses the Global Burden of Disease Study 2016 (GBD 2016) results published for Australia by the Global Health Data Exchange.[6] The database was accessed on 30 April 2018.
Methods	This indicator displays descriptive trends for selected diseases retrieved from the Global Burden of Disease (GBD) project database over the period 1990-2016. The trends are presented for Disability-Adjusted Life Years (DALYs), mortality rates and incidence rates per year over the period. Trends are described for: all causes, dengue, diarrheal diseases, environmental heat and cold exposure, exposure to forces of nature, malaria, malignant skin melanoma, and protein-energy malnutrition. We plotted for each year 1990-2016 the DALYs,

	deaths and incidence rates.
Caveats	The GBD estimates are derived from modelling, not from direct observations. The methods have been described elsewhere[6] and should not be interpreted as observed rates of death and disease. In Australia the registers of deaths and diseases is managed by a number of government agencies with complex access procedures and so the observed data were not available for use in this report. These trends do not describe the burden of death and disease attributable to climate change. Rather they present trends for diseases known with relative certainty to be influenced by climate. Therefore this indicator shows only the trends in climate relevant and climate sensitive diseases on death and disease rates since 1990 and is only a very non-specific proxy for impacts from climate change. Importantly, as a blunt instrument these data do not necessarily illustrate any burden from health outcomes that are known to be of significant public health concern in Australia. For example, the data for dengue give the impression that there is no dengue in Australia, however each summer there is an outbreak in Far North Queensland averaging about 700 cases. While of significance to the affected communities and the subject of massive public health mobilisation, these cases are all but lost on a national scale with 23 million people as the denominator.
Indicator figure	Figure A2
Future form of indicator	This indicator would be more robust and more specific were the disease trends based on observed direct measurements using longitudinal mortality and disease registers, rather than the GBD modelled estimates. Even if empirical data remain elusive, the GBD estimates are revised annually and hence new data are added enabling future versions of this indicator to include longer term trends, including capture of changing trends and re-analysis of old years. Additional future modifications could include other health conditions, and may extend to subnational scales. Increased capabilities in burden of disease attribution is likely to lead to future forms of this indicator which ascribe trends of diseases to climate change signals (such as changes in rainfall anomalies driven by the

	ENSO circulation).

Indicator	1.6. Climate-sensitive infectious diseases
Data	Data for this indicator are the same as those used for Dengue in "Indicator 1.8 Climate-sensitive infectious diseases" in Watts et al.[3]
Methods	Methods for this indicator are the same as those used for Dengue in "Indicator 1.8 Climate-sensitive infectious diseases" in Watts et al.[3]
Caveats	The caveats for this indicator are the same as those for Dengue in "Indicator 1.8 Climate-sensitive infectious diseases" in Watts et al.[3]
Future form of indicator	The future form of this indicator is the same as that for "Indicator 1.8 Climate-sensitive infectious diseases" in Watts et al.[3]

Indicator	1.7. Food insecurity and malnutrition
Sub-Indicator	1.7.1. Prevalence of food insecurity
Data	ABS[7] Australian Health Survey: Nutrition 2011-2012 ABS[8] Australian Aboriginal and Torres Strait Islander Health Survey 2012-2013
Methods	Information was collected from persons aged 18 years and over in the National Nutrition Physical Activity Survey.[7,8] Adult respondents were asked if there was any time in the last 12 months that they, or members of their household, had run out of food and couldn't afford to buy more. Respondents who answered yes were asked if they, or members of their household, had gone without food.
Caveats	Assessment of food insecurity in Australia: Food security, according to the World Health Organisation definition, requires constant access to sufficient, safe, nutritious food to maintain a healthy and active life.[9] The method described here only collects information on the number of households that have experienced financial barriers in regards to purchasing food. Others are examining measures of

	food affordability in Australia.[10,11]
Future form of indicator	A multi-item tool to assess all dimensions of food insecurity including: physical availability of enough nutritionally adequate, quality food; adequate financial resources and physical means of accessing such food; food utilisation; and the stability of the previous three dimensions over time through seasonal and temporal changes (for example see, Kleve et al.[12]).

Indicator	1.7. Food insecurity and malnutrition
Sub-Indicator	1.7.2. Prevalence of malnutrition
Data	ABS Australian Health Survey: Nutrition 2011-2012.[7] ABS Australian Health Survey: First Results, 2014-15.[13]
Methods	Malnutrition refers to deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients.[14] It therefore covers 'undernutrition' as well as overweight, obesity and diet-related non-communicable diseases (NCDs). Overweight and obesity: Body Mass Index (BMI) is a commonly used measure for defining whether a person is underweight, normal weight, overweight or obese. In the National Health Survey,[7] respondents' height and weight were measured to determine their BMI score. Fruit and vegetable consumption: Usual consumption of fruit (fresh, dried, frozen, tinned, not juice) was recorded as serves of fruit per day.[7] Usual consumption of vegetables (fresh, frozen, tinned) was recorded as serves of vegetables per day.[7] Intakes of iron, zinc and discretionary foods: 24-hour diet recall data.[13] The Australian Dietary Guidelines states discretionary foods are: "foods and drinks not necessary to provide the nutrients the body needs, but that may add variety. However, many of these are high in saturated fats, sugars, salt and/or alcohol, and are therefore described as energy dense. They can be included sometimes in small amounts by those who are physically active, but are not a necessary part of the diet.".[15]

Caveats	Assessment of nutrient intake in Australia: Nutrient intake, by means of the 24-hour dietary recall, is as reported by respondents. Recall error such as under-reporting or deliberate misreporting can occur. In addition, the food composition data that are used to determine nutrient intakes may be out-dated or based on data collected outside of Australia.
Future form of indicator	Prevalence of overweight and obesity. Prevalence of fruit and vegetable consumption and intakes of iron, zinc and discretionary foods calculated using multiple 24 hour recall data along with up-to-date and relevant food composition data.

Indicator	1.8. Migration and population displacement
Data	Data source: 1) Peer-reviewed literature mentioning climate change and migration, with a focus on Australia.
Methods	Simple systematic review. Using PubMed database, searched for terms "migrat*" AND "climate change" AND "Australia" appearing in any indexed article with no restrictions on language or publication year. This yielded 124 items. Titles and abstracts for these 124 articles were reviewed for relevance. Those relating to non-human species were discarded, as were those referring to historical climate change (e.g., genetic bottlenecks), or to health exposures or outcomes that were not then related to migration. There were four remaining papers that addressed human migration and climate change.[16-19] The search and review process above was repeated, replacing "Australia" with "Pacific" to find papers relevant to the region, on the assumption that the vulnerability of small islands to climate change is well established and that climate change migration in the region may therefore be significant. This initial search yielded 90 articles, and of these, using the same criteria above, only two linked human migration to climate change, and only one of these was relevant to the Pacific[20] (the other mentioned drought in Africa, as originating from a Pacific El Niño).[21] The remaining 5 papers were read in full to determine

	whether there were estimates of number of people in the region who have migrated in the region due to climate change.
Caveats	Unable to quantify migration that has already taken place due to climate change, whether solely due to climate change or where climate change is a contributing factor. Only the peer-reviewed academic literature was searched, omitting any government assessments and reports on past and potential migration due to climate change. Even then, climate change as a reason for the relocation (past or planned) would only be cited in very acute cases, where whole communities have re-located, for example. Individuals, families and farming businesses that are able to choose to relocate proactively because of noticeable trends (e.g., fruit growers moving to cooler areas to continue to be able to produce fruit) to protect their business, families moving to more comfortable climates, are not able to be included.
Indicator table	Table A3
Future form of indicator	Tracking migration from 'climate vulnerable' case study areas over time. Better understanding of both detrimental and protective effects of migration on health and wellbeing under particular circumstances (e.g., forced or planned migration) in migrant populations. A broader literature search and review that includes non-peer reviewed literature such as government and intergovernmental reports would be an important next step in attempting to quantify climate change impact on migration in Australia and the Pacific region.

Indicator	1.9 Mental health
Data	Death rates due to self-harm (suicide) data for females and males for each state and territory were taken from the ABS standardised death rates for every year of the decade 2007-16 (latest available year at the time of writing). Standardised rates are deaths per 100,000 of estimated mid-year population adjusted for age structures (see http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/3303.0~2016~Main%20Features~Intentional%20self-harm:%20key%20characteristics~7). With 28 (5.71%) missing values, we were able to extract a total

	of 132 observations for the decade (8 jurisdictions * 10 years * 2 sexes, less 28 missing values). We did not impute missing values primarily because death rates are highly variable across years and jurisdictions and imputation would have led to the introduction of too much error. We identified two extreme outliers in suicide rates, both from the NT, one for males in 2007 and one for females in 2015. These outliers heavily biased initial results and were removed. To match the death rates time series, mean annual maximum temperatures for each state and territory were calculated from Bureau of Meteorology climate data archives for every year of the same decade, 2007-16 (see http://www.bom.gov.au/climate/current/statement_archives.shtml). Maximum annual recorded temperatures for each weather station in each district in each jurisdiction were summed and the total value was divided by the number of observations to derive a mean annual maximum temperature for that year. This process was repeated for all eight jurisdictions for each of ten years, delivering a total of 77 observations (there were no data for WA for 2007-09). An identical process was used to derive the mean difference between each annual temperature observation and the long-term moving mean (calculated from all available data). This delivered 76 observations with four missing data points. In both cases, there were missing values for a very small number of weather stations in some jurisdictions in some years. We did not impute these missing values but used the available data from the weather stations in that district and all the other districts to calculate mean scores for that state/territory for that year. Following initial exploratory analyses, data for Antarctica (district 300, Macquarie Island) were removed from the dataset for Tasmania because these data were extreme outliers and heavily biased initial results. For example, in 2015 (an average year with no deviation from the long-term mean), the maximum temperature from the Macquarie Island station was 6.6°C when the equivalent value for the rest of Tasmania was 16.57°C with a mean variation of +0.18°C.
Methods	We began by conducting one-way analyses of variance to test whether mean suicide rates and mean maximum annual temperatures differed significantly by jurisdiction. All means on both variables differed significantly from all other means indicating that each

	state and territory had its own unique heat and suicide profile for the decade 2007-16. Pearson Product Moment correlations indicated that, nationally over the decade, suicide rates were significantly but weakly positively correlated with mean maximum annual temperatures (r=.23, p-value <.05). In a multiple linear regression model, sex and temperature each made statistically independent contributions to explaining variance in suicide rates. A scatterplot was produced to examine the shape of the relationship; in contrast to a linear regression line, which fit the data significantly but weakly for males and non-significantly for females (Figure A3top), a cubic regression line fit the data optimally and well for both females and males (Figure A3bottom). It also appeared evident from the scatterplot that the pattern of associations between suicide and temperature differed by sex (two clearly separate groups of observations were evident as shown below; blue markers = males, green markers = females). To test this, we conducted a linear regression analysis using sex and mean maximum annual temperature as simultaneous predictors of suicide rate, controlling for annual state-level temperature anomalies to hold constant annual deviation from the long-term mean. Standardised beta coefficients indicated that both predictors significantly independently predicted suicide rate, sex particularly strongly, such that higher temperatures and being male predicted a higher suicide rate. Standardised residuals statistics indicated the possible presence of two different groups (reflecting the findings from the scatterplots). The sample was therefore split by sex and separate analyses were conducted for males and females. These analyses fit the data slightly better for males but not for females, for whom the results were non-significant. This was inconsistent with the findings from the scatterplots. The introduction into the regression analysis of dummy variables for seven of the states and territories (NSW, the most populous state, was the reference category) produced a strong model, adding substantively to the model fit, and revealed that, when accounting for state/territory, temperature was a much stronger predictor of suicide than the previous models indicated. We noticed that some of the beta coefficients were negative (indicating higher suicide rates in the presence of cooler weather). Based on exploratory analyses, the

	states were allocated to one of two groups based on their mean maximum annual temperatures, warm (NSW, VIC, QLD, SA, WA, NT) or cool (TAS, ACT). Separate regression analyses by warm or cool state/territory categories produced well-fitting linear associations between mean maximum annual temperature and suicide rate, and revealed sex differences in the nature and strength of this relationship (see main text).
Indicator figure	Figure A3
Caveats	The use of standardised rates rather than raw data overcomes errors in suicide rates due to inter-year and between-jurisdiction variations in population size and age profile. However, there are well-rehearsed problems with suicide data, problems that cannot easily be overcome (such as suspected substantial under-reporting). Thus, to establish patterns of relationship between unusually hot or cool weather and mental health, investigations using other mental health outcomes will be needed. Using mean maximum annual temperature is a crude measure of exposure to unusually hot or cool weather, especially in states and territories with substantial climate variation (e.g., NSW has hot dry desert, wet sub-tropical, cold mountainous and temperate coastal climate zones). Annual temperature also fails to account for seasonal variation in weather, which is associated with mental health and suicide. Further, only ten years of data have been analysed and so we cannot account for longer-term trends or for exposures and impacts in previous years. Additionally, population size, characteristics and dispersion vary enormously among jurisdictions. The use of more fine-grained (but still substantively meaningful) geographic resolution will help address these problems and also permit within-year analyses which are not possible with a cell size of eight states and territories. This indicator, if used in future years, will be refined to account for these data limitations and opportunities. We found preliminary evidence of important interactions between gender, location, underlying climate and suicide. This is not the appropriate place to analyse these factors but they need to be investigated in detail because they have substantive implications for policy and service development and, ultimately, for human health and wellbeing. In this respect, the

	jurisdiction-level analysis that we have conducted is useful and appropriate because state and territory governments are key actors in adaptation planning and implementation, and in health and related service delivery. Finally, we found no clear upward or downward trend nationally in the strength of the association between mean maximum annual temperature and rates of death by self-harm over the decade and the reason for this will need to be investigated at finer spatial resolution.

Section 2: Adaptation planning and resilience for health

Indicator	2.1. Australian adaptation plans for health
Data	The data for this indicator consists of the adaptation plans obtained through the various internet searches and other related documents.
Methods	This indicator explores the status of adaptation plans for health for Australia and for each of Australia's six states (New South Wales (NSW), Queensland, South Australia (SA), Tasmania, Victoria, and Western Australia (WA)) and two territories (Australian Capital Territory (ACT) and Northern Territory (NT)). It also considers some broader aspects of adaptation planning in Australia. Documents were sourced through internet searches using combinations of search terms such as "Australia", the various state/territory names, "adaptation", "plan", and "health".
Future form of indicator	Could do WHO Climate and Health Country Survey at state/territory level.

Indicator	2.2. City-level climate change risk assessments
Data	Data source: 1. Publicly available risk assessments and adaptation strategies from all state and territory and governments, and from local council for each capital city. 2. Cities Power Partnership, member councils http://citiespowerpartnership.org.au/ Data included 1. Whether a risk assessment had been conducted for a given city by its State/Territory government and/or local council and/or the existence of

	a city adaptation strategy for the state or city; 2. Whether elements of that assessment or strategy explicitly target health and wellbeing and health services; 3. Number and location of city councils (local government) with renewable energy pledges made under the Cities Power Partnership.
Methods	Using Google, each of Australia's eight capital cities were searched for separately by name along with keywords 'climate change' AND 'risk assessment' and 'climate change' AND 'adaptation'. Links to State and Territory government websites were followed to find their climate change risk assessments and adaptation strategies. To ensure capture of relevant documents, each State and Territory's website was searched using 'climate change' to determine the department/s responsible for climate change risk assessment and adaptation. Local city council websites were also searched for 'climate change' in order to find any council specific risk assessment and adaptation reports. This search was limited to the local government councils with the same name as the capital city. The names of all city councils participating in the Cities Power Partnership was sourced from the publicly available list at http://citiespowerpartnership.org.au/wp-content/uploads/2018/01/list-of-first-second-round-councils-alphabetical-order_FINAL.pdf and was current at January 2018. The number of all state and territory councils were obtained from official contact lists of state and territory.[22-28]
Caveats	Only publicly available reports have been used. There may be additional analyses by government agencies that have been conducted but were not able to be included. Only the report that was deemed to be the primary report for each state/city was used, e.g. sector specific reports were not used unless they specifically related to health. In many instances, individual local governments (councils) had also produced risk assessment or adaptation reports. As these councils are numerous even within a single city, only assessments from the council named as 'City of Sydney' or City of Melbourne', which include the central business district, were sought. It cannot be assumed that the existence of an adaptation strategy means that that risks or hazards associated with climate change had been formally identified through a risk or impact assessment.

	The Cities Power Partnership is a free, non-profit support and networking initiative to facilitate renewable energy projects at local level. This is an opt-in partnership, and may not represent all local councils who are supporting renewable energy projects.
Indicator table	Tables A4, A5, A6, A7
Future form of indicator	Comprehensive adaptation strategies for all capital cities and regional population centres that include a focus on health and wellbeing; the linking of health to other sectors (e.g., water, housing, urban planning, energy, infrastructure); links between greenhouse gas mitigation and adaptation, including co-benefits.

Indicator	2.3. Detection and early warning of, preparedness for, and response to health emergencies
Data	Government websites and personal communications
Methods	Online searching
Caveats	Relevant indicators are obtained by online searching.
Future form of indicator	Working closely with EMA and SES/Health Departments in each jurisdiction to have regular updated information.

Indicator	2.4. Climate information services for health
Data	Bureau of Meteorology (BOM) Data Catalogue website: http://www.bom.gov.au/metadata/catalogue/ Public website: http://www.bom.gov.au/weather-services/ Vic Emergency website: https://emergency.vic.gov.au/prepare/#thunderstorm-asthma-forecast BOM service development and collaborative research projects.
Methods	The Bureau of Meteorology provides weather and climate products that are directly targeted or tailored to

	the public health sector. This indicator counts the types of products that are currently available.
Caveats	Some products are currently in pilot stage and may not be continued, pending results from the pilot. Others are fully operational (i.e., technically and scientifically supported in an ongoing way).
Indicator table	Table A8
Future form of indicator	The Bureau is improving its capability to provide information relevant to the public health sector, and additional services may be possible in future.

Indicator	2.5. National assessment of vulnerability, impacts, and adaptation for health
Data	Data source: The Australian Government's Garnaut Climate Change Review (2008)[29] and Garnaut Climate Change Review – Update 2011;[30] the Climate Commission "Critical Decade" report series (2011-2013).[31-37]
Methods	The original and updated Garnaut reports were sourced from http://www.garnautreview.org.au/ The archived reports from the Climate Commission were sourced from https://climatecommission.wordpress.com/ The national level reports were read for sector coverage and key findings/recommendations.
Caveats	The 2008 Garnaut Review and its 2011 update are the only two multi-sectoral national assessments of climate change commissioned by the Australian Government. Both of these were commissioned under Labor governments. Australia has had a conservative coalition government (Liberal-National) since September 2013. There have been no further government sponsored, cross-sectoral national assessments. The government funded independent body, the Climate Commission, produced a number of sector-specific reports between 2011 and 2013, but was disbanded soon after the Coalition government took office in 2013. The crowd-funded Climate Council formed in response to the abolition of the Climate Commission, founded by ex-Commission members, and has since become Australia's key producer of climate change assessments and policy advice. The

	Climate Council has produced more than 90 reports and fact sheets since 2013. (https://www.climatecouncil.org.au/category/reports). These are the result of private funding and have not been included here with the government sponsored assessments.
Indicator table	Table A9
Future form of indicator	Australia is overdue for a comprehensive, national assessment of climate change impacts and mitigation and adaptation options. A new assessment must extend beyond the impact of climate change on the economy and consider the costs to people and their communities, and the cost to the natural environment including biodiversity, the costs to people's health and to the health system. With the health impacts of climate change in Australia now well understood, the focus should be on building resilience both in underlying population health and in the systems that support health. This assessment should emphasise co-benefits of mitigation to both population health and the environment, and include broader strategies to improve the underlying health of populations and ecosystems.

Indicator	2.6. Climate-resilient health infrastructure
Data	Data source: 1. Publicly available risk assessments and adaptation strategies from all state and territory governments, and from local council for each capital city, sourced as described under Indicator 2.2. Data included 1. Whether a risk assessment/adaptation strategy explicitly considered health services and/or systems as (a) being affected by climate change and (b) whether there were strategies for increasing resilience of infrastructure.
Methods	Reports from State and Territory governments were sourced using the search strategy described under Indicator 2.2.[38-60]
Caveats	Only publicly available reports have been used. There may be additional analyses by government agencies that have been conducted but were not able to be included. Only the report that was deemed to be the primary report for each state/city was used, e.g. sector specific reports were not used unless they specifically

	related to health. In many instances, individual local governments (councils) had also produced risk assessment or adaptation reports, and these sometimes referred to health and health infrastructure. For these, only assessments from the council named as 'City of Sydney' or City of Melbourne', etc., which include the central business district, were sought. It cannot be assumed that the existence of an adaptation strategy means that that risks or hazards associated with climate change had been formally identified through a risk or impact assessment.
Future form of indicator	Comprehensive adaptation strategies for all states and territories that examine the vulnerabilities of their health infrastructure, with a view to both the external climate pressures (e.g., withstanding floods, fires, and other extreme events) and coping with (oftentimes unpredictable) surges in patient care, due to some climate-change related event, as well as the relatively steady increasing patient load due to combined pressure of both an aging population alongside these events that increase population vulnerability.

Section 3: Mitigation actions and health co-benefits

Indicator	3.1. Carbon intensity of the energy system
Data	This indicator measures the carbon output per unit of energy consumed. Data for this indicator are based on data provided by the International Energy Agency.[61]
Methods	In accordance with Watts et al.[1], the technical definition for this indicator is tonnes of CO_2 emitted for each unit (TJ) of primary energy supplied. The indicator has been selected by Watts et al.[1] as the carbon intensity of the energy system provides insights into the level of fossil fuel use, which in turn impacts air pollution. Higher values for the carbon intensity of the energy system indicate that the energy system is dominated by carbon-intensive (i.e., fossil-fuel-intensive) energy production, and is likely to have a higher share of coal-powered energy production. The indicator for Australia is calculated based on total CO_2 emissions from fossil fuel combustion in Australia divided by Total Primary Energy Supply (TPES), that is, the total amount of primary energy used in

	Australia, accounting for the flow of energy imports and exports. Australian data are available mostly from 1960 - 2013.
Caveats	This indicator only provides information about the overall carbon intensity of the energy system, but does not provide more detailed information about the energy mix within Australia (for example, the relative share of different fossil fuels, also across in different sectors), the extent to which pollution abatement measures have been put into place going forward, as well as the absolute levels of usage of fossil fuels.
Future form of indicator	Data can be updated to include more recent years.

Indicator	3.2. Coal phase-out
Data	The graphic presented in this document is available freely for download. However, the corresponding report and dataset are only available for purchase: https://www.iea.org/bookshop/751-Coal_Information_2017
Methods	The following indicator is used here: Total primary coal supply for Australia (in Mtoe), also in comparison with total primary coal supply by India, China, and the US. The indicator allows to assess changes in coal consumption across the selected countries and regions.
Caveats	The indicator provides a proxy for air quality emissions associated with the combustion of coal, however, it does not provide detailed information about how the combustion of different coal types translates into different air quality pollutants.
Indicator figure	Figure A4
Future form of indicator	The indicator can be improved in the future to convert coal use by sector and type into emissions of different air quality pollutants.

Indicator	3.3. Zero-carbon emission electricity

Data	Data for this indicator are available from the OECD: https://www.oecd-ilibrary.org/energy/data/iea-electricity-information-statistics/oecd-electricity-and-heat-generation_data-00457-en
Methods	In accordance with Watts et al.[1], several different metrics are used to determine the installed power and generation of renewables. • Electricity generation (gross electricity) from low carbon sources (TWh/EJ) • Share of electricity generation from low carbon sources (%) (including nuclear), estimated as a % of total generation • Generation from renewables (gross electricity) (excluding hydro, TWh/EJ) • Share of electricity generation from renewables (%), estimated as a % of total generation Low-carbon sources are defined as sources that have zero-carbon or low-carbon emissions at the point of energy production (i.e., this excludes biomass, but includes nuclear and hydro). Renewable sources are defined as sources that produce energy from renewable sources in a sustainable manner (this includes bioenergy, geothermal, hydropower, ocean energy, solar energy and wind energy, but excludes nuclear).[1] Increase in the use of low carbon and renewable energy for electricity generation will decrease the reliance on fossil fuels, and thus create improvements in air quality, with benefits to health.[1] Following Watts et al.[1], generation (instead of capacity) has been chosen as a metric as low-carbon and renewable energy generation will replace fossil-based generation.
Caveats	Information on electricity generation from low carbon and renewables sources does not provide information regarding implications for air pollutant emissions.
Indicator figures	Figures A5, A6, A7

Future form of indicator	Future analysis can attempt to provide further insights into implications for air pollutant emissions.

Indicator	3.4. Access to clean energy
Data	This indicator relies on secondary data provides by the Clean Energy Council.
Methods	Watts et al.[1] focus on access to electricity worldwide, and health issues arising from burning unsafe, unsustainable and inefficient fossil fuels, in particular in indoor settings. Given that Australia is a developed country and essentially all of Australia's population has access to electricity (noting issues with reliable access in remote areas), the indicators used by Watts et al.[1] are not directly applicable for the Australian setting. As such, this indicator was modified to draw on data from the Clean Energy Council and other sources to provide data on renewable energy uptake in Australia, as well as access to small-scale renewable energy systems.
Caveats	Essentially there is limited information for Australia's remote and indigenous communities.
Future form of indicator	Data on renewable energy access in indigenous and remote communities is sparse. Diesel generators are often used in these communities, and the future form of this indicator could try and track both the use of such unsustainable energy generation as well as the update of renewable alternatives.

Indicator	3.5. Exposure to ambient air pollution
Sub-Indicator	3.5.1. Exposure to air pollution in cities
Data	Daily average $PM_{2.5}$ data (24-hour averages) were utilised for the years 2013, 2014 and 2015 from state government agency ground-based monitoring stations in 75 locations around Australia. This represents all the $PM_{2.5}$ monitoring sites from across the entire country. The majority of monitoring stations were located in major cities, as they are concentrated around larger population centres. Some stations were located in rural and regional areas.

	Each state and territory provided data upon request: Environment Protection Authority Victoria, NSW Office of Environment and Heritage, Department of Environment and Science Queensland, Environment Protection Authority SA, Environment Protection Authority Tasmania, Department of Water and Environmental Regulation WA, Environment Protection and Water Regulation ACT and NT Environment Protection Authority.
Methods	This indicator measures urban background annual average concentration of fine particulate ($PM_{2.5}$) air pollution in selected cities. Measurements are from monitoring stations located in urban 'background' areas. We used the spatial boundaries of all urban centres published by the ABS.[62] All urban centres with greater than 100,000 population were selected and all monitoring site data were linked if they were within 50km of the geographic centroid of each urban boundary. Annual averages for each monitoring site were calculated from the daily averages for years where the site had more than 60% days observed. These site-specific annual averages were then aggregated into an annual average for each city. Results are shown in Table A10 for 2013, 2014 and 2015 (along with the number of sites used in each city and year to compute the city-wide averages).
Caveats	Some sites used different measurement method and some site locations changed over time.
Indicator table	Table A10
Future form of indicator	In future assessments this indicator will use improved spatial models of $PM_{2.5}$ across cities and population weighted exposure estimates.

Indicator	3.5. Exposure to ambient air pollution
Sub-Indicator	3.5.2. Premature mortality from ambient air pollution by sector
Data	**Spatial and temporal coverage** Data were obtained for the years 2015 for the entire country.

	Health data Age-specific mortality rates were obtained from the ABS database: "Deaths, Year of occurrence, Age at death, Age-specific death rates, Sex, States". **Population data** We utilised several datasets to represent the spatial and demographic attributes of the population: Spatial boundaries were obtained from the ABS.[63] Mesh Blocks are the smallest geographic region for which Census data are available. The number of inhabitants of the Mesh Blocks were from ABS dataset "2074.0 - Census of Population and Housing: Mesh Block Counts, Australia, 2016". Populations for the medium sized geographic units called Statistical Area 2 (SA2) were obtained from the ABS dataset "2016 Census of Population and Housing General Community Profile Tables (Catalogue number 2001.0)". **Particulate Matter less than 2.5 µm in diameter ($PM_{2.5}$)** Annual average $PM_{2.5}$ concentrations were obtained from a modelled dataset "Surface $PM_{2.5}$ Global Estimates (V4.GL.02): Atmospheric Composition Analysis Group at Dalhousie University Data". We used the estimated data for "All Composition $PM_{2.5}$ Satellite-Derived $PM_{2.5}$, 2015, at 35% RH [$\mu g/m^3$], 0.01° × 0.01° with Geographically Weighted Regression (GWR) adjustment". This dataset has grid cell sizes of 0.01 x 0.01 decimal degrees or approximately 1km x 1km. Some Mesh Blocks were not covered by any 1km x 1km grid cells due to masking of water bodies and the coastline, so the 10km x 10km grid cell data were used to fill those gaps. The methodology for this model is described by van Donkelaar et al.[64]
Methods	**Aim** This indicator aims to quantify contributions of individual source sectors to ambient $PM_{2.5}$ exposure and its health impacts. However, source specific estimates of air pollution exposure were not available for Australia and so the current assessment estimates the burden of premature mortality due to all anthropogenic sources, based on assumed levels of non-anthropogenic sources (see below). **Overview of quantification of the annual burden of mortality attributable to air pollution** Due to the generally low levels of air pollution exposure in Australia we followed the approach of the World Health Organization's (WHO) Health Risks of

	Air Pollution in Europe project (HRAPIE) report.[65] We applied the linear Relative Risk (RR) recommended by the HRAPIE project for effects of long-term $PM_{2.5}$ exposure on all-cause mortality. This is a relative risk of 1.062 (95% CI = 1.040, 1.083) per 10 μg/m^3 change in the pollutant, with no lower threshold on the concentration-response function. In this approach the Attributable Number (AN) of each small area's expected deaths to the anthropogenic $PM_{2.5}$ was calculated as: $Attributable_i = \sum\left[\left(e^{(\beta \times PM2.5anthro_j)} - 1\right) \times \left(Rate_i \times Pop_{i,j}\right)\right]$ Where: β is a exposure-response coefficient defining the relationship between exposure to $PM_{2.5}$ and all-cause mortality $PM2.5anthro_j$ is the level of exposure to anthropogenic $PM_{2.5}$ in small area j $Rate_i$ is the age-specific all-cause mortality rate for age-group i in the standard population $Pop_{i,j}$ is the population affected in age-group i, in small area j. The HRAPIE report recommendations were for impact assessments to estimate of the burden of long-term (annual average) exposure to $PM_{2.5}$ on all-cause mortality (also known as 'natural' causes) in adult populations (age 30+ years) and state this should be calculated at all levels of $PM_{2.5}$ (WHO[65] p. 12). These age-specific numbers were first summed across age-groups to give a total of attributable deaths for each SA2. Finally these SA2 numbers were summed to SA3 totals, and then into Capital City / Rest Of State figures for reporting. **Health data** We linked each State/Territory's age-specific deaths data with the age-specific populations at SA2 by 5 year age ranges (up to age group 100 plus). In the HRAPIE framework the relationship between the annual average $PM_{2.5}$ concentration and mortality is known only for those aged 30 and older. Therefore we restricted our age categories to only those aged 30 years and over. We multiplied the age-specific rates by the populations to calculate an estimated number of deaths in each age group for each SA2. Then we summed up these age-specific estimates to calculate total expected deaths for each SA2. Finally we linked the expected deaths with the estimated anthropogenic $PM_{2.5}$ for each SA2. **Exposure to $PM_{2.5}$ from all sources (non-anthropogenic and anthropogenic)** To produce population weighted estimates, the gridded air pollution data were linked with the 2016 ABS Mesh

	Blocks (MB) spatial boundaries. We extracted the value of each grid cell at the MB centroid location. Some MB centroids did not have a $PM_{2.5}$ grid cell due to geographical issues such as pixels over part of lakes being excluded and misclassifying land area as lake. We used the values from the 10km x 10km gridded dataset for these MB centroids. **Estimated level of anthropogenic $PM_{2.5}$** To estimate the anthropogenic component of the modelled $PM_{2.5}$ concentrations, we assumed that the MB with the lowest concentration in each State or Territory was unaffected by anthropogenic emissions and subtracted the value of this MB from all others. This approach of taking the minimum value per State/Territory aims to take account of the expected geographical variability in non-anthropogenic sources due to the different ecosystems in the different States/Territories. The assumption is made that the MB with the lowest concentration per State/Territory represents the concentration of a place unaffected by anthropogenic emissions, and therefore represents a reasonable estimate of the level of non-anthropogenic emissions naturally found in that State/Territory. We aggregated the estimates of MB anthropogenic $PM_{2.5}$ into SA2 level population weighted estimates using the total persons resident in the MBs at the 2016 census. **Results** The estimated attributable number of premature deaths due to anthropogenic $PM_{2.5}$ in 2015 is shown in Table A11. The counterfactual level of anthropogenic $PM_{2.5}$ assumed in 2015 is shown in Table A12.
Caveats	**Health data** The ABS deaths data we used is for all causes of death, not just 'All cause (non-external)' (which is also known as 'natural causes' and coded using ICD-10 chapters I–XVIII, codes A–R). All non-external causes is theoretically preferred for air pollution burden of disease work because the causal mechanisms by which air pollution might influence external causes such as suicide, accidents and injuries are not clear. **Exposure to $PM_{2.5}$** **Modelled versus monitored air pollution data** The estimate of $PM_{2.5}$ exposure used in this is assessment of the burden of mortality is based on a global model of air pollution as this is currently the most detailed high resolution Australia wide data available. There is substantial variability between

	$PM_{2.5}$ exposure estimated from the model compared to those estimated from fixed site monitoring in the urban locations where monitor data is available. In some locations such as Sydney and Melbourne the modelled $PM_{2.5}$ generally underestimates exposure compared to the monitoring sites while in others such as Perth and Darwin the modelled estimates are similar to the monitoring site estimates. These issues will be investigated in more in the next version of the indicator with improved high resolution exposure estimates. **Estimated level of non-anthropogenic concentrations used as a counterfactual** The approach used here assumes that the MB with the lowest estimated concentration in each State/Territory represents the natural background level (or non-anthropogenic concentration). However, this is likely to lead to an underestimate of the true anthropogenic component, because anthropogenic air pollution is likely to be present even in the cells with lowest concentrations. **Exposure-response function** Premature deaths are calculated using the methodology of WHO.[65] This differs to the calculation in the 2018 *Lancet* Countdown where deaths were calculated using the methodology of the WHO assessment on the burden of disease from ambient air pollution, which relies on integrated exposure response relationships (IERs) developed within the Global Burden of Disease 2013 study.[66] We did not use that method because the IER makes additional assumptions regarding the distribution of causes of death between countries. However in Australia the frequency of causes of death is similar to that in the US. Instead we chose to use the linear exposure-response function for all-cause mortality as recommended by the HRAPIE: "experts judged, however, that the frequency of the causes of death linked with exposure [in the epidemiological studies] was sufficiently similar [to that in the population being assessed (EU)] to justify the use of all-cause mortality in the cost-benefit analysis. If the frequency of causes of death linked with exposure differs markedly between countries, as is the case for global burden estimates, then the use of all-cause CRFs will lead to both over- and underestimation of impacts at the country level. This issue should be addressed through comparison of the two alternative methods recommended and in the uncertainty analysis". The estimated RR was derived from meta-analysis of

	many studies, and takes into account a wide range of settings, and so is a valid approach to use in the Australian context.
Future form of indicator	Future forms of this indicator will a) utilise improved exposure estimates, b) aim to quantify Years of Life Lost (YLL) and Years Lived with Disability (YLD) incorporating hospitalisation, GP visits and medication usage attributable to air pollution and c) decompose the anthropogenic $PM_{2.5}$ into sector specific pollution.

Indicator	3.6. Clean fuel use for transport
Data	ClimateWorks.[67]
Methods	Directly sourced from document (EV sales per 10,000 vehicles – converted to %).
Caveats	Data only available for point 1: Share of new vehicles in a particular geography that are electric drive rather than combustion engine. Unable to find data for point 2: Share of electric drive vehicles for the light-duty fleet in a particular year. Exact data given is the Electric Vehicle Sales per 10,000 vehicles by State or Territory. Data collected was for 2016. Geographic area is whole state/territory, not just GCCSA (Greater Capital City Statistical Area).
Indicator table	Table A13
Future form of indicator	As the electric vehicle fleet begins to grow, with rapidly increasing uptake predicted over the next decade, there is potential to stratify this indicator further – i.e., by examining proportions of hybrid vehicles, full electric vehicles, and vehicles using alternative fuel sources (e.g., biofuels). Other valuable data could include details of trip characteristics specific to electric vehicles (e.g., average km travelled per trip, total km per year, share of total km driven, etc.)

Indicator	3.7. Sustainable travel infrastructure and uptake
Data	Household travel survey data for Australian capital

	cities (statistical area: ABS GCCSA) – (i) total terrestrial passenger km travelled, (ii) km per capita, (iii & iv) total km by mode type (private, public), (v & vi) km by mode type per capita, (vii & viii) km share by mode type. Data Source: Bureau of Infrastructure, Transport and Regional Economics.[68]
Methods	(i) Values direct from source document (Table T3.3) (ii) Values for GCCSA population sourced from document (Table I1.5), per capita calculated by total km/GCCSA population. (iii) Values from source document (Table T3.3); PRIVATE km = sum of columns 'Passenger Cars', 'Commercial Vehicles', and 'Motor Cycles' (iv) Values from source document (Table T3.3); PUBLIC km = sum of columns 'Rail', 'Light Rail', and 'Bus' (v) Calculated by section (iii)/GCCSA population (PRIVATE) (vi) Calculated by section (iv)/GCCSA population (PUBLIC) (vii) Calculated by section (iii)/total km (PRIVATE) (viii) Calculated by section (iv)/total km (PUBLIC)
Caveats	Data collected was for 2014-2015. Geographic area is the GCCSA for each State/Territory. These differ markedly in population, area, and configuration. Complete data for part 2 of this indicator could not be found: Share of electric drive vehicles for the light-duty fleet in a particular year – the ABS collects a motor vehicle census, however does not differentiate between uncommon fuel types (i.e., EVs are grouped with LPG and dual injection).
Future form of indicator	This indicator could be developed to incorporate emerging modes of travel, such as ride sharing, electric vehicles and autonomous vehicles, and other innovations, such as community car shares, that blur

	the divide between private and public transport modes.

Indicator	3.8. Ruminant meat for human consumption
Data	ABS – input-output tables (5209.0.55.001 & 5215.0.55.001),[69,70] Australian Industrial Ecology Virtual Laboratory,[71] National Greenhouse Gas Accounts.[72]
Methods	Input-output analysis relies on input-output tables for assessing the supply chain impacts of a product, process, sector or an organisation.[73] This technique can be used for scanning all upstream supply chains that provide inputs for the production of outputs of an industry sector, for example beef cattle, which is then further used as an input into the meat production and processing sector for human consumption. Using a mathematical formulation developed by Wassily Leontief,[74,75] we carried out a footprint assessment to quantify the performance of the beef cattle and meat producing and processing sectors in terms of greenhouse gas emissions. This assessment was done in the Australian Industrial Ecology Virtual Laboratory,[71,76] which is a cloud computing environment that allows for the construction of customised input-output models for undertaking sustainability assessments.[77] It is important to note that input-output tables include aggregated data for different economic sectors. In particular, the beef cattle and meat production sectors do not distinguish different production systems. Different production systems yield different estimates for GHGe. This is supported by prior research in this area, however these assessments do not look at the complete supply chain, hence a system boundary is drawn and only impacts falling within the boundary are taken into account. For a comprehensive assessment of the GHGe embodied in different meat production systems, we propose a hybrid input-output based LCA approach, which involves defining a range of scenarios for different production systems and integrating data for those scenarios into a supply chain model for assessing scope 3 emissions.

Future form of indicator	To further refine and build on this indicator, we therefore propose a hybrid life cycle assessment approach for integrating detailed data-sets on production systems and sources of red meat to comprehensively assess the GHG emissions in a range of supply chains for red meat production.

Indicator	3.9. Health-care sector emissions
Data	Australian Institute of Health and Welfare report 2014-15,[78] ABS – input-output tables (5209.0.55.001 & 5215.0.55.001),[69,70] Australian Industrial Ecology Virtual Laboratory,[71] National Greenhouse Gas Accounts.[72]
Methods	Data for 15 health care expenditure categories for eight Australian states were collected from the Australian Institute of Health and Welfare report 2014-15.[78] The report includes expenditure data on a range of sub-categories of hospitals, primary health care, refereed medical services, other services, and research and capital expenditure.[78] The expenditure data for Australia's health care categories were then coupled with economic data from input-output models,[69,70] and data on carbon dioxide emissions[72] in the Australian Industrial Ecology Virtual Laboratory[71] to undertake a comprehensive supply chain assessment to quantify the carbon footprint of the Australia's health care sector. In addition, information about health care expenditure of the eight Australian states was used for calculating the percentage contribution of each of the eight Australian states to the national health care CO_2-e footprint. This work builds on the methodology described by Malik et al.[79] In summary, CO_2-e emission footprint calculations were carried out using mathematical equations developed by Wassily Leontief,[74,75] to calculate both the direct and indirect emissions for various health care categories. Unlike conventional life cycle assessments, input-output analysis allows for the scanning of all upstream supply chains, hence all upstream impacts are taken into account.[80]
Caveats	This assessment is based on a national input-output matrix; hence the results are based on national emission factors for determining the carbon footprint of healthcare in various Australian states. For further refining the results, a sub-national multi-regional input-

	output model for Australia would need to be constructed, harboring information on the differences in the energy mix of Australian states, hence providing a more refined assessment of the emissions from state-wise healthcare services.
Indicator figures	Figures A8 and A9
Future form of indicator	The future form of this indicator should include other potent greenhouse gases, in addition to carbon dioxide, nitrous oxide and methane.

Indicator	3.10. Soil organic carbon
Data	The Soil Carbon Research Program (SCaRP)[81] was a nationally coordinated program of soil carbon research bringing together researchers from the CSIRO, universities and state government agencies.
Methods	The Soil Carbon Research Program (SCaRP)[81] was a nationally coordinated program of soil carbon research bringing together researchers from the CSIRO, universities and state government agencies. The SCaRP has been the largest and most extensive soil sampling and analysis program undertaken in Australia to measure stocks of soil carbon. More than 20,000 samples were taken from a wide range of soil types and farming operations across more than 4000 different locations in selected farming regions.
Future form of indicator	Changes in soil organic carbon content across a range of soil types and farming practices.

Section 4: Economics and finance

Indicator	4.1. Investments in zero-carbon energy and energy efficiency
Data	The indicator reports the investment in renewable zero-carbon energy in the electricity sector, based on actually installed generation capacity.
Methods	The data for this indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator (AER) and the Australian Energy Market Operator[82] Generation Information Page. Numbers are reported as installed capacity and not as

	investment in AUD. A summary of the investments for each financial year from 1999/2000 until 2015/16 is provided in AER.[83] The investment is attributed to the year in which a new plant or the upgrade of an existing one became operational. Other areas of expenditure, including operation and maintenance, research and development, financing costs, mergers and acquisitions or public markets transactions, are not included.
Caveats	The reported numbers only refer to investment in renewable zero-carbon energy in the Australian electricity sector, measured by generation capacity. Additional investment into energy efficiency or small-scale photovoltaic installation for private households or companies is not reported.
Future form of indicator	It is not envisaged that the form of this indicator will change over time. However, actual figures for investment into energy efficiency or small-scale photovoltaic installation for private households or companies can be added.

Indicator	4.2. Investment in coal capacity
Data	The indicator reports the investment in coal capacity between 1998 and 2017, based on installed generation capacity in MW.
Methods	The data for this indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator (AER) and the Australian Energy Market Operator[82] Generation Information Page. Numbers are reported as generation of MW capacity and not as investment in AUD. A summary of investments into coal-fired generation for each financial year from 1999/2000 until 2015/16 is provided in AER.[83] The investment is attributed to the year in which a new plant or the upgrade of an existing one became operational.
Caveats	The reported numbers only refer to investment in coal-fired generation in the Australian electricity sector measured by generation capacity (MW). Other areas of expenditure, including operation and maintenance, research and development, financing costs, mergers and acquisitions or public markets transactions, are not included.

Future form of indicator	It is not envisaged that the form of this indicator will change over time.

Indicator	4.3. Funds divested from fossil fuels
Data	Two indicators are being reported. The first indicator provides the number of companies and government organisations in Australia who have partially or entirely committed to divest from fossil fuels. The data for this indicator are collected from 350.org. The second indicator reports historical and announced withdrawals of coal- and gas- fired power plants, i.e. divestment from fossil fuel electricity generation.
Methods	The data for the first indicator are collected from 350.org and Fossil Free Australia.[84] Organisations are committed to divestment if they fall into any of the following five categories: **Fossil Free:** An institution or corporation that does not have any investments (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) in fossil fuel companies (coal, oil, natural gas) and committed to avoid any fossil fuel investments in the future. **Full:** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any fossil fuel company (coal, oil, natural gas). **Partial:** An institution or corporation that made a binding commitment to divest across asset classes from some fossil fuel companies (coal, oil, natural gas), or to divest from all fossil fuel companies (coal, oil, natural gas), but only in specific asset classes (e.g., direct investments, domestic equity). **Coal and Tar Sands:** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal and tar sands companies. **Coal only:** An institution or corporation that made a

	binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal companies. More details on the list of organisations, including banks, pension funds, local governments, universities, and corporations is available from Fossil Free Australia.[84] The data for the second indicator are sourced from the annual State of the Energy Market reports by the Australian Energy Regulator (AER) and the Australian Energy Market Operator[82] Generation Information Page. Numbers are reported in MW of generation that have been retired, placed into cold storage or mothballed.
Caveats	Due to confidentiality, the actual amount of divestment in Australian Dollars for the organisations is not available for publication. However, interested readers may visit 350.org.au for further information.
Future form of indicator	Future forms of this indicator should report the actual value of funds divested from fossil fuels by the organisations. The ideal future form of this indicator would have two elements. The first element would track the value of institutional investments in fossil fuels assets, both in absolute terms and as a proportion of their total portfolios. This would also allow for tracking of associated funds that are moved out of fossil fuels, but are not explicitly advertised as 'divesting'. However, such data is unlikely to be available. The second element of this indicator would more explicitly track the value of funds divested from fossil fuels by healthcare institutions. It is not envisaged that the form of the second indicator (historical and announced withdrawals of coal- and gas- fired power plants) will change over time.

Indicator	4.4. Economic losses due to climate-related extreme events
Data	The provided indicator tracks the total insured economic losses from climate-related extreme events.
Methods	Reported data is based on figures on total insured economic losses from disaster events provided in the Historical Catastrophe Database 1967 - Present Day of

	the Insurance Council of Australia.[85] The database includes recorded data from the ICA on disaster events that have occurred over the last 50 years in the Australian market. This database has recently undergone a significant review and upgrade, in order to fill in gaps in knowledge and to ensure that the most accurate information can be presented. The review included accessing ICA's archives to collect historical information previously only available in hard copy, in staff diaries, reports, member information submitted to ICA and collected media articles. Events that were not declared a Catastrophe have been included where records of the event have been found in ICA archived documents. This provides a more complete picture of actual insured economic losses from climate-related extreme events. Cumulative annual insured losses arising from bushfires, cyclones, flooding, hail storms, storm flooding, tornados and other climate-related extreme events are considered. Extreme events related to earthquakes, arson, gas disruptions, etc. (that are also reported in the ICA database), have been excluded.
Caveats	Uninsured economic losses are not reported. The indicator also does not allow attribution of economic losses to events induced by a changing climate. Possibly, in the long run, the trend of economic losses from climate-related extreme events will allow to draw conclusions on which share of economic losses can be attributed to climate change.
Future form of indicator	An ideal form of this indicator would allow attribution of economic losses to events induced by climate change. However, such attribution is unlikely to be feasible. As such, it is not envisaged that this indicator will significantly alter.

Indicator	4.5. Employment in low-carbon and high-carbon industries
Data	This indicator reports direct full-time equivalent (FTE) employment in renewable energy activities and mining operations in Australia.
Methods	The data for this indicator are provided by the ABS. Data for FTE employment in renewable energy

	activities are sourced from http://www.abs.gov.au/ausstats/abs@.nsf/mf/4631.0. As pointed out by the ABS, the estimates should be regarded as experimental as improvements continue to be made to the estimation methods and as new data sources continue to be identified. FTE employment in mining operations is taken as a proxy for employment in high-carbon industries. The data for FTE employment in mining operations are sourced from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8415.0Main+Features12014-15?OpenDocument. This indicator includes the sub-categories 06 Coal mining, 07 Oil and gas extraction, 08 Metal ore mining, 09 Non-metallic mineral mining and quarrying, 10 Exploration and other mining support services.
Caveats	Currently, the most recent release by the ABS for mining operations only provides data up to the 2014-15 financial year. Also, there is no unique definition of high-carbon industries. Different definitions will lead to substantially different FTE employment estimates for the industry.
Future form of indicator	An ideal future form of this indicator would track both direct and indirect employment from the renewables and fossil fuel extraction industries.

Indicator	4.6. Fossil fuel subsidies
Data	Data were obtained directly from the source: BAEconomics.[86]
Methods	Fossil fuel subsidies are collected by the International Energy Agency; however, they are not calculated for Australia. An estimate of Australian fossil fuel subsidies for energy production was obtained from Minerals Council of Australia (2017), however this estimate should be interpreted with caution (as there is a conflict of interest present from the MCA). This estimate was that total fossil fuel subsidies are equal to $63 million, which accounts for only 2.1% of total electricity generation subsidies. No data was found for estimates of national expenditure on fossil fuels.

Caveats	Detailed fossil fuel subsidies data are collected by the International Energy Agency (IEA); however, they are not calculated for Australia. An estimate of Australian fossil fuel subsidies for energy production (does not include consumption) was obtained from Minerals Council of Australia (2017), however this estimate should be interpreted with caution (as there is a conflict of interest present from the MCA). No data was found for estimates of national expenditure on fossil fuels.
Future form of indicator	Accurate and systematic estimation of fossil fuel subsidies is a valuable data indicator. Access to this data from an international agency without conflicts of interest, such as the IEA, will provide important comparative information for Australian energy usage and the Australian energy market. Other useful evolutions of this indicator may include metrics of renewable energy subsidies and expenditure, renewable energy investment, and proportions of renewable versus fossil fuel expenditure.

Indicator	4.7 Coverage and Strength of Carbon Pricing
Data	Federal Register of Legislation, Independent Pricing and Regulatory Tribunal NSW.
Methods	Narrative analysis from existing documentation of emissions trading schemes and equivalents at state and national level for the years 2008-2018 (including any scheme that occurred during any part of this time).
Caveats	The lack of a carbon price in Australia means that any direct comparison, or assessment against, other countries' schemes is not currently possible.
Future form of indicator	A change of national government may result in a return to an emissions trading scheme in some form, thereby allowing this indicator to be brought into the international assessment tool provided by the World Bank's Carbon Pricing Dashboard.

Indicator	4.8 Use of Carbon Pricing Revenues

Data	Australian Budget documents
Methods	Analysis from existing documentation of national climate policies (the Clean Energy Fund and Direct Action) for the years 2008-2018 (including any scheme that occurred during any part of this time).
Caveats	This indicator is based on a current lack of carbon price (and flow on revenue) in Australia.
Future form of indicator	A transparent method to identify any government sources of revenue from emissions trading or carbon tax would be of value.

Indicator	4.9. Spending on adaptation for health and health-related activities
Data	NCCARF, CSIRO
Methods	Online searching
Caveats	Online information could be incomplete
Future form of indicator	To work closely with Health Departments, DEE to obtain further detailed information.

Indicator	4.10. Health adaptation funding from Australian climate financing mechanisms
Data	Federal and State government website
Methods	Online searching
Caveats	All information is from online searching.
Future form of indicator	To set up a mechanism with relevant organisations/funding bodies to have such information regularly.

Section 5: Public and political engagement

Indicator	5.1. Media coverage of health and climate change
Sub-Indicator	5.1.1. Australian newspaper reporting on health and

	climate change
Data	Thirteen national or regional newspapers were included as sources, including *The Australian*, *Sydney Morning Herald*, *Australian Financial Review*, *The Age* (Melbourne), *Herald Sun* (Melbourne), *Sun Herald* (Sydney), *The Daily Telegraph* (Sydney), *Canberra Times*, *The Courier Mail* (Brisbane), *The West Australian* (Perth), *Adelaide Advertiser*, *Hobart Mercury*, and *Northern Territory News* (Darwin).
Methods	We identified temporal trends in coverage in thirteen selected newspaper sources across Australia and major cities on climate change and health, from 1 January 2008 through 31 December 2017. We collected the data by accessing the Factiva databases via the University of Sydney library. These newspapers were selected based on four factors considered by the *Lancet* Countdown report on climate change and health but modified with Australian contexts, including: (1) geographical diversity (covering all major cities), (2) circulation (higher circulating newspapers), (3) national and regional sources, and (4) reliable access to archives over time in Factiva. The following keywords were used for searching in 'headline and lead paragraph' and English publications only. The narrower searching strategy would enable us to select articles that are most relevant. The keywords were based on the *Lancet* Countdown global report but with the use of search operators to include more relevant articles: AND - search for both terms; OR-search for either term; * Truncation-locate variant endings of a word; nearN-search terms on either side of this operator mush appear within up to the specified number of words of each other. (malaria or dengue or diarrhoea or infecti* or disease or sars or measles or pneumonia or epidemic or pandemic or public health or (health near5 care) or epidemiology or health or mortality or morbidity or nutrition or illness or disease or NCD or non-communicable disease or communicable disease or air pollut* or nutrition or malnutrition or mental or disorder or stunting) AND ((climate near5 change) or global warming or temperature* or extreme weather or global environmental change or climate variability or greenhouse or low carbon or greenhouse gas emission* or renewable energy or carbon emission* or co2

	emission* or climate pollut*)
Caveats	There were some limitations with the findings. We did not include newspapers at local council levels, and those newspapers in other languages, which may exclude different views from the Australian multicultural communities.
Indicator figure	Figure A10
Future form of indicator	In future, endeavours to include more media coverage in addition to newspapers, e.g., online social media, would allow for a better presentation of the debate in Australian communities.

Indicator	5.1. Media coverage of health and climate change
Sub-Indicator	5.1.2. In-depth analysis of newspaper coverage on health and climate change
Data	Thirteen national or regional newspapers were included as sources, including *The Australian*, *Sydney Morning Herald*, *Australian Financial Review*, *The Age* (Melbourne), *Herald Sun* (Melbourne), *Sun Herald* (Sydney), *The Daily Telegraph* (Sydney), *Canberra Times*, *The Courier Mail* (Brisbane), *The West Australian* (Perth), *Adelaide Advertiser*, *Hobart Mercury*, *Northern Territory News* (Darwin).
Methods	Based on the searching results for indicator 5.1.1 with 1,314 articles included, a further qualitative analysis of the articles from all sources over the last three years was performed. A total of 259 articles were reviewed, among which 68 were not relevant to climate change and health even temperate and health were mentioned in the articles. The qualitative review focused on three aspects consistent with the *Lancet* Countdown global report 2017 but modified with Australian contexts. - Context: This category distinguishes whether the article was about an Australian or international event (e.g., G20, Australian Federal Election), the publication of a study/scientific report (e.g., *Lancet* Commission), health crisis (e.g., increased emergency department visits), agricultural/environmental crisis (e.g., coral bleaching), economic/business case (e.g., government budget), or an extreme weather event (e.g., flooding,

	heatwaves). - Recommendations: we identified whether the dominant recommendation (if there was one) was about mitigation, adaptation, or co-benefits. - Tone: neutral, positive, negative, and mixed.
Caveats	We reviewed the newspapers of the last three years only and could not identify any trend during the short timeframe. There might be some differences in media coverage across regions due to experiencing different extreme weather events, state political changes, and demographic changes in local populations.
Indicator table	Table A14
Future form of indicator	Future analysis will involve a longer term analysis, and include online media sources and media in other languages to better capture the focus of the discussion across various cultural and age groups in the Australian community.

Indicator	5.2. Health and climate change in scientific journals
Data	To harmonise with the methodological approach adopted in the *Lancet* Countdown,[1] a bibliometric search in Scopus, PubMed and Web of Science databases for climate-related terms and their co-occurrence with health terms, and Australia was conducted. The following Boolean searches in English: Climate change or Global warming or Climate variability or greenhouse effect or GHGE AND Health or Disease or Non-communicable or NCD or communicable disease or Epidemiology or Lifestyle or health co-benefits or mortality or morbidity or nutrition or malnutrition or dehydration or migration or mental disorders.
Methods	The methodology applied mirrors that used in the *Lancet* Countdown 2017[1] with minor adjustments to improve the fit with Australian climatic changes that affect human health, as well as locations specific terminology.

	Climate-related terms and their co-occurrence with health terms and Australia were searched using a bibliometric search in Scopus, PubMed and Web of Science databases for articles published throughout the period 2008-2017. The search terms in Table A15 were searched to the database, limited by year human and English. The Boolean searches (climate term OR climate term) AND (health term OR health terms) AND (Australia term). Identified references were then downloaded into year specific Endnote libraries and duplicates deleted. Titles and abstracts were then reviewed to ensure the articles met the criteria. Analysis involved categorising the articles as research, policy, review, commentary, and tracking the publication trends throughout the time period. Due the political controversies associated with climate change in Australia, an additional category was identified that discussed climatic effects, such as health impact/response to elevated drought risk, but failed to expressly link with climate change.
Caveats	Interpretation of the findings must take into account the influence of external factors on publication trends. The establishment of a Federally funded Climate Change Adaptation Research Network for Human Health prompted 1) a surge in publications in 2009, 2) another surge arising from a special issue in the *Asia-Pacific Journal of Public Health* on climate change and Australian human health risks and policies (2011. Supplement 2. See http://journals.sagepub.com/toc/apha/23/2_suppl) and 3) publication of results arising from the targeted project funding which peaked in 2014. The subsequent decline in funding reflects the cessation of research project funding for climate change and human health.
Indicator figure	Figure A11
Future form of indicator	Adding additional categorisations according to different criteria (geographical focus, health outcome, type of climate change measurement, etc.) to future analysis of indicator 5.2 will maintain harmonisation with future global reports. Australia is perhaps also well served by categorising specific health impacts that reflect the key impacts on Australia's climate. Bushfires, droughts and heatwaves are especially

	extreme in Australia, and exert high impacts. Categorising publications according to specific health risks such as vector borne disease, sea level rise, and glacial melt which have less influence on Australia's health burden, and floods and tropical cyclones would allow for cross-country comparisons with nations subjected to similar climatic threats.

Indicator	5.3. Health and climate change in the Parliament of Australia
Data	The dataset of the Government of Australia public website for statements was used. Here, the frequency of references to health and climate change in publicly available documents was considered between 2008 and 2017. Government of Australia, Parliamentary Records: Bills and Legislation House of Representatives chamber and business documents Senate and Senate Committee Documents and Inquiries Ministerial Speeches Minister of Health website - publications available: speeches, media releases and resources.
Methods	A search of Federal Parliamentary documents covering Bills and Legislation, Business Documents, Speeches, Media Releases, Programs and resources that included climate change and/or human health in the past 10 years to end of 2017. A detailed search was then conducted on those identified for the expanded search terms: for (a) heath: "malaria", "dengue", "VBD", "diarrhoea", "infection", "disease", "pneumonia", "epidemic", "pandemic", "public_health", "health_care", "epidemiology", "healthcare", "health", "mortality", "morbidity", "nutrition", "illness", "infectious", "ncd", "non-communicable_disease", "noncommunicable_disease", "communicable_disease", "air_pollution", "nutrition", "malnutrition","mental_disorder", "mental health", "depression", "suicide".

	for (b) climate change: “climate_change”, “global_warming”, “green_house”, "temperature", "extreme_weather", "global_environmental_change", "climate_variability", "greenhouse", "low_carbon", "ghge", "renewable_energy", "carbon_emission", "co2_emission", "climate_pollutant, drought, flood, bushfire, heat.
Caveats	The full array of government publications at the three levels of Australian Government (Federal, State and Territory, Local) is less amenable to searching than the scientific literature. Focus here was Federal Government. This analysis presented here is based on a relatively narrow range of search terms, which excludes reference to many of indirect links between climate change and health. Changes in Government, Ministers and staffing and ultimately policy, results in removal of some documentation from websites. For example, statements from previous Minsters for Health were not readily available, and thus were not included in the searchable dataset.
Indicator table	Table A16
Future form of indicator	An important inclusion for this indicator’s future is to expand the scan, to incorporate governance at all three levels of Australian government. The Australian constitution designates Environmental Health to be a responsibility of the State and Territory Governments. Local Governments also play a key role in protecting human health at the local level. Consideration could be given to a detailed examination of jurisdictional focus on climate change and human health at the State and Territory level, in addition to Local Government. In the future, we plan on looking more closely at the references to indirect links between climate change and health. For example, what are the main ways in which governments view climate change impacting on health?

References

1 Watts N, Amann M, Ayeb-Karlsson S, et al. The *Lancet* Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *Lancet* 2018; 391: 581–630.

2 Lee WV. Historical global analysis of occurrences and human casualty of extreme temperature events (ETEs). *Nat Hazards (Dordr)* 2014; 70: 1453–1505.

3 Watts N, Amann M, Arnell N, et al. The 2018 report of the *Lancet* Countdown on health and climate change: shaping the health of nations for centuries to come. *Lancet* 2018; in press.

4 Australian Bureau of Statistics. Labour Force, Australia, Mar 2018. (Catalogue Number 6202.0). Canberra: ABS, 2018. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6202.0Main+Features1Mar%202018?OpenDocument (accessed Jun 2018).

5 Blanchi R, Leonard J, Haynes K, et al. Environmental circumstances surrounding bushfire fatalities in Australia 1901-2011. *Environ Sci Policy* 2014; 37: 192-203.

6 Global Health Data Exchange (GHDx). Global Burden of Disease Study 2016 (GBD 2016) Results. Seattle: Institute for Health Metrics and Evaluation (IHME), 2017. http://ghdx.healthdata.org/gbd-results-tool (accessed Apr 2018).

7 Australian Bureau of Statistics. Australian Health Survey: Nutrition - State and Territory results, 2011-12. (Catalogue Number 4364.0.55.009). Canberra: ABS, 2015. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4364.0.55.009main+features12011-12 (accessed Jun 2018).

8 Australian Bureau of Statistics. Australian Aboriginal and Torres Strait Islander Health Survey: Nutrition Results - Food and Nutrients, 2012–13. (Catalogue Number 4727.0.55.005). Canberra: ABS, 2015. http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4727.0.55.0052012-13?OpenDocument (accessed Jun 2018).

9 Food and Agriculture Organization of the United Nations. Rome Declaration on World Food Security. World Food Summit, 13-17 November 1996, Rome Italy. http://www.fao.org/docrep/003/w3613e/w3613e00.HTM (accessed Jun 2018).

10 Australian Bureau of Statistics. Feature Article: Australian Dietary Guidelines Price Indexes. Canberra: ABS, 2016. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/6401.0Feature+Article1Dec+2015 (accessed Jun 2018).

11 Lee AJ, Kane S, Ramsey R, et al. Testing the price and affordability of healthy and current (unhealthy) diets and the potential impacts of policy change in Australia. *BMC Public Health* 2016; 16: 315.

12 Kleve S, Gallegos D, Ashby S, et al. Preliminary validation and piloting of a comprehensive measure of household food security in Australia. *Public Health Nutr* 2018; 21: 526–534.

13 Australian Bureau of Statistics. National Health Survey: First Results, 2014-15. (Catalogue Number 4364.0.55.001). Canberra: ABS, 2015. http://www.abs.gov.au/ausstats/abs@.nsf/mf/4364.0.55.001 (accessed Jun 2018).

14 World Health Organisation (2016) What is malnutrition. http://www.who.int/features/qa/malnutrition/en/ (Accessed Apr 2018)

15 National Health and Medical Research Council. Australian dietary guidelines. Canberra: National Health and Medical Research Council, 2013. https://www.nhmrc.gov.au/_files_nhmrc/file/publications/n55_australian_dietary_guidelines1.pdf (accessed Jun 2018).

16 Maxwell SL, Venter O, Jones KR, Watson JEM. Integrating human responses to climate change into conservation vulnerability assessments and adaptation planning. *Ann N Y Acad Sci* 2015; 1355: 98-116.

17 McMichael C. Climate change-related migration and infectious disease. *Virulence* 2015; 6: 548-553.

18 McMichael C, Barnett J, McMichael AJ. An ill wind? Climate change, migration, and health. *Environ Health Perspect* 2012; 120: 646-654.

19 Schwerdtle P, Bowen K, McMichael C. The health impacts of climate-related migration. *BMC Med* 2018; 16: 1.

20 Wetzel FT, Kissling WD, Beissmann H, Penn DJ. Future climate change driven sea-level rise: secondary consequences from human displacement for island biodiversity. *Glob Chang Biol* 2012; 18: 2707-2719.

21 Bezirtzoglou C, Dekas K, Charvalos E. Climate changes, environment and infection: facts, scenarios and growing awareness from the public health community within Europe. *Anaerobe* 2011; 17: 337-340.

22 Local Government NSW. NSW council links. Sydney: LGNSW, 2018. https://www.lgnsw.org.au/about-us/nsw-council-links (accessed Jun 2018).

23 State Government of Victoria. Victorian local councils. 2018. https://www.vic.gov.au/government-economy/local-councils/victorian-local-councils.html (accessed Jun 2018).

24 Queensland Government. Local government directory. Brisbane: Department of Local Government, Racing and Multicultural Affairs, 2018. http://www.dilgp.qld.gov.au/local-government-directory/ (accessed Jun 2018).

25 Government of Western Australia. Local Government Directory. Perth: Department of Local Government, Sport and Cultural Industries, 2018.

https://www.dlgsc.wa.gov.au/localgovernment/forcommunity/Pages/LG-Directory.aspx (accessed Jun 2018).

26 Local Government Association of South Australia. SA Councils. Adelaide: LGASA, 2018. http://www.lga.sa.gov.au/councils (accessed Jun 2018).

27 Local Government Association Tasmania. Council Map and Contacts. Hobart: LGAT, 2018. http://www.lgat.tas.gov.au/page.aspx?u=221 (accessed Jun 2018).

28 Northern Territory Government of Australia. Find your council. 2017. https://nt.gov.au/community/local-councils-remote-communities-and-homelands/find-your-council (accessed Jun 2018).

29 Garnaut R. The Garnaut Climate Change Review: Final Report. Cambridge: Cambridge University Press, 2008.

30 Garnaut R. The Garnaut review 2011: Australia in the global response to climate change. Cambridge: Cambridge University Press, 2011.

31 Flannery T, Sahajwalla V (Climate Commission). The Critical Decade: Generating a renewable Australia. Canberra: Commonwealth of Australia, 2012.

32 Flannery T, Beale R, Hueston G (Climate Commission). The Critical Decade: International action on climate change. Canberra: Commonwealth of Australia, 2012.

33 Flannery T, Beale R, Hueston G (Climate Commission). The Critical Decade: Global action building on climate change. Canberra: Commonwealth of Australia, 2013.

34 Hughes L, McMichael T (Climate Commission). The Critical Decade: Climate change and health. Canberra: Climate Commission Secretariat (Department of Climate Change and Energy Efficiency), 2011.

35 Steffen W. The Critical Decade: Climate science, risks and responses. Canberra: Climate Commission Secretariat, 2011.

36 Steffen W, Hughes L. The Critical Decade 2013: Climate change science, risks and responses. Canberra: Climate Commission Secretariat, 2013.

37 Steffen W, Hughes L, Karoly D. The Critical Decade: Extreme weather. Canberra: Climate Commission Secretariat, 2013.

38 Australian Capital Territory Government Environment and Planning Directorate. ACT Climate Change Adaptation Strategy: Living with a warming climate. Canberra: EPD, 2016.

39 Australian Capital Territory Government Environment, Planning and Sustainable Development Directorate. Climate change adaptation and resilience. Canberra: EPSDD, 2018. http://www.environment.act.gov.au/cc/what-government-is-doing/climate-change-adaptation-and-resilience (accessed Jun 2018).

40 City of Adelaide. Climate Change Adaptation: Action Plan 2013-2015. no date

41 Brisbane City Council. Brisbane. Clean, green, sustainable: 2017-2031. Brisbane: Brisbane City Council, 2017.

42 City of Darwin. Climate Change Action Plan 2011-2020. Darwin: Darwin City Council, 2011.

43 Hobart City Council. Hobart City Council corporate climate change adaptation plan 2013-2016. Hobart: Southern Tasmanian Councils Authority, 2012.

44 City of Melbourne. City of Melbourne Climate Change Adaptation Strategy. Melbourne: Maunsell Australia Pty Ltd, 2008.

45 City of Perth. Towards an energy resilient city: Strategic directions paper. Perth: City of Perth, no date

46 City of Sydney. Adapting for Climate Change: A long term strategy for the City of Sydney. Sydney: City of Sydney, no date

47 New South Wales Government, Office of Environment and Heritage. Towards a resilient Sydney: urban adaptation research synthesis. Sydney: NSWOEH, 2014.

48 New South Wales Government Office of Environment and Heritage. Adapt NSW. Sydney: NSWOEH, 2018. http://climatechange.environment.nsw.gov.au/ (accessed Jun 2018).

49 Queensland Government Department of Environment and Heritage Protection. Pathways to a climate resilient Queensland: Queensland climate adaptation strategy 2017-2030. no date.

50 Queensland Government Department of Environment and Heritage Protection. Queensland Climate Change Response. 2018. https://www.qld.gov.au/environment/climate/response (accessed Jun 2018).

51 Government of South Australia, Department of Environment, Water and Natural Resources. South Australia's Climate Change Strategy 2015-2050: towards a low carbon economy. 2015. https://www.environment.sa.gov.au/files/sharedassets/public/climate-change/sa-climate-change-strategy-2015-2050-towards-low-carbon-economy.pdf (accessed Jun 2018).

52 Government of South Australia. Towards a resilient state: the South Australian Government's climate change adaptation action plan. Adelaide: Government of South Australia, 2018.

53 Tasmania Government Department of Premier and Cabinet. Adapting to climate change in Tasmania: issues paper. Hobart: Tasmanian Climate Change Office, 2012.

54 Tasmania Department of Premier and Cabinet: Tasmanian Climate Change Office. Climate Action 21: Tasmania's Climate Change Adaptation Plan 2017-2021. 2017.

55 Tasmanian Government Department of Premier and Cabinet: Tasmanian Climate Change Office. Climate Change Priorities. 2018. http://www.dpac.tas.gov.au/divisions/climatechange/Climate_Change_Priorities (accessed Jun 2018).

56 Victorian Government Department of Land Water and Planning. Victoria's Climate Change Adaptation Plan 2017-2020. 2016.

57 Victorian Government Department of Environment, Land, Water and Planning. Victoria's Climate Change Framework. Melbourne: DELWP, 2018. https://www.climatechange.vic.gov.au/victorias-climate-change-framework (accessed Jun 2018).

58 Western Australia Department of Health. Health impacts of climate change: adaptation strategies for Western Australia. Perth: Department of Health, 2008. http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Environmental%20health/Climate%20change/Health-impacts-of-climate-change.pdf (accessed Jun 2018).

59 Western Australian Government Department of Environment and Conservation. Adapting to our changing climate. 2012.

https://www.der.wa.gov.au/images/documents/your-environment/climate-change/adapting-to-our-changing-climate-october-2012.pdf (accessed Jun 2018).

60 Western Australia Department of Water and Environmental Regulation. Adapting to climate change. 2018. https://www.der.wa.gov.au/your-environment/climate-change/254-adapting-to-climate-change (accessed Jun 2018).

61 International Energy Agency. IEA CO2 emissions from fuel combustion statistics. Paris: IEA, 2016. http://dx.doi.org/10.1787/data-00433-en (accessed Jun 2018).

62 Australian Bureau of Statistics. Australian Statistical Geography Standard (ASGS): Volume 4 - Significant Urban Areas, Urban Centres and Localities, Section of State, July 2016. (Catalogue Number 1270.0.55.004). Canberra: ABS, 2016.

63 Australian Bureau of Statistics. Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2016. (Catalogue Number 1270.0.55.001). Canberra: ABS, 2016.

64 van Donkelaar A, Martin RV, Brauer M, et al. Global estimates of fine particulate matter using a combined geophysical-statistical method with information from satellites, models, and monitors. *Environ Sci Technol* 2016; 50: 3762−3772.

65 World Health Organization. Health risks of air pollution in Europe – HRAPIE project: Recommendations for concentration–response functions for cost–benefit

analysis of particulate matter, ozone and nitrogen dioxide. Copenhagen: WHO Regional Office for Europe, 2013.

66 Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016; 388: 1659–1724.

67 ClimateWorks Australia. The state of electric vehicles in Australia. Melbourne: ClimateWorks Australia, 2017.

68 Bureau of Infrastructure, Transport and Regional Economics (BITRE). Yearbook 2017: Australian Infrastructure Statistics, Statistical Report. Canberra: BITRE, 2017.

69 Australian Bureau of Statistics. Australian National Accounts: Input-Output Tables (Product Details), 2013-14. (Catalogue Number 5215.0.55.001). Canberra: ABS, 2016.

70 Australian Bureau of Statistics. Australian National Accounts: Input-Output Tables, 2014-15. (Catalogue Number 5209.0.55.001). Canberra: ABS, 2017.

71 Lenzen M, Geschke A, Wiedmann T, et al. Compiling and using input–output frameworks through collaborative virtual laboratories. *Sci Total Environ* 2014; 485-486: 241-251.

72 Department of Climate Change and Energy Efficiency. Australian National Greenhouse Accounts: National Greenhouse Accounts Factors. Canberra: Department of Climate Change and Energy Efficiency, 2012.

73 Murray J, Wood R, editors. The sustainability practitioner's guide to input-output analysis. Champaign: Common Ground Publishing, 2010.

74 Leontief W, Ford D. Air pollution and the economic structure: empirical results of input-output computations. In: Bródy A, Carter AP, editors. Input-output techniques. Amsterdam: North-Holland Publ. Co., 1972: 9-30.

75 Leontief W. Input-Output Economics. 2nd ed. Melbourne: Oxford University Press, 1986.

76 Lenzen M, Geschke A, Malik A, et al. New multi-regional input-output databases for Australia – enabling timely and flexible regional analysis. *Econ Syst Res* 2017; 29: 275-295.

77 Malik A, Lenzen M, Geschke A. Triple bottom line study of a lignocellulosic biofuel industry. *Glob Change Biol Bioenergy* 2016; 8: 96-110.

78 Australian Institute of Health and Welfare. Health Expenditure Australia 2014-15. Health and Welfare Expenditure series no. 57. Cat. no. HWE 67. Canberra: AIHW, 2016.

79 Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care. *Lancet Planet Health* 2018; 2: e27-e35.

80 Lenzen M. Errors in conventional and input-output-based life-cycle inventories. *J Ind Ecol* 2000; 4: 127-148.

81 Commonwealth Scientific and Industrial Research Organisation (CSIRO). The Soil Carbon Research Program (SCaRP). 2015-2017. http://csiropedia.csiro.au/soil-carbon-research-program/ (accessed Jun 2018).

82 Australian Energy Market Operator. Generation Information Page. Melbourne: AEMO, 2018. http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information (accessed Jun 2018).

83 Australian Energy Regulator. State of the energy market, May 2017. Melbourne: AER, 2017. https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-may-2017 (accessed Jun 2018).

84 Fossil Free Australia. Who's divested? Sydney: 350.org, 2018. https://gofossilfree.org.au/whos-divested/ (accessed Jun 2018).

85 Insurance Council of Australia. Historical Catastrophe Database 1967 - Present Day. Sydney: ICA, 2018. http://www.icadataglobe.com/access-catastrophe-data/ (accessed Jun 2018).

86 BAEconomics. Electricity production subsidies in Australia. Prepared for the Minerals Council of Australia. Canberra: BAEconomics, 2017.

87 International Energy Agency. IEA Atlas of Energy. Paris: IEA, 2018. http://energyatlas.iea.org (accessed Jun 2018).

Appendix tables

Table A1. Occurrences of four climate-related disaster types (drought, flood, storm, and wildfire) and associated deaths and affected per decade from 1930 to 2018 in Australia

Disaster type	Decade	Deaths	Affected	Deaths and Affected	Occurrences
Drought	1930-1940	0	0	0	0
	1940-1950	0	0	0	0
	1950-1960	0	0	0	0
	1960-1970	600	0	600	1
	1970-1980	0	0	0	4
	1980-1990	0	80000	80000	1
	1990-2000	0	7000000	7000000	2
	2000-2010	0	0	0	2
	2010-2018	0	0	0	0
Flood	1930-1940	0	0	0	0
	1940-1950	0	0	0	0
	1950-1960	70	0	70	1
	1960-1970	0	0	0	0
	1970-1980	60	22000	22060	8
	1980-1990	71	0	71	10
	1990-2000	38	55331	55369	12
	2000-2010	34	35391	35425	21
	2010-2018	46	202497	202543	10
Storm	1930-1940	0	0	0	0
	1940-1950	0	0	0	0
	1950-1960	0	0	0	0

	1960-1970	0	0	0	0
	1970-1980	112	45740	45852	20
	1980-1990	40	1012	1052	22
	1990-2000	51	3938284	3938335	26
	2000-2010	12	42851	42863	26
	2010-2018	33	126377	126410	13
Wildfire	1930-1940	71	3900	3971	1
	1940-1950	49	2100	2149	1
	1950-1960	0	0	0	0
	1960-1970	74	4900	4974	2
	1970-1980	3	0	3	5
	1980-1990	86	11140	11226	4
	1990-2000	7	48161	48168	6
	2000-2010	202	17809	18011	10
	2010-2018	9	3118	3127	10

Table A2. Occurrences of four climate-related disaster types (extreme temperature, flood, storm, and wildfire) and associated deaths and affected

Disaster type	**Deaths**	**Affected**	**Occurrences**
Extreme temperature	486	2000	2
Flood	60	220097	16
Storm	35	153777	16
Wildfire	189	13072	11

Table A3. Reasons for climate-related migration

Slow-onset processes	**Acute events**
Sea level rise: contaminated freshwater aquifers; loss of land	Cyclones
Degraded coral ecosystems from ocean warming and acidification	Coastal storm surges
Declining fish populations	Severe storms and flooding
Drought	Bushfires
Land degradation	
Declining agricultural productivity	
Declining food security	
New or intensifying conflict over resources	
Altered distribution or intensity of infectious disease, e.g., vector-borne diseases including malaria, dengue, tick	
Declining physical comfort	
Loss of amenity, loss of livelihood	

Table A4. Number of councils in each state and the number which have pledged to participate in Cities Power Partnership (CPP)

State/Territory	**Total number of councils**	**Number pledged to CPP**
NSW	65	38
Vic	86	7
QLD	77	7
WA	150	10
SA	75	1
ACT	1	1
Tas	29	4
NT	8	2
Total	**491**	**70**

Table A5. Summary of climate change risk assessments by Australian State and Territory

City	Population	% total Aust population	Median age (years)	Key climate group and subdivision	State/Territory department/s	Overall climate change framework / adaptation strategy name	State government regional /city analyses	Topics/links included
Australia overall					Department of the Environment and Energy	http://www.environment.gov.au/climate-change/climate-science-data/climate-science/impacts		

Sydney	4,823,991	20.61	36	Temperate, no dry season (warm summer)	NSW Government Department of Environment and Heritage	Adapt NSW http://climatechange.environment.nsw.gov.au/	Yes, analyses are by region and Sydney is specifically included	Climate projections; impacts; Adaptation; Educational resources
Melbourne	4,485,211	19.17	36	Temperate, no dry season (warm summer)	Victorian Government Department of Land, Water and Planning	Victoria's Climate Change Framework https://www.climatechange.vic.gov.au/victorias-climate-change-framework	No, statewide only	Legislation; Emissions reduction; Adapting to climate change impacts; Virtual Centre for Climate Change Innovation; Local Government; Information and resources; Media releases

Brisbane	2,270,800	9.70	35	Subtropical, no dry season	Queensland Department of Environment and Heritage Protection	Queensland climate change response https://www.qld.gov.au/environment/climate/response	No, statewide only	Adapting to climate change; Transition to a zero carbon economy; climate change resources; News: Events
Perth	1,943,858	8.31	36	Temperate, distinctly dry summer	Western Australia Department of Water and Environmental Regulation	Adapting to Climate Change https://www.der.wa.gov.au/your-environment/climate-change/254-adapting-to-climate-change	No, statewide only	Adapting to climate change; Water; Agriculture, forestry and fisheries; Energy and infrastructure; People and communities; Ecosystems and biodiversity
Perth (2)					Western Australia Department of Health	Health impacts of climate change: Adaptation strategies for	No, minimal breakdown of the state into 'South-West' and North-	Impacts; Vulnerability; Adaptive capacity

						Western Australia http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Environmental%20health/Climate%20change/Health-impacts-of-climate-change.pdf	West' in some sections, otherwise statewide only	
Adelaide	1,295,714	5.54	39	Temperate, distinctly dry (and hot) summer)	Department of Environment, Water and Natural Resources	South Australia Climate Change Strategy https://www.environment.sa.gov.au/Science/Science_research/climate-change/climate-change-initiatives-in-south-australia/sa-climate-	Yes, looks specifically at Adelaide in carbon neutral planning	Reducing greenhouse emissions; Adapting to climate change; Premier's Climate Change Council; SA's climate change legislation; National and international engagement; SA Low Carbon Economy Experts Panel

						change-strategy		
Canberra	395,790	1.69	35	Temperate, no dry season (warm summer)	Environment, Planning and Sustainable Development Directorate	Climate Change Adaptation and Resilience http://www.environment.act.gov.au/cc/what-government-is-doing/climate-change-adaptation-and-resilience	N/A. Most of the ACT is the city of Canberra	Emission reduction targets; Climate change adaptation and resilience; Reducing government emissions; Carbon neutral government newsletter; National and international activities

Hobart	222,356	0.95	40	Temperate, no dry season (mild summer)	Department of Premier and Cabinet: Tasmanian Climate Change Office	Climate Change Priorities http://www.environment.act.gov.au/cc/what-government-is-doing/climate-change-adaptation-and-resilience	No, statewide only	Tasmania's Climate Change Action Plan; Reducing emissions; Climate risks and opportunities; Review of Tasmania's Climate Change Act; Climate Action 21 - Implementation Plan; Climate change: key facts and figures; What you can do; Calendar of events; Tasmania's Climate Change Action Plan 2017-2021; Newsletter
Darwin	136,828	0.58	33	Equatorial, savanna	N/A	N/A	N/A	N/A

Table A6. Summary of climate change risk assessments by capital city councils

City	Climate change risk assessment / adaptation report title, URL	Year	Key risks / hazards identified wrt human health and health services	Other sectors/topics included	Is the risk assessment/adaptation plan comprehensive?
Sydney	Towards a Resilient Sydney: Urban Adaptation Research Synthesis http://climatechange.environment.nsw.gov.au/~/media/A84392B4393B424CA10372ADF30FF8A8.ashx	2014	Extreme weather including heat, storms, floods, drought; vector-borne disease; food safety and quality; air quality; water quality; mental health; disproportionate impacts on Indigenous and other socioeconomically disadvantaged groups; impacts on health services and infrastructure	Economy & industry; Natural assets; Cultural assets; Settlements & communities; Buildings & neighbourhoods; Emergency management; Infrastructure	Somewhat
Melbourne	Victoria's Climate Change Adaptation Plan 2017-2020 https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0024/60729/Victorias-Climate-Change-Adaptation-Plan-2017-2020.pdf	2016	Heatwaves; other extreme weather events (floods, bushfires); emergency management	Natural environment; Water resources; Built environment;	No

Brisbane	Pathways to a climate resilient Queensland. Queensland Climate Adaptation Strategy 2017-2030 https://www.qld.gov.au/environment/assets/documents/climate/qld-climate-adaptation-strategy.pdf	2017	None identified other than the mention of the Human health and wellbeing sector. Queensland's Health Climate Adaptation Plan (H-CAP) is currently in early stage of development.	Built environment and infrastructure; Agriculture; Small and medium business; Industry and resources; Tourism; Biodiversity and ecosystems; Emergency services	No
Perth	Western Australian Government: Adapting To Our Changing Climate https://www.der.wa.gov.au/images/documents/your-environment/climate-change/adapting-to-our-changing-climate-october-2012.pdf	2012	Heat stress morbidity and mortality; increased food and water costs; increased bushfire risk	Water; Energy; Agriculture; Built environment; Transport; Infrastructure; Emergency management; Industry; Natural environment; Tourism and recreation	No

Perth (2)		no date	Heat stress and physical trauma from extreme weather events; gastro-intestinal disease from heavy rainfall and contamination in drought and from proliferation of food-borne pathogens due to increased temperatures and heavy rainfall events; water stress; vector-borne disease including Ross River and Barmah Forest viruses, dengue, Murray Valley Encephalitis; dietary changes from altered food production and quality; Respiratory disease relating to air quality declines with bushfires, drought, heat and ozone; unspecified impacts of biodiversity loss and chemical exposure from infrastructure damage and drought increased concentrations of soil and water contaminants; mental health impacts from heat-related sleep deprivation, losses associated with extreme events, loss of amenities and social cohesion, dislocation.	Some mentioned under 'current responses'	Yes
Adelaide	South Australia's Climate Change Strategy 2015-2050: Towards a low carbon economy https://www.environment.sa.gov.au/files/sharedassets/public/climate-change/sa-climate-change-strategy-2015-2050-towards-low-carbon-economy.pdf	2015	None identified explicitly, only by implication under managing bushfire risk	Entirely focused on energy production and use	For energy, yes

Canberra	ACT Climate Change Adaptation Strategy: Living with a warming climate http://www.environment.act.gov.au/__data/assets/pdf_file/0004/912478/ACT-Climate-Change-Adaptation-Strategy.pdf	2016	Extreme weather including heat, bushfires, floods, and drought; mental health impacts; vulnerable groups such as disadvantaged, elderly, children, homeless; managing green space for improved ambient temperatures and broader mental and physical health benefits; Health services resilience and building social cohesion; Fresh and affordable local food; Worker productivity; Resilient buildings to withstand extreme events; Improved underlying population health e.g. physical activity; Functional housing with improved energy and water efficiency; Urban refuges; Public and active transport.	Disaster and emergency management; Settlements and infrastructure; Water; Natural resources and ecosystems	Yes
Hobart	Adapting to Climate Change in Tasmania http://www.dpac.tas.gov.au/__data/assets/pdf_file/0009/174834/Adapting_to_climate_change_in_Tasmania.pdf	2012	Extreme weather, including heatwaves, flooding and bushfires; Air pollutants and aeroallergens; Vector-borne disease; Vulnerable groups and communities including low socio-economic or geographically isolated, children and elderly, in poor health or with a disability; Health and emergency services response to extreme events; Reduced cold-related illness (not off-set by increased heat-related and other climate change associated illness); Increased population from climate change	Human settlements and infrastructure; Natural systems; Water management; Industry sectors; Natural disasters	No

			immigrants from more severely affected regions nationally and internationally		
Hobart(2)	Climate Action 21: Tasmania's Climate Change Action Plan 2017-2021 http://www.dpac.tas.gov.au/__data/assets/pdf_file/0015/332106/Climate_Action_21_Tasmanias_Climate_Action_Plan_Web_version.pdf	2017	Not really, implied under 'Building climate resilience' with mention of extreme weather events and disaster management	Energy; Transport; Economy;	No
Darwin	N/A	N/A	N/A	N/A	N/A

Table A7. Australian capital city climate change risk assessments and adaptation plans

City	**Local Council risk assessment / adaptation plan**	**Year**	**Key risks / hazards identified wrt human health and health services**	**Other sectors/topics included**	**Is the risk assessment comprehensive?**
Sydney	Yes. City of Sydney. Adapting for Climate Change: A long term Strategy for the City of Sydney http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0013/250123/2016-022571-Adapting-to-Climate-Change_accessible.pdf Also other Sydney city councils e.g. Liverpool	2016	Extreme heat and other extreme weather (floods, droughts); bushfires; air quality; food production; physical activity	Urban planning (relating to sea-level rise) and building standards; Natural assets especially biodiversity; transport; energy; workforce productivity; infrastructure	Somewhat
Melbourne	Yes. City of Melbourne. City of Melbourne Climate Change Adaptation Strategy https://www.melbourne.vic.gov.au/SiteCollectionDocuments/climate-change-adaptation-strategy.pdf	2008	None identified	Water; Transport; Buildings; Business and Industry; Energy and telecommunications; Emergency services	No

Brisbane	Not really climate change related, except for emphasis on reducing carbon. City of Brisbane. Brisbane: Clean, Green, Sustainable 2017-2031 https://www.brisbane.qld.gov.au/sites/default/files/20180207-brisbane_clean_green_sustainable_2017-2031.pdf	2017	None identified	Energy; Transport, Water; Urban planning; Waste management; Infrastructure; Air quality	No
Perth	Focus is on energy resilience only. City of Perth. Towards an Energy Resilient City: Strategic Directions paper https://www.perth.wa.gov.au/sites/default/files/City%20of%20Perth%20Energy%20Resilience%20Strategic%20Direction.pdf	no date	None identified	Energy	No

Adelaide	Yes. City of Adelaide. Climate Change Adaptation Action Plan 2013-2015 https://www.cityofadelaide.com.au/city-living/sustainable-adelaide/climate-change/	no date	Health impacts of extreme heat and flooding, especially on more vulnerable groups (elderly, homeless, low income)	Council assets and infrastructure; Natural environment including water quality, vegetation, biodiversity	No
Canberra	N/A				
Hobart	Yes. City of Hobart. Hobart City Council Corporate Climate Change Adaptation Plan 2013-2016	2012	Not explicitly cited in relation to health, but extreme events are a focus: extreme heat, bushfires, flooding from rainfall and coastal inundation	Emphasis is on corporate risks and council assets rather than population impact	Yes

Darwin	Yes. City of Darwin. Climate Change Action Plan 2011-2020 https://www.darwin.nt.gov.au/sites/default/files/DCC_ClimateChangeActionPlan_web.pdf	2011	None identified explicitly	Water; Land; Air quality; Biodiversity; Recycling and waste; Energy	No

Table A8. Australian climate information services for health

Health hazard	**Description**	**More information**
Ultraviolet radiation intensity	1. National forecasts of 3-hourly UV Index, updated daily 2. National forecasts of daily maximum UV Index, updated daily 3. Monthly UV Index climatology	http://www.bom.gov.au/uv/about_uv_index.shtml
Heat wave	1. National heatwave assessment map for the last two 3-day periods, updated daily during Oct-Mar 2. National heatwave forecast for the next five 3-day periods, updated daily during Oct-Mar	http://reg.bom.gov.au/australia/heatwave/ http://media.bom.gov.au/social/blog/891/how-will-i-know-if-a-heatwave-is-coming/
Thunder-storm asthma	Forecast risk of thunderstorm asthma in Victoria, updated daily during Oct-Dec	https://emergency.vic.gov.au/prepare/#thunderstorm-asthma/preparing-for-thunderstorm-asthma

Table A9. Summary of national climate change assessment reports for Australia

Title	**Commissioning body**	**Year**	**Topics/sectors**	**Key findings/recommendations**
Garnaut Climate Change Review	Commonwealth, State and Territory governments	2008	Economic modelling across numerous sectors including health, agriculture, tourism	Costs of mitigating (reducing emissions) would be substantially less than inaction. Carbon tax preferable to complex emissions trading scheme. Investment in low emissions technology required.
Garnaut Climate Change Review - Update 2011	Commonwealth, State and Territory governments	2011	Update of 2008 report, considering shifts in science and international politics.	Emphasis on Australia's national (economic) interests being best served by mitigation. Recognition too of the value of natural and social capital and other less quantifiable assets.
The Critical Decade: Climate Change and Health	Commonwealth Government/ Climate Commission	2011	Human health	Emphasis on population health co-benefits of mitigation, and strengthening underlying population health and systems to plan for changing climate conditions.
The Critical Decade: International action on climate change	Commonwealth Government/ Climate Commission	2012	Energy	Australia’s participation in international action on renewable energy and carbon pricing would be in Australia's best interests.

The Critical Decade: Extreme weather	Commonwealth Government/ Climate Commission	2013	Extreme weather	Severity and frequency of extreme weather events is increasing due to climate change, threatening communities, agriculture and iconic ecosystems. Need substantial action to reduce emissions.
The Critical Decade: Generating a renewable Australia	Commonwealth Government/ Climate Commission	2012	Energy	Australia's potential for renewable energy is under exploited, while globally renewables are gaining strength in the energy sector. Renewable energy development in Australia provides regional job opportunities.
The Critical Decade: Climate science, risks and responses	Commonwealth Government/ Climate Commission	2011	Climate projections	Emissions reductions required to limit risks imposed by climate change
The Critical Decade: Climate science, risks and responses	Commonwealth Government/ Climate Commission	2013	Climate projections. Update of 2011 report	Emissions reductions required to limit risks imposed by climate change. Update of 2011 report
The Critical Decade: Global action building on climate change	Commonwealth Government/ Climate Commission	2013	Energy	Momentum for deep emissions reduction is building globally, especially US and China. Australia needs to play its part and take action by 2020.

Table A10. Daily average $PM_{2.5}$ data in cities, 2013-2015

Urban centre	**$PM_{2.5}$ 2013**	**$PM_{2.5}$ 2014**	**$PM_{2.5}$ 2015**
Sydney	8.1	7.7	7.8
Central Coast	6.6	5.5	5.2
Tweed Heads	NA	NA	NA
Newcastle	7.5	7.0	7.5
Wollongong	7.1	6.7	6.7
Melbourne	NA	8.4	7.8
Brisbane	6.4	6.0	5.4
Gold Coast	4.5	4.9	4.4
Toowoomba	NA	5.9	5.8
Adelaide	7.2	7.1	7.5
Perth	7.8	8.0	8.5
Hobart	6.1	6.7	5.8
Darwin	7.0	8.7	8.2
Canberra	6.7	6.5	6.5

Table A11. Estimated attributable number of premature deaths due to anthropogenic $PM_{2.5}$ in 2015 in urban and rural Australia

Region	Attributable number	Population (total)	Premature deaths (per 1,000,000 population)	$PM_{2.5}$ (anthropogenic) population weighted mean for regions	$PM_{2.5}$ (all sources) population weighted mean for regions
Australian Capital Territory	1.3	234052	5.4	0.1	2.7
Greater Sydney	785.4	2912994	269.6	4.3	6.2
Rest of NSW	261.9	1707077	153.4	1.9	3.8
Greater Darwin	15.6	78620	198.4	3.8	8.1
Rest of NT	6.0	46392	128.8	2.5	6.8
Greater Brisbane	319.7	1338423	238.8	3.9	5.6
Rest of Qld.	270.4	1509302	179.2	2.6	4.3
Greater Adelaide	130.7	812921	160.7	2.0	4.3
Rest of SA	25.2	252685	99.7	1.3	3.6
Greater Hobart	15.7	140445	112.0	1.3	3.5
Rest of Tas.	15.3	188906	80.9	0.9	3.1
Greater Melbourne	517.7	2700495	191.7	3.0	5.2
Rest of Vic.	90.7	928828	97.6	1.3	3.5
Greater Perth	447.5	1169450	382.6	6.1	8.3
Rest of WA	45.2	328400	137.6	2.7	4.9
TOTAL	2948.1	14348990			

Table A12. Counterfactual level of anthropogenic $PM_{2.5}$ assumed in 2015 for each Australian state and territory

State	**$PM_{2.5}$ minimum**
SA	2.3
WA	2.2
NT	4.3
TAS	2.2
VIC	2.2
NSW	1.9
ACT	2.6
QLD	1.7

Table A13. Share of new vehicles in a particular geography which are electric.

State/ Territory	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
Share of new vehicles which are EVs (or hybrid) (%)	0.07	0.08	0.05	0.09	0.03	0.05	0.04	0.18	0.07

Table A14. Findings of the qualitative review of all included articles on health and climate change, 2015-2017.

	All	National sources	Sydney	Melbourne	Hobart	Brisbane	Adelaide	Canberra	Darwin	Perth
Number of articles	191	32	48	32	21	17	15	11	9	6
Context (%)										
Australian or International event	19	25	19	22	38	6	7	18	0	17
Scientific announcement	20	19	23	22	10	12	13	27	33	33
Health crisis	9	0	10	22	0	12	0	18	11	17
Extreme climate event	17	6	31	9	14	24	20	9	11	17
Economic/Business case	13	44	4	3	10	6	13	0	0	17
Agricultural/Environmental crisis	7	0	6	9	14	6	20	0	22	0
Undefined	14	6	6	13	14	35	27	27	22	0
Recommendations (%)										
Mitigation dominant	23	28	21	34	10	18	7	36	22	33
Adaptation dominant	19	3	21	13	19	18	40	27	33	50
Co-benefits dominant	4	3	6	6	5	0	7	0	0	0
No recommendation	53	66	52	47	67	65	47	36	44	17
Tone (%)										
Neutral	42	41	44	38	52	35	60	36	22	33
Positive	26	22	23	28	29	18	20	27	33	67
Negative	29	34	31	31	19	41	7	27	44	0
Mixed	4	3	2	3	0	6	13	9	0	0

Table A15. Terms used for searching for articles on health and climate change in scientific journals

Climate & Climatic effect terms	**Health related terms**	**Australian location terms**
Climat* Chang*	Health	Australia*
Global warming	Disease	Sydney
Climate variability	Non-Communicable, NCD, Communicable	Melbourne
Greenhouse effect	Epidemiology	Canberra
Greenhouse gas emission*	Lifestyle	Brisbane
Drought	Co-Benefits	Adelaide
Bushfire	Mortality	Perth
Tropical cyclone	Morbidity	Hobart
Heatwave	Nutrition	Darwin
	Malnutrition	
	Dehydration	
	Migration	
	Mental disorders	
	Human	

Table A16. Health and climate change in the Parliament of Australia

Document type	**Level of Government**	**Political Party**	**No. identified**
Chamber and business documents	House of Representatives	All	Nil
Resource documents available on website	Federal Minister of Health	All	1 (lead author Prof Tony McMichael)
Bills presented to Parliament mentioning Climate Change and health	Senate	All	Nil
Bills presented to Parliament mentioning Climate Change	Senate	All	1 (with 2 revisions 2009 & 2010) comprising 6 bills to give effect to Carbon Pollution Reduction Scheme (CPRS), and establish Australian Climate Change Regulatory Authority 1 (with 1 revision in 2013) to repeal the CPRS and abolish the ACRA. Health not mentioned in either
Senate Inquiry - "Current and future impacts of climate change on housing, buildings and infrastructure."	Senate	All	Health or wellbeing not listed as relevant issues
Senate Inquiry- "Recent trends in and preparedness for extreme weather events". Report released 2013			344 Submissions received, many from the health sector, largely focussing on critical gaps in preparedness. Health and the Health Sector included in the final report

National Climate Change Adaptation Research Facility (NCCARF)	Federal Government Initiative		Only Federal Program that included specific focus on Climate Change and Human Health, the Human Health Adaptation Research Network (ARN) was hosted by the Australian National University. The ARN received 4 years of funding from 2009, plus small extension to finalise research. Half the total designated funding for research was eventually allocated via 7 independent studies (1).

Appendix figures

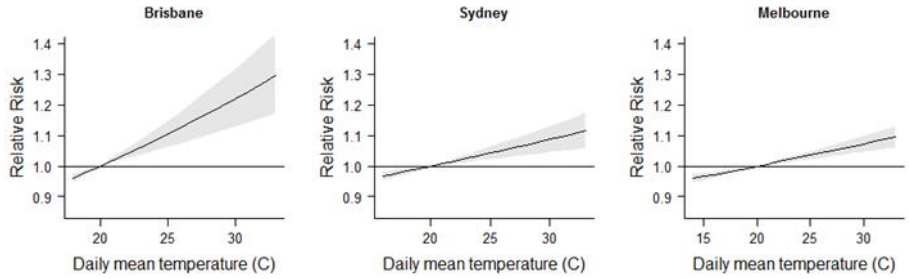


Figure A1. The association between summer daily mean temperature (lag 0-3) and non-accidental mortality (shaded area: 95% Confidence Interval) in Brisbane, Sydney, and Melbourne, 1988-2009. A natural cubic spline with 4 degrees of freedom was used for temperature.

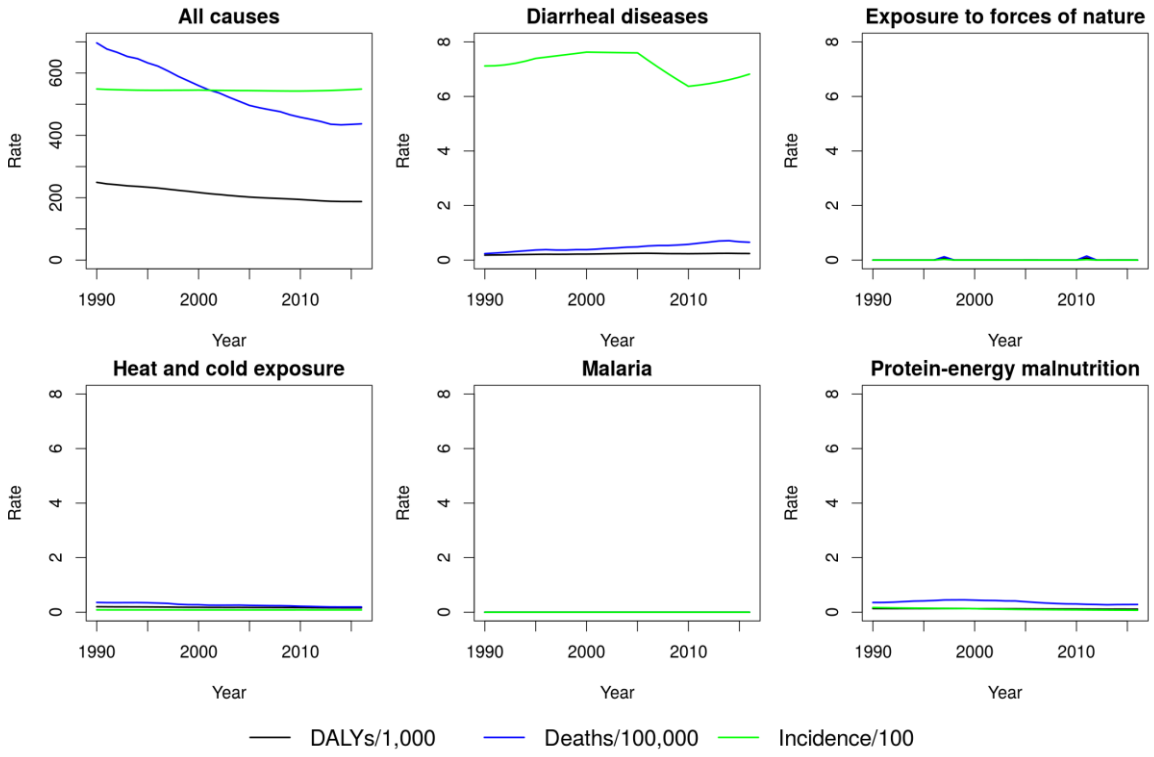


Figure A2. Disability-Adjusted Life Years (DALYs), deaths and incidence rates for all causes, diarrheal diseases, exposure to forces of nature, environmental heat and cold exposure, malaria, and protein-energy malnutrition in Australia, 1990-2016

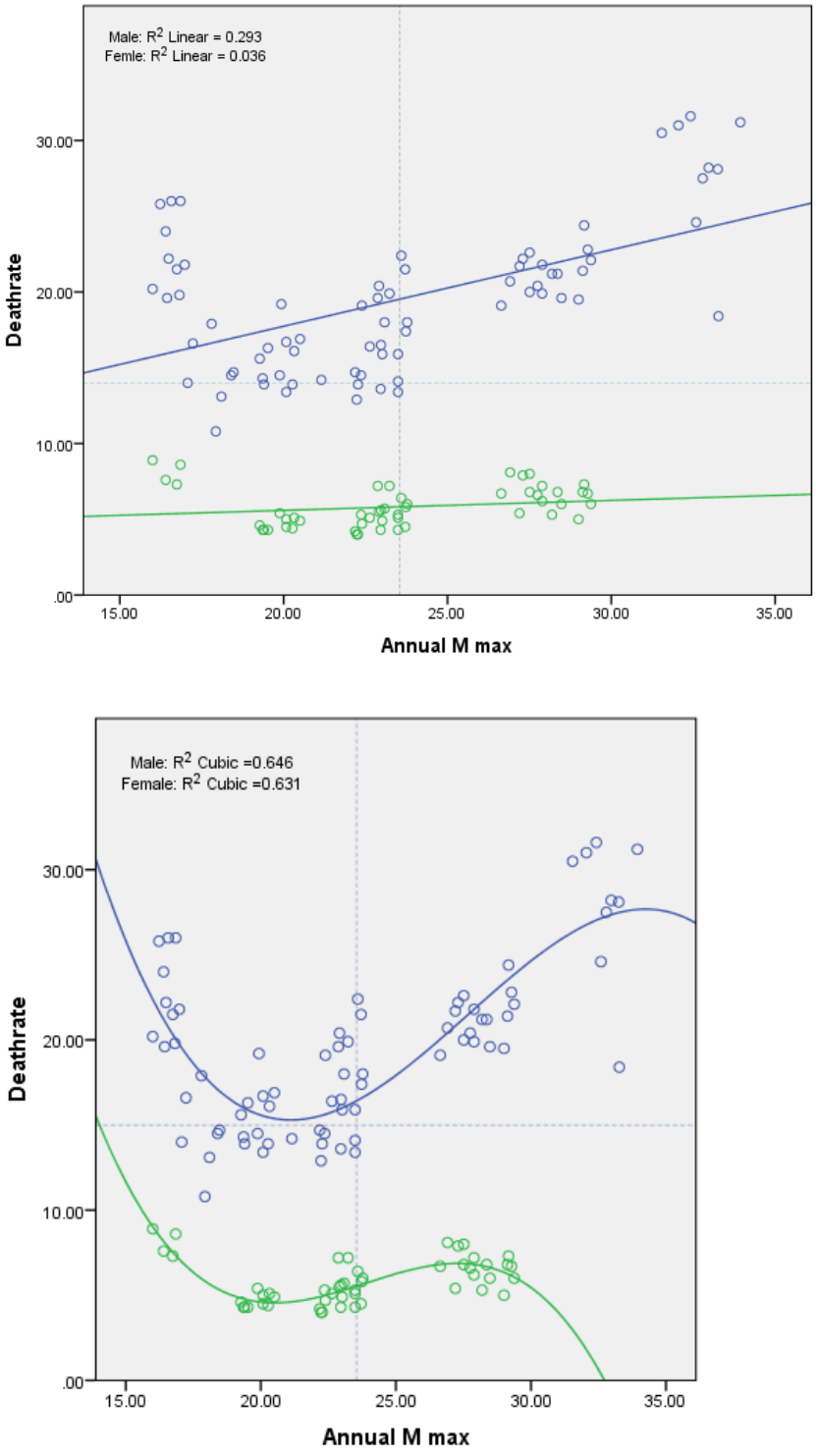


Figure A3. Scatterplots of female (green markers) and male (blue markers) suicide rates (per 100,000) versus mean annual maximum temperatures (°C) in all states and territories of Australia, 2007-2016, with linear regression lines (top) and cubic regression lines (bottom)

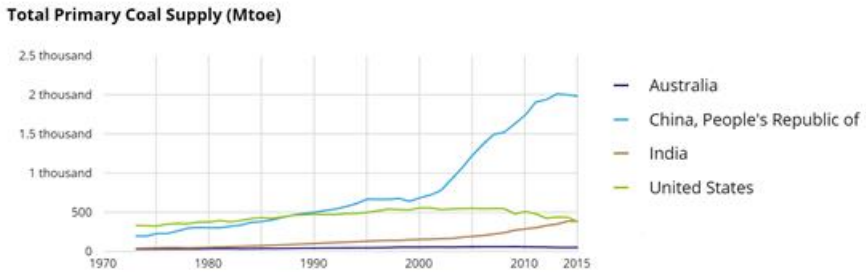


Figure A4. Total primary coal supply in Australia, China, India, and the US, 1973-2015 (Source: International Energy Agency[87])

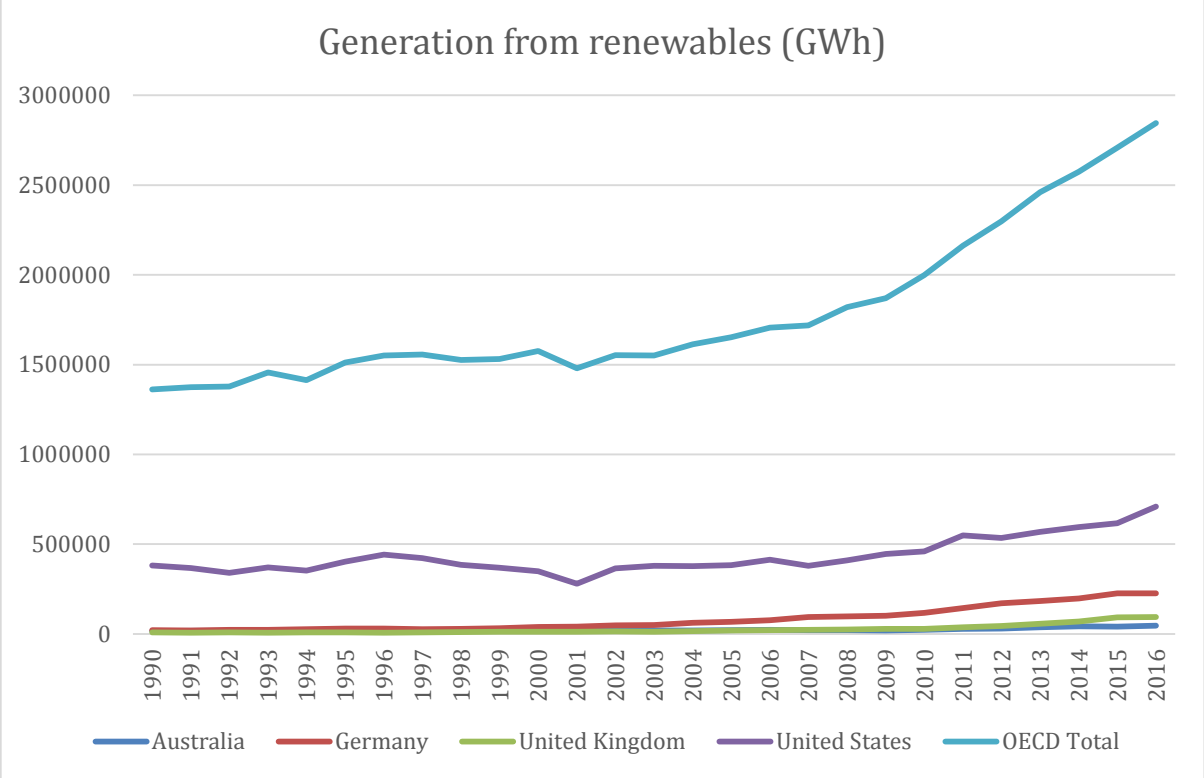


Figure A5. Generation of electricity from renewables in Australia, Germany, United Kingdom, United States, and the Organisation for Economic Co-operation and Development (OECD) total, 1990-2016

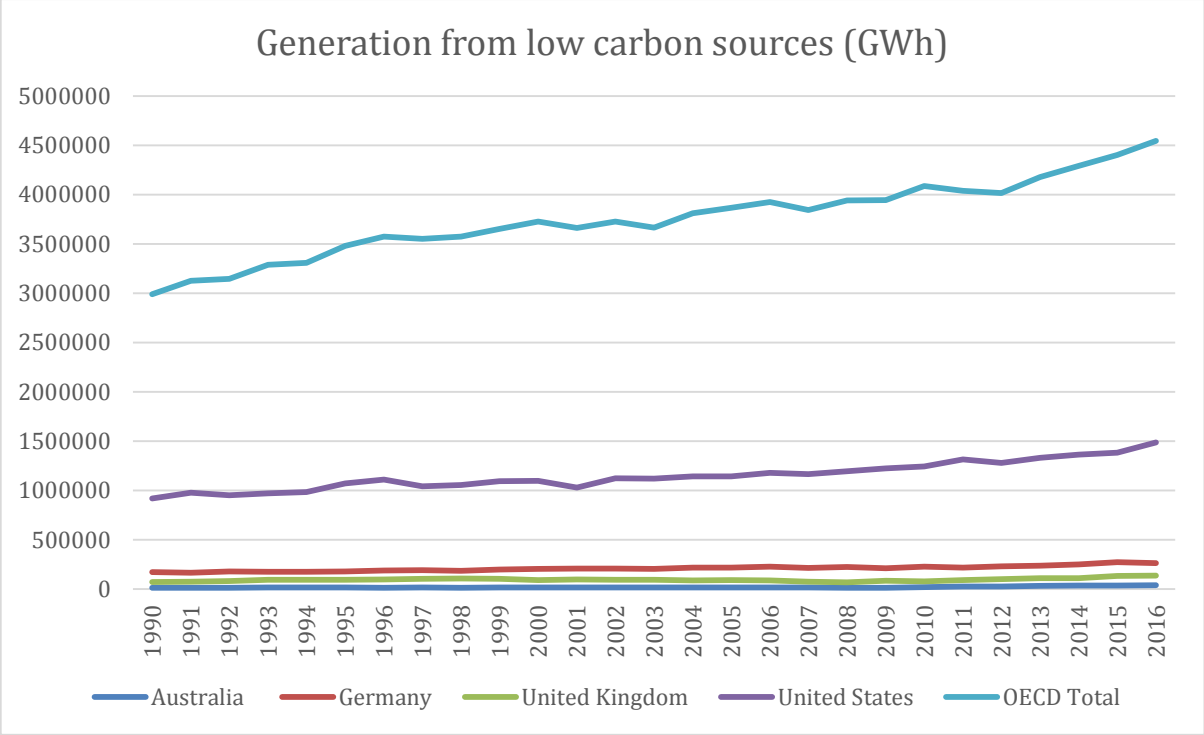


Figure A6. Generation of electricity from low carbon sources in Australia, Germany, United Kingdom, United States, and the Organisation for Economic Co-operation and Development (OECD) total, 1990-2016

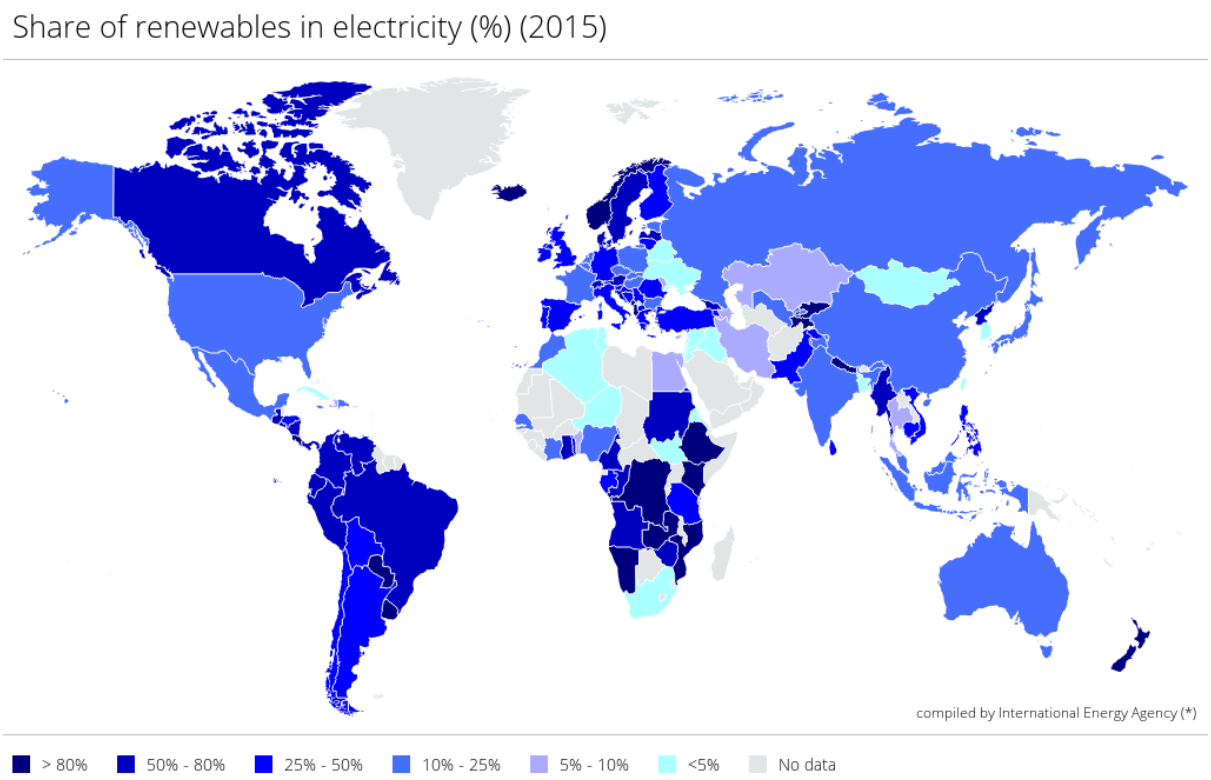
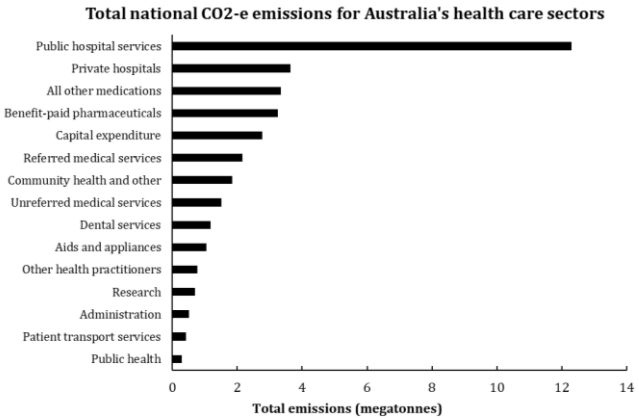


Figure A7. Share of renewables in electricity generation by country, 2015 (Source[87]: Based on IEA data from the Electricity Information: Overview © OECD/IEA 2018, www.iea.org/statistics, Licence: www.iea.org/t&c)

Figure A8. Total national CO_2-e emissions for Australia's health care sectors, 2014-15



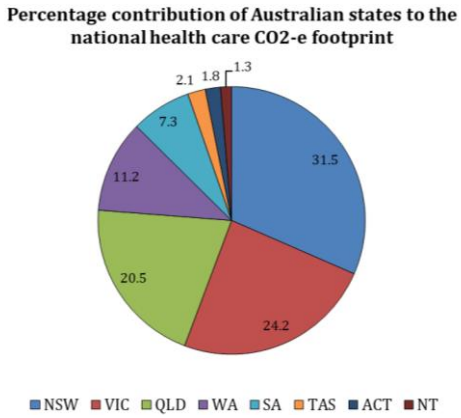


Figure A9. Percentage contribution of Australian states and territories to the national health care CO_2-e footprint, 2014-15

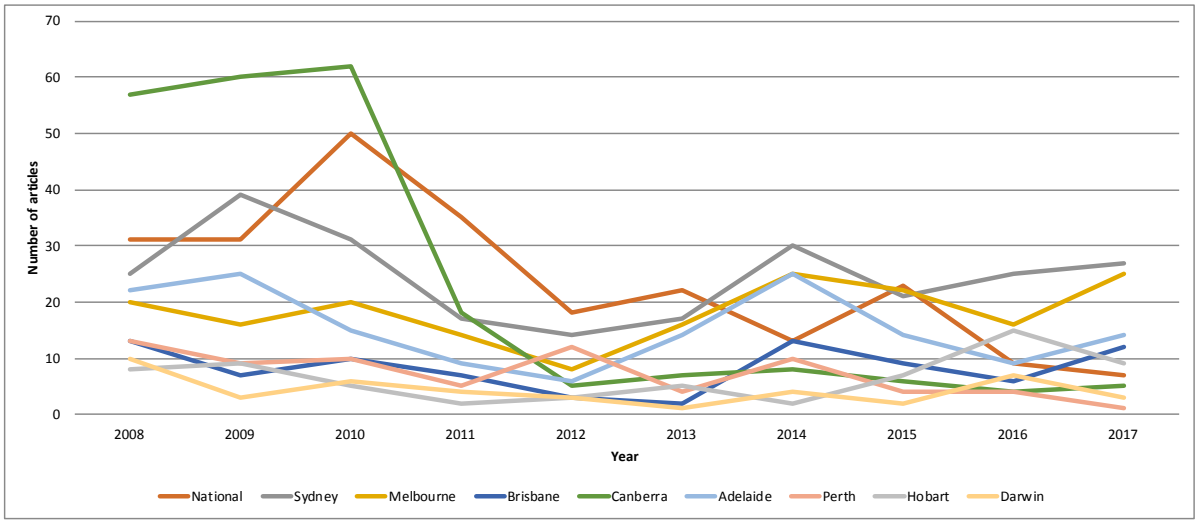


Figure A10. Annual number of articles reporting on health and climate change by regions, 2008-2017

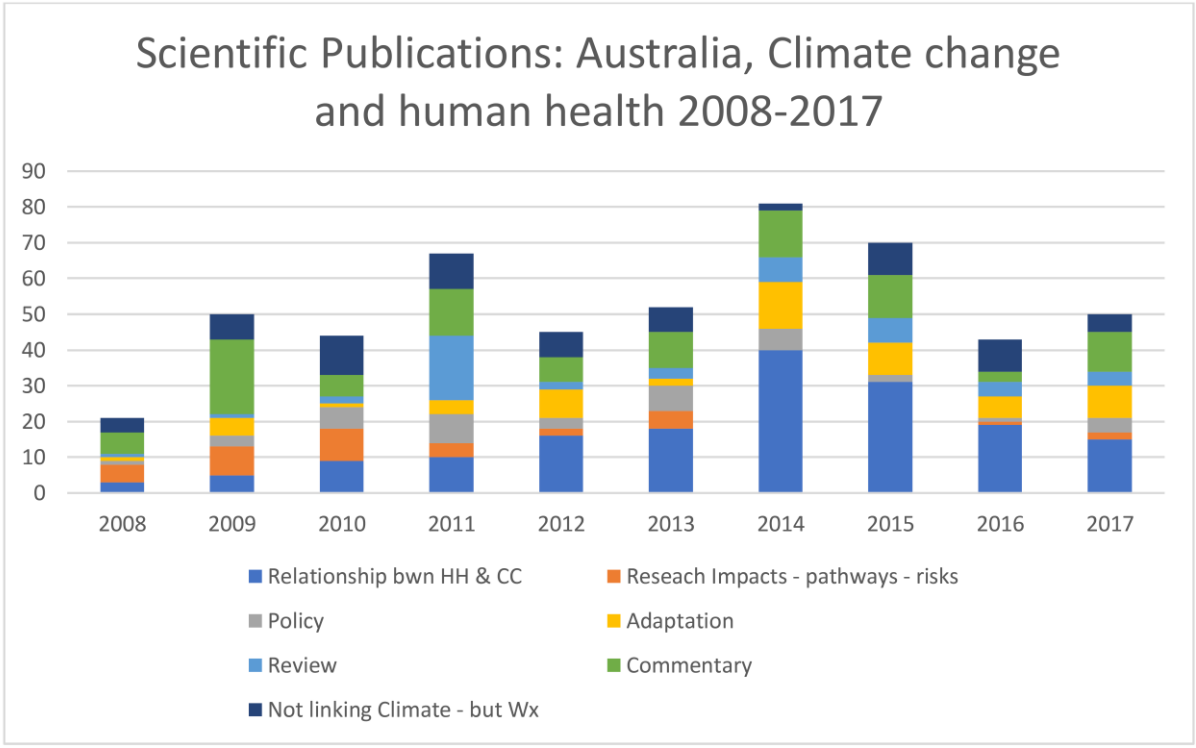


Figure A11. Australian scientific publications on climate change and human health, 2008-2017