Briefing Paper

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Health and Energy Policy

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Executive Summary

The health implications associated with energy policy are increasingly being recognised by health, energy, climate and environment stakeholders around the world.

Carbon intensive energy systems are driving climate change and causing direct harm to human health and wellbeing from air pollution produced by the combustion of fossil fuels for energy and transport.

The energy sector in Australian is extremely carbon intensive, based as it is on coal, gas, and oil. Technically and economically viable energy alternatives exist however, especially since Australia has some of the best renewable energy resources in the world.

The health costs associated with fossil fuel energy production and consumption are significant and, if reflected in the price of electricity, would conservatively double or triple the price of power.

Current global and national energy policy privilege fossil fuels at the expense of safer, renewable, and more sustainable energy options.

The profound risks posed by climate change and the enormous economic damages associated with a failure to reduce emissions from carbon intensive energy systems and other sources of greenhouse gas emissions demand that these implications be considered and reflected in the development of energy policy.

In Australia, the health implications of energy policy are not currently considered in policy decisions regarding the allocation of energy sector subsidies, in plans for Australia's energy future, in decisions regarding new energy infrastructure projects, nor in energy trade.

Major health care stakeholders, such as the Public Health Association of Australia, the Australian Healthcare and Hospitals Association, the National Rural Health Alliance, the National Centre for Climate Change Adaptation Research Facility – Adaptation Research Network: Human Health, and the Climate and Health Alliance recognise that health and wellbeing is being compromised by energy policy choices in Australia and globally.

This paper has been produced to highlight the risks to policymakers, the media, the health and energy sectors, and the community more broadly, and to encourage health professionals and health organisations to advocate for the implications for health to be recognised and reflected in Australian and international energy policy.

Introduction

Health and well-being are closely associated with social, economic, and environmental factors which public policy, not only health policy, should acknowledge.

Health in All Policies[1] is a tool and a process for policy development that assists leaders and policymakers to integrate considerations for health, well-being and equity into the development, implementation and evaluation of policies and services across all sectors of government.

"Good health improves quality of life, improves workforce productivity, increases the capacity for learning, strengthens families and communities, supports sustainable habitats and environments, and contributes to security, poverty reduction and social inclusion."[2]

This quote from the *Adelaide Statement on Health in All Policies* underscores what is understood by all people everywhere: that health underpins all that is valuable for individuals, communities and societies.

Protecting and promoting health must therefore be a central goal for our society. "Health" is much more than "health care" and health and well-being depends on factors well beyond the health system.

Human individual and societal health is determined by ecological as well as social factors. The provision of clean air, fresh water, and fertile soil are all ecosystem services that underpin society's ability to feed, house, and clothe itself, provide protection from weather, help prevent the spread of disease and support psychological and emotional well-being.

This paper explores the ways in which different energy sources impact on health, and demonstrate the need for health impacts to be evaluated and included in energy policy.

[1] Health in All Policies Collaboration, Intersectoral Action to achieve Health in All Policies: A practical approach for a healthy Tasmania, 2012
[2] Adelaide Statement on Health in All Policies, WHO and Government of South Australia, 2010.

The Health Implications of Energy Policy

Energy systems impact on health and wellbeing at every level, from the domestic to the global scale. The routine release of pollutants from energy extraction, distribution and energy use have significant implications for human health, both directly as local environmental health impacts as well as indirectly through impacts on ecosystems and global environmental change.

Therefore the sources of energy we choose for electricity, transport and industrial processes and our patterns of energy use have significant implications for human health.

Health and medical research increasingly demonstrates that energy policy can be a driver of ill-health and avoidable deaths.[3] The use of coal for electricity generation, for example, has negative health impacts that may challenge health gains associated with access to electricity.[4]

While there have been signs of ill health associated with energy production for decades, and warnings from health professionals about the implications for health from energy policy over 40 years ago, little attention has been paid to health impacts by policy makers when it comes to decision making about energy technology.

In 1976, Comar and Sagan wrote in the *Annual Review of Energy*: "The development of national energy policies and strategies must be guided not only by market economics but by careful consideration of the health and the environmental impacts not necessarily reflected in pricing."

It is now time to pay attention.

As this paper will subsequently discuss, the externalities (i.e. costs not reflected in energy prices) associated with health and environmental effects of our global energy systems amount to more than a trillion dollars annually.[5]

The energy sector offers an ideal example of how the integrated approach associated with Health in All Policies that recognises the health, social, economic and environmental consequences of energy policy can deliver improved outcomes across all these domains.

Achieving these outcomes requires the cooperation of government, civil society and the private sector.

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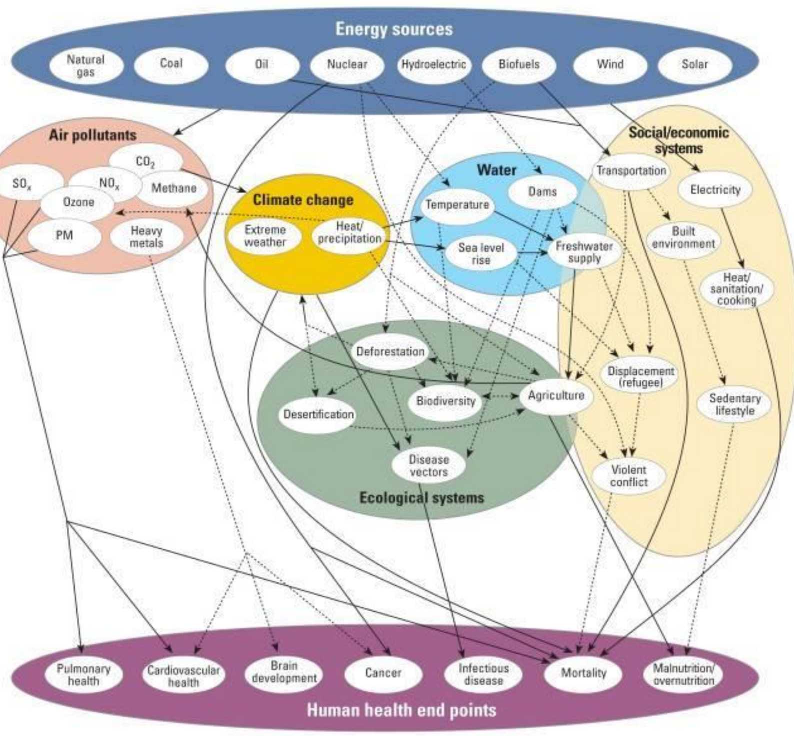
[3] Gohlke, J. M. et al. Estimating the global public health implications of electricity and coal consumption, EHP, 119:6, pp.821-826, 2011.
[4] Gohlke, J. M. et al. Estimating the global public health implications of electricity and coal consumption, EHP, 119:6, pp.821-826, 2011.
[5] DARA 2012 Climate Vulnerability Monitor, A Guide to the Cold Calculus for a Hot Planet, 2012.

The graphic below illustrates the many and diverse ways in which different energy sources impact on air and water; on climate, ecological, social and economic systems; and how all of these create impacts on human health.



From: Golke, J. et al. Environmental Health Perspectives, 2008 June; 116 (6): A236–A237.

Implications of energy policy in Australia for human health

The interrelationship between health and well-being and the energy sector is writ large in the adverse impacts for human health from climate change driven largely by greenhouse gas emissions arising from the energy sector globally.

These greenhouse gas emissions arise from the burning of fossil fuels for power generation and transport as well as through ‘fugitive’ emissions released during the mining of coal and gas.

In addition to the health impacts of climate change, the fossil fuel based energy sector processes that produce greenhouse gases such as carbon dioxide, methane, and nitrous oxide also produce more localised pollutants that cause direct harm to human health.

Local pollutants such as coal dust, particulate matter, and toxins (e.g. arsenic, sulphuric and nitric acids, boron, fluorides and mercury) are associated with the mining and combustion of coal for electricity generation, while the production of particulates, nitrogen dioxide, ground level ozone and carbon monoxide is associated with combustion of fossils fuels for transport.[6] Mining and production of unconventional gas (e.g. coal seam gas) involves the use of many chemicals, some of which are associated with short and long term health effects.[7]

In Australia, it is estimated that that the adverse health impacts from coal fired electricity generation - from associated respiratory, cardiovascular, and nervous system diseases - is costing A$2.6 billion annually.[8]

The health costs from air pollution in Australia arising from burning fossil fuels (petroleum and gas) for transport amounts to several billion dollars a year - a 2005 estimate put the national cost at A$3.3 billion annually; however 2009 figures from NSW indicate the annual health costs of air pollution from transport, power generation and industry in that state were A$4.7 billion.[9]

These 'externalities' - health, social and environmental costs not accounted for in the market price of electricity or fuel costs - are nonetheless borne by the community and by taxpayers.

The per capita greenhouse gas emissions from the energy sector in Australia are larger than in other developed countries – the third highest of any OECD country.[10] If exports of coal were included in our total national emissions accounts, it would be evident that Australia is the source of 4.8% of global emissions.[11]

The 2012 DARA Climate Vulnerability report, *Cold Calculus for a Hot Planet*, suggests the failure to prevent climate change is causing 400,000 deaths each year. The carbon intensive global economy is responsible for a further 4.5 million deaths per year, largely from air pollution, hazardous occupations and cancer.[12]

The costs to human health associated with the carbon intensive energy systems of the global economy is costing the world another $540 billion each year, on top of the climate change losses.[13] Put together, these climate change and carbon economy losses are costing the global economy $1.2 trillion annually. Continued intensive usage of fossil fuel energy sources are estimated to lead to these costs doubling over the next decade and a

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[6] Environment Protection and Heritage Council, Expansion of the multi-city mortality and morbidity study, Final Report, 2010.
[7] Colborn, T. et al. Natural gas operations from a human health perspective, Human and Ecological Risk Assessment, 2011, 17:5, pp.1039-1056.
[8] ATSE, Hidden costs of power generation, 2009.
[9] NSW Government, Air Pollution, www.health.nsw.gov.au/publichealth/environment/air/air_pollution.asp
[10] Garnaut Review
[11] Christoff, P. End Old King Coal's reign now or wait for a perfect storm to hit the planet, *Sydney Morning Herald*, 12 December 2012.
[12] DARA 2012 Climate Vulnerability Monitor, A Guide to the Cold Calculus for a Hot Planet, 2012.
[13] DARA 2012 Climate Vulnerability Monitor, A Guide to the Cold Calculus for a Hot Planet, 2012.

half, causing six million deaths each year and costing 3.2% of global GDP by 2030. A business as usual emissions trajectory would see costs would continue to increase, with damages accelerating throughout this century.

Energy policy and climate change

Global emissions of the principal greenhouse gas, CO_2, are currently 35,000 million tonnes per annum,[14] and increasing at 3% each year.[15] Present CO_2 concentrations are now higher than at any time in the last 15 million years.[16] Global emissions of all greenhouse gases combined are about 50,000 million tonnes of CO2-equivalent.

This has lead to an increase in global mean temperature of 0.8 degrees Celsius, but regional variations mean some parts of the world, including the Arctic have warmed up by to 2^oC, twice as fast as the global average.[17]

Even if current emissions reduction pledges and commitments are met, the world's emissions trajectory is now predicted to lead to a $4\text{-}6^oC$ - global average temperature increase by the end of this century, but a warming of 4°C degrees could occur as early as 2060.[18]

This is well beyond the two degrees guardrail considered by climate scientists to be the point beyond which catastrophic and irreversible climate change may be triggered,[19] and the target agreed to by all nations at the 2009 global climate change negotiations in Copenhagen.

Even with a 0.8°C global average temperature increase, sea levels have risen by 3.5cm per decade. It is thought that each 1cm of sea level rise may lead to 1 metre of coastal erosion.[20] If this rate continues, this would deliver a 30cm rise this century and many coastal cities and communities will face constant flooding.[21]

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[14] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.
[15] Olivier, J. et al. *Trends In Global Co2 Emissions 2012 Report*, PBL Netherlands Environmental Assessment Agency, 2012.
[16] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.
[17] Monastersky, R. Nature News Blog, *Arctic Report Card: Dark Times Ahead*, 5 December 2012; Romanovsky, V. et al. *Arctic Report Card: Update for 2012*, National Oceanic and Atmospheric Administration, 5 December 2012.
[18] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.
[19] ibid.
[20] West Australian Government, Department of Planning, Coastal Planning and Management Manual, 2003.
[21] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.

Anthropogenic global warming is contributing to increases in the severity and frequency of extreme weather events that pose serious health risks to all Australians and all people around the world.[22,23]

The recent World Bank report *Turning Down the Heat* chronicles the "exceptional number of extreme heat waves that have occurred around the world with consequential severe impacts". One such example is the Russian heat wave of 2010, which is estimated to have caused 55,000 deaths, wiped out ¼ of the national food crop, and led to economic losses of US $15 billion.[24] The unprecedented national heatwave and floods in Australia in January 2013, wild weather of 2012, severe floods of 2011, and bushfires of 2009 provide a grim insight into the weather of a warming world.

Further increases in global mean temperatures are predicted to lead to severe drought across much of the globe, severely impacting economic growth and leading to declining industrial output and food production, leading to political instability,[25] and societal destablisation.[26]

An increase of 4°C is anticipated to lead to increases of 6°C in parts of the world, and may reach 10°C in some regions.[27]

The International Energy Agency World Energy Outlook 2011 warned that continuing to invest in fossil fuel intensive infrastructure would lead to 'lock-in' of carbon intensive energy infrastructure and prevent the world from reaching its climate goal of limiting warming to less than 2°C.

The chief economist at the International Energy Agency, Fatih Birol, said in 2011 that the world has just five years to dramatically alter the way it uses energy, and that unless investment in fossil fuels ceases, and the world begins the wide-scale and rapid deployment of renewable energy technology and energy efficiency measures, we may lose the opportunity to prevent irreversible climate change.[28]

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[22] Trenberth, K. Framing the way to relate climate extremes to climate change, *Climatic Change*, 2012, DOI 10.1007/s10584-012-0441-5.

[23] Hansen J, Sato M, Ruedy R (2012) Perceptions of climate change. *Proceedings of the National Academy of Sciences of the United States of America*. http://www.pnas.org/content/early/2012/07/30/1205276109. Accessed September 10, 2012.

[24] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.

[25] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.

[26] McMichael, A. J. Insights from past millennia into climatic impacts on human health and survival, *Proceedings of the National Academy of Sciences*, 2011, 109:13, 4730–4737.

[27] World Bank, *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*, Report by the Potsdam Institute for Climate Impact Research and Climate Analytics, November 2012.

[28] Harvey, F. World headed for irreversible climate change in five years, IEA warns, *The Guardian*, 9 November 2011.

The IEA is quite explicit on the economic costs of delaying action, calling it a false economy, since: “for every $1 of investment in cleaner technology that is avoided in the power sector before 2020, an additional $4.30 would need to be spent after 2020 to compensate for the increased emissions.”[29]

The International Energy Agency World Energy Outlook 2012 warns that the world will be locked into a dangerous emissions trajectory if planned coal industry projects are allowed to proceed. No more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2°C goal.[30]

Human health and energy sources

Coal and health

Australia's coal contributes to climate change and its global health impacts as well as to direct and localised adverse health effects in communities living and working in proximity to coal-fired power stations, coal mines and coal transportation. Each phase of coal's lifecycle (mining, disposal of contaminated water and tailings, transportation, washing, combustion, and disposing of post-combustion wastes) produces pollutants that affect human health.

Communities in which coal mining or burning occurs have been shown to suffer significant health impacts. The ‘consumption’ of coal for electricity has “significant detrimental health impacts”, which outstrip the benefits afforded by access to electricity.[31] The health and climate costs of coal are largely unseen, and when costs to health systems are included, coal is an expensive and harmful fuel.[32]

The direct health costs to Australia from the coal industry are borne largely by the communities that live and work in proximity to coal mines and coal-fired power stations. Coal mining and the combustion of coal for electricity carries serious health risks, with international research indicating cancer, heart and lung disease, and stroke and intellectual development delays in children, and lung cancer are all implicated.

Despite the substantial evidence of significant harm to human health associated with coal internationally, there is a lack of research on the issue in Australia and limited understanding about the full extent of harm being caused by this industry.

Coal mining is inherently dangerous to the health of workers in both open cut and underground mining, with explosions and mine collapse significant risks in the latter. Long

[29] http://www.iea.org/newsroomandevents/pressreleases/2011/november/name,20318,en.html
[30] International Energy Agency, World Energy Outlook, 2012.
[31] Gohlke, J. Estimating the global public health implications of electricity and coal consumption, *Environmental Health Perspectives*, , 119:6, 821-826.
[32] Casteden, W. et al. The mining and burning of coal: effects on health and the environment, *Medical Journal of Australia*, 2011; 195: 333–335.

term exposure to coal dust leads to pneumoconiosis, and if the dust contains silica, to silicosis. Toxic gases such as carbon monoxide produced during mining pose serious health risks to miners.[33] The use of coal in steel production poses risks to health through the production of volatile polycyclic aromatic hydrocarbons - exposure to which puts steel workers at twice the risk of lung cancer as the general population.[34]

Coal combustion produces harmful air pollution, including particulate matter (PM) and emissions that can contain (depending on the composition of the coal) arsenic, mercury, fluorides, boron, cadmium, sulphuric and nitric acids, lead, selenium and zinc. Mercury emissions are converted into methylmercury, which dissolves in the sediment of waterways, and enters the human food chain through fish.[35] Over 40% of mercury emissions in the US come from power generation sources, which carries an estimated cost of $1.3 billion annually from lost productivity associated with decrements in IQ from mercury toxicity in children.[36] Mercury levels in Australian export coal are estimated to be between 0.01-0.08mg/kg,[37] compared to China's average of 0.16mg/kg.[38] Uncertainty exists as to the mercury content of coal burnt in Australian power stations as well as in regard to the efficiency of mercury capture devices.[39]

Particulate matter (PM) from coal combustion (particularly the smallest particles – PM2.5) is harmful to health and contributes to cardiovascular and respiratory disease and lung cancer.[40] Coal-fired power stations also produce sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). Even short periods of exposure to low levels of sulphur dioxide can affect pulmonary function (as short as ten minutes); while exposure to nitrogen dioxide reduces lung function and contributes to increased asthma [41] and can cause permanent lung damage.[42]

The health and environmental costs associated with coal are however not reflected in the price of coal fired electricity. Public health impacts, including premature mortality and morbidity, constitute the bulk of these currently externalised costs.[43,44]

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[33] Kjellstrom, T. *Energy, the Environment and Health*, in Holdren, J.P. and Smith K. R. (eds), World Energy Assessment: Energy and the Challenge of Sustainability, 2000, Chapter 3, pp.61-110.
[34] Ibid.
[35] Castleden, W. et al. The mining and burning of coal: effects on health and the environment, *Medical Journal of Australia*, 2011; 195: 333–335.
[36] Traande,L. et al. Public health and economic consequences of methyl mercury toxicity to the developing brain. Environmental Health Perspectives, 2005, Environmental Health Perspectives, 113: 5, 590-596.
[37] Commonwealth Scientific and Industrial Research Organisation, *Mercury in Australian export thermal coals*, Fast Facts, 21 July 2010, updated 14 October 2011.
[38] US Geological Survey (USGS), cited in United National Environment Program (UNEP), *Reducing mercury emissions from coal combustion in the energy sector*, February 2011.
[39] Nelson, P. Atmospheric emission of mercury from Australian point sources, *Atmospheric Environment*, 2007, 41:8, pp.1717-1724.
[40] Witter, R. et al. *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008*), School of Public Health, University of Colorado.
[41] World Health Organisation, Air quality and health, Fact Sheet No. 313, September 2011.
[42] National Library of Medicines, Nitrogen Oxides, November 2012.
[43] NAS, Hidden Costs of Energy, 2009.

Research from Europe published in *The Lancet* estimates that 24 people die for every terrawatt (TWh) of coal combusted, from the harmful effects of the airborne particulates, nitrogen oxide, and toxic metals such as mercury and lead released.[45] The International Energy Agency estimates that more than 7,500TWh of electricity was generated by burning coal in 2009.[46] According to this and other estimates,[47] the toll from coal-fired power generation globally may exceed over 200,000 deaths per annum.

A recent review of broad health indicators across 40 years in 41 countries revealed large unaccounted for costs associated with coal consumption.[48] Studies from the US National Academies of Sciences suggest the 'hidden costs' of energy systems (i.e. the monetized value of energy related burdens and damages) cost the US more than $120 billion in 2005.[49]

A more recent analysis of the costs associated with the lifecycle of coal in the US – extraction, transport, processing, and combustion – estimates the cost at over one-half of a trillion dollars annually.[50] Accounting for these damages would "conservatively double to triple" the price of electricity from coal per KWh generated.[51]

The most recent study evaluating the economic costs associated with power generation on health and environment in Australia was released by the Australian Academy of Technological Sciences and Engineering (ATSE) in March 2009.[52]

ATSE found that the health costs of burning coal are equivalent to a national health burden of around $A2.6 billion per annum. If the currently externalised total climate and health costs is considered (including greenhouse gas effects) the estimate rises to $8.3 billion annually.[53]

A recent report from the University of Sydney evaluated the impacts of coal on communities in the Hunter Valley in New South Wales.[54]

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[44] Gohlke, 2011.
[45] Markandya, A., and Wilkinson, P. Energy and Health 2: Electricity generation and health, *The Lancet,* Sep 15-Sep 21, 2007; 370, 9591.
[46] International Energy Agency, Emissions From Fuel Combustion, IEA Statistics, 2011 edition, p.122.
[46]Available at http://www.iea.org/co2highlights/co2highlights.pdf
[47] Gohlke, J. Health, Economy, and Environment: Sustainable Energy Choices for a Nation, Environmental Health Perspectives. 2008 June; 116(6): A236–A237.
[48] Gohlke, 2011.
[49] NAS, Hidden Costs of Energy, 2009.
[50] Epstein, P. Full cost accounting for the life cycle of coal, Annals of New York Academy of Sciences, 1219: 73-98.
[51] Epstein, P. Full cost accounting for the life cycle of coal, Annals of New York Academy of Sciences, 1219: 73-98.
[52] Biegler, T. The hidden costs of electricity: Externalities of power generation in Australia, Report for the Australian Academy of Technological Sciences and Engineering (ATSE), 2009.
[53] Biegler, T. The hidden costs of electricity: Externalities of power generation in Australia, Report for the Australian Academy of Technological Sciences and Engineering (ATSE), 2009.
[53] ibid
[54] Colagiuri R, Cochrane J, Girgis S. Health and Social Harms of Coal Mining in Local Communities: Spotlight on the Hunter Region, *Beyond Zero Emissions,* Melbourne, 2012.

This review found there are serious health and social harms associated with coal mining and coal fired power stations for people living in proximity to them.[55] Some of the potential risks to health from the international literature include lung cancer, chronic heart, lung and kidney diseases; respiratory symptoms, higher prevalence of birth defects; poorer self rated health and reduced quality of life.[56]

Coal seam gas and health

Increasing difficulty in accessing easily exploited reserves of conventional fossil fuels such as oil and gas is leading to a massive expansion in exploration for unconventional energy resources, including coal seam, shale, and other forms of unconventional gas.

Coal seam gas (CSG) exploration and extraction carries potentially significant human health and environmental impacts, as well as risks to animal health,[57] however many of these risks are currently unquantified.

For example, there are serious concerns being raised with regard to the safety of chemicals used in the coal seam gas mining process known as 'fracking' in Australia - with potential risks of neurological, respiratory, reproductive, cardiovascular, endocrine and kidney disorders.[58]

Very few of the chemicals used in coal seam gas mining have been evaluated for their health effects when used for this purpose.[59] Some of the chemicals used in coal seam gas mining are associated with hormonal disruption, effects on fertility and reproductive systems and are potentially carcinogenic.[60] Other chemicals are associated with damage to kidneys, and harm to the nervous system as well as carrying respiratory and cardiovascular risks.[61]

The air emissions from unconventional gas activities also pose health risks: while little monitoring has been done of air quality around Australian gas fields, high levels of toxic air contaminants are found in around US gas operations, including acrylonitrile, methylene chloride, benzene and hydrogen sulphide – which pose risks of cancer, as well as nervous system and respiratory damage.[62]

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[55] ibid
[56] ibid
[57] Carey. M. Coal Seam Gas: future bonanza or toxic legacy? *Viewpoint*, 23 January 2012, p.26-31.
[58] Lloyd-Smith, M. and Senjen, R. *Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment and Climate*, Briefing Paper, prepared for the National Toxics Network, February 2011
[59] Carey. M. Coal Seam Gas: future bonanza or toxic legacy? *Viewpoint*, 23 January 2012, p.26-31.
[60] Shearman, D. Coal seam gas could be a fracking disaster for our health, *The Conversation*, 26 May 2011.
[61] Hunt, C. Coal gas seams good … until you measure the methane, *The Conversation*, 1 December 2011.
[62] Lloyd-Smith, M. and Senjen, R. ibid.

Coal seam gas exploration poses risk to food security, through displacement of food production from fertile agricultural land, and threats to surface and groundwater.

Fracking operations also raise serious concerns about water quality and harm to underground aquifers from coal seam gas mining, as well as serious climate implications from large qualities of fugitive methane emissions during coal seam gas extraction. Methane is one of the most powerful of the short term greenhouse gases.[63]

Natural gas and health

Natural gas exploration and drilling carries risks for human health, but these are considerably less than coal and oil.[64]

There is emerging evidence that the climate impacts of gas may be being underestimated and the emissions from gas, particularly unconventional gas, may be much higher than reported levels. A recent paper prepared for the US National Climate Assessment indicates methane from gas exploration and production accounts for 40% of anthropogenic greenhouse gas emissions in the US,[65] considerably higher than the 10% reported by the US EPA in 2010.[66] In addition, gas from shale deposits (currently rapidly replacing conventional natural gas) is estimated to have a higher greenhouse signature than coal, and if developed as predicted, may increase the proportion of US methane emissions by 40% to 60% or more over the next two decades.[67]

Wind and health

The external costs of wind power are "extremely low", according to four US National Academies (Science, Engineering, Medicine and Research).[68]

Despite claims to the contrary, wind power does not pose any direct adverse health effects, with over 17 international reviews concluding that there is no credible peer reviewed scientific evidence that demonstrates a direct causal link between wind turbines and adverse health impacts in people.[69,70] While a small number of people do claim adverse

[63] Kember, O. *Coal seam gas emissions: Facts, Challenges and Questions*, The Climate Institute, September 2012.
[64] Gohlke, J. Health, Economy, and Environment: Sustainable Energy Choices for a Nation, *Environmental Health Perspectives*. 2008 June; 116(6): A236–A237.
[65] Howarth, R et al. *Methane Emissions from Natural Gas Systems*, Background Paper Prepared for the National Climate Assessment, February 2012.
[66] http://epa.gov/climatechange/ghgemissions/gases/ch4.html
[67] Howarth RW, Santoro R, and Ingraffea A (2012). Venting and leakage of methane from shale gas development: Reply to Cathles et al. Climatic Change, doi:10.1007/s10584-012-0401-0
[68] NAS, Hidden Costs of Energy, 2009.
[69] Chapman, S. 17 reviews on wind turbines and health ... and not a single one referenced, *British Medical Journal*, 11 March 2012.

effects, these effects are thought to be related to the nocebo effect, or annoyance, or a negative attitude to wind turbines, while an income from turbines is demonstrated to provide a “protective effect” against annoyance and/or health symptoms.[71] The recent increase in concern regarding health and wind turbines in Australia is thought to take the form of a psychogenic or “communicated” disease i.e. it spreads via the nocebo effect through being talked about.[72]

Solar power and health

Few studies currently exist comparing the life cycle costs of solar cells versus conventional energy systems. Those available suggest lifecycle emissions are far less than other conventional energy systems and health risks negligible in comparison.[73,74]

Whilst there are no known ill health effects associated with solar power use, the production of photovoltaic cells does pose some environmental and health risks for those involved in the extraction and manufacture of the cells themselves.[75] Depending on the materials used, the manufacturing of photovoltaic cells may lead to exposure to silica and cadmium.[76] Silica dust is a known carcinogen and regular exposure is documented to cause lung, renal and autoimmune problems. However, it is important to note that only 2% of the world’s silica is utilised in the production of metallurgical silicon. Over 80% of the world’s silica is used in the glass, ceramic and other industries.[77] Environmental exposure to cadmium during solar PV manufacture can be minimised through rigorous industrial hygiene practices, and environmental risk eliminated through recycling.[78]

Potential health and environmental risks of solar panels can be minimised if products are properly decommissioned. Recycling solar cells prevents the potential for toxic metals in the cells to leech into landfill and reduces the extraction of new materials.

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[70] Knopper, L. and Ollson, C. Health Effects and Wind Turbines: A Review of the Literature, *Environmental Health*, 2011, 10:78.
[71] Chapman, S. 17 reviews on wind turbines and health ... and not a single one referenced, *British Medical Journal*, 11 March 2012.
[72] Chapman, S. Wind turbine syndrome: a classic “communicated” disease, *The Conversation*, 20 July 2012.
[73] Keith, G. et al. *The Hidden Costs of Electricity: Comparing the Hidden Costs of Power Generation Fuels*, Report prepared for the Civil Society Institute, September 19, 2012.
[74] Bergerson and Lave 2002; Golke et al
[75] Williams, E. *Global Production Chains and Sustainability: The Case of High-purity Silicon and its Applications in IT and Renewable Energy*. Tokyo: United Nations University Institute of Advanced Studies.
[76] Fthenakis VM, Kim HC, Alsema E Environ Sci Technol. 2008 Mar 15; 42(6):2168-74.
[77] Williams, 2000
[78] Fthenakis, V., and Zweibel, K. CdTe PV: Real and Perceived EHS risks, Presentation to NCPV Meeting, 2003.

Renewable energy opportunities in Australia

At present, Australia is failing to take advantage of the nation's abundant renewable energy resources. Renewable energy resources are largely undeveloped - Australia gets just 8% of its electricity from renewable energy, mainly from hydro and wind power. The increasing domestic installation of solar photovoltaic power is being attributed as a major factor in decreasing energy demand from the electricity grid, with energy demand declining 4% since 2008. Increasing rates of installation of energy efficiency measures is another contributor.

Australia boasts the best solar resources in the world and among the world's best wind resources,[79] with higher average solar radiation per square metre than any other continent.[80] The amount of the Sun's energy falling on Australia in one day is equal to half the total annual energy required by the whole world.[81]

The rollout of renewable energy technologies in Australia has been slow due to uncertainty and volatility in the policy environment,[82] and historical differences in costs of renewable technologies and fossil fuel generation.[83]

Australian research demonstrates conclusively that there are no technological or financial impediments for Australia to move to 100% renewable energy for its stationary energy (electricity) supply. Wind can achieve a capacity factor of up to 45% in Australian conditions, and solar thermal can provide base-load (i.e. overnight) power due to its ability to store power for up to 16 hours. With upgrades to the national electricity grid to accommodate distributed generation, combined with energy efficiency improvements, renewable energy technologies could comfortably supply all Australia's power requirements.

The Zero Carbon Australia 2020 Plan developed by the Melbourne Energy Institute (MEI), University of Melbourne and research consultancy Beyond Zero Emissions (BZE) in 2010 demonstrates that Australia has sufficient non-fossil renewable energy resources to power its entire stationary energy sector and that a transition to 100% renewable energy is affordable and can be accomplished in a short time frame.[84]

Modelling at the University at New South Wales also demonstrates that 100% renewable energy is feasible for Australia using commercially available technologies to supply high levels of variable resources such as wind and solar.[85] This modelling suggests there needs

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[79] Geoscience Australia and ABARE, *Australian Energy Resource Assessment*, 2010, Canberra. Available at https://www.ga.gov.au/image_cache/GA17412.pdf
[80] Geoscience Australia and ABARE, chapter 10.
[81] Australian Academy of Science, *Australia's renewable energy future*, December 2009.
[82] Garnaut, R. The Garnaut Climate Change Review, Final Report, 2008.
[83] Climate Change Authority, Issues paper: Renewable Energy Target Review, Australian Government, August 2012.
[84] Beyond Zero Emissions, *Zero Carbon Australia: Stationary Energy Plan*, 2010.
[85] Elliston, B., Diesendorf, M., and MacGill, I. Simulations of scenarios with 100% renewable electricity in the Australian National Electricity Market, Energy Policy, Volume 45, 2012, pp.606–613.

to be a re-conception of the electricity supply-demand system to accommodate large volumes of variable resources in a great diversity of locations, and if this was achieved, a transition away from conventional base-load power could be accomplished entirely.

The 2010 report on renewable energy by the Australian Academy of Science found reliable renewable energy technologies such as wind and solar are commercially available right now for electricity generation.[86]

This is also supported by research from Stanford University that shows that the world could be powered entirely with renewable energy within 20-40 years, using technology that is available today and at a cost comparable to that of conventional, fossil-fuel-based energy.[87] Like the UNSW modelling and the MEI/BZE report, the Stanford modelling uses wind and solar as the predominant resources, finding that the barriers to the implementation of policy to deliver this scenario are not technological or financial but social and political.[88]

Evaluations of Australian's attitudes towards renewable energy suggest Australians "overwhelmingly support renewable energy", with the strongest support for solar, wind and hydro power.[89] The benefits cited by people in both rural and urban areas include: reduced pollution, reduced electricity costs, and increased jobs.[90] A CSIRO study of community attitudes to wind found strong community support for the development of wind farms in Australia and that community resistance attributable to visual amenity could be improved through effective community engagement.[91]

The energy sector in Australia

Australia's energy sector is comprised of electricity generation, coal mining, gas and oil exploration, extraction and refining, gas supply and energy services.[92]

Fossil fuels account for around 90% of Australia's electricity generation and 96% of Australia's energy consumption.[93] Around 80% of Australia's energy resources are exported.[94] Coal dominates energy production (60%; 80% of coal is exported), followed by uranium (20%, all of which is exported), and gas (13%).[95]

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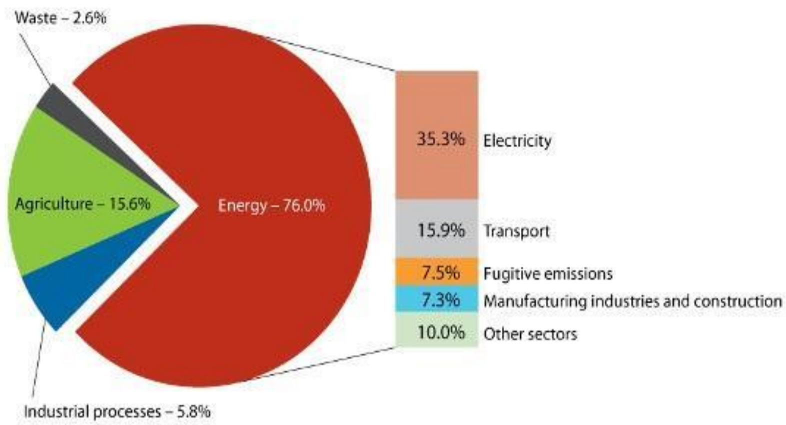
[86] Australian Academy of Science ibid
[87] Bergeron, L. The world can be powered by alternative energy, using today's technology, in 20-40 years, says Stanford researcher Mark Z. Jacobson, *Stanford Report*, 26 January 2011.
[88] Delucchi, M. and Jacobson, M. Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies, *Energy Policy* 39 (2011) 1170–1190.
[89] Climate Institute, State of the Nation, 2012.
[90] NSW Department of Environment, Climate Change and Water, Community attitudes to wind farms and renewable energy in NSW, 2010.
[91] Hall, N. et al. *Exploring community acceptance of rural wind farms in Australia: a snapshot*, CSIRO Science into Society Report, 2012.
[92] Energy White Paper ibid
[93] Energy White Paper
[94] Energy White Paper
[95] Energy White Paper

The energy sector accounts for around 75% of Australia's greenhouse gas emissions.[96]

Despite abundant renewable energy resources in Australia, renewable energy currently contributes just 8% to national energy supply.[97]

Fig.2: Australia's greenhouse gas emissions profile (excluding land use change)



The largest energy sources in Australia are coal, gas and renewables, in that order.
Coal

Coal for energy generation

Until recently, coal fired power supplies around 80% of Australia's electricity.[98] The main coal fired power stations in Australia are: in **Victoria**: Loy Yang A, Hazelwood, and Yallourn; in **New South Wales**: Bayswater, Liddell and Eraring; and in **Queensland**: Tarong, Gladstone, and Stanwell.[99] The total annual national output from all coal-fired power is estimated to be 197 TWh.[100] The annual emissions of PM10 from coal fired power stations are 41,000, tonnes/year; the average emission rate of PM10 for all Australian coal-fired plants is 210 mg/kWh – compared to 34mg/kWh in Germany, and 110mg/KWh in the UK, for example.[101]

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[96] DCCEE, 2011 cited in Energy White Paper, 2012.
[97] Climate Change Authority, Issues paper: Renewable Energy Target Review, Australian Government, August 2012.
[98] Castelden, W. et al. The mining and burning of coal: effects on health and environment, *Medical Journal of Australia*, 195:6, 2011.
[99] The Australian Academy of Technological Sciences and Engineering (ATSE), T*he Hidden Costs Of Electricity: Externalities of Power Generation in Australia,* March 2009.
[100] ATSE ibid
[101] ATSE ibid

Coal mining

Black coal is mined mainly in New South Wales and Queensland. Almost 840Mt of coal was mined in Australia in 2009-10. Brown coal, which has higher water content than black coal, and produces more greenhouse gas emissions, is mostly mined in Victoria (96%).[102] The Latrobe and Hunter Valleys - in Victoria and New South Wales respectively – are centres of coal mining and power generation in Australia. Coal is also mined in Western Australia and South Australia. Most coal mining in Australia is from open cut mines.

It is estimated the one billion tonnes of coal reserves from the Wandoan coal mine would generate 1.3 billion tons of carbon emissions over 30 years and clear 11,000 hectares of farmland. The resource base for the Bacchus Marsh mine is estimated at between 1-2 billion tonnes of coal. Several major new mines are proposed for the Gunnedah Basin and the Hunter Valley in NSW, and nine 'mega mines' are proposed for the Galilee Basin in Qld. If these mines reach estimated production, the combustion of the coal would produce 705 million tonnes of additional CO_2 emissions - almost double Australia's total annual emissions.[103] This would make the Galilee Basin the world's seventh largest producer of CO_2 emissions.

Coal for export

Australia is the world largest coal exporter, responsible for 300Mt of coal exports in 2010, worth $36 billion.[104] Metallurgical coal represented 159 million tonnes of coal exports, while thermal coal accounted for 141 million tonnes.[105] Half of Australian coal exports go to Japan. Other major customers are South Korea (18.5%), Taiwan (14%) and China (10%).

The coal mining industry in Australia is undergoing a rapid and massive expansion. Around 30 coal mines and coal mine expansions are in various stages of planning approval in New South Wales and exports are expected to double in Queensland. Much of this extra volume is likely to come from mega-mine projects in the Gunnedah Basin of NSW and the Surat and Galilee Basins in Queensland.

Gas

Australia produced 2095 petajoules (PJ) of gas - including coal seam gas (239PJ) - in 2010/11, of which 1515 PJ was used domestically. Around half of total production (1086 PJ) was exported.[106] About 87% of domestic gas consumption is used in manufacturing,

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[102] Department of Resources, Energy and Tourism, *Energy in Australia 2011*, Australian Government.
[103] Greenpeace Australia Pacific, *Cooking the Climate, Wrecking the Reef: The global impact of coal exports from Australia's Galilee Basin*, 2012.
[104] Australian Bureau of Agricultural and Resource Economics, *Australian mineral statistics*: December quarter 2010, March 2011, page 21.
[105] ibid
[106] Bureau of Resources and Energy Economics, *Energy in Australia*, 2012. (BREE 2012c)

electricity generation and mining; the residential sector consumes a further 10%.[107] Most of Australia's gas is produced in WA, in the Carnarvon Basin; with the remainder from the Gippsland, Otway and Bass Basins. Australia's gas production is projected to quadruple over the next two decades, reaching over 8000 PJ in 2034–35, 5663 PJ of which is expected to be exported, with domestic consumption expected to reach 2611 PJ by 2034-35.[108] An increasing proportion of this is likely to come from coal seam gas (methane).

Coal seam gas

The coal seam gas industry is new to Australia. Production of coal seam gas has expanded dramatically in recent years, increasing from zero in 1995 to 195PJ in 2009.[109]

According to the Australian Energy Market Operator (AEMO), the bulk of proven and probable reserves of coal seam gas are in Qld (93%) with the remainder in NSW.

There are currently around 3500 producing coal seam gas wells in Qld and New South Wales.[110]

It is estimated there will be 40,000 gas wells in Australia over the next two decades. It is estimated these will require 300Gl of water and produce 31 million tonnes of salt waste.[111]

Renewables

Generation from renewable energy resources accounts for about 8% of Australia's electricity production (19,711 gigawatt hours (GWh) per year).[112]

The main sources of renewable energy in Australia are hydro, biomass, wind and solar power with recent growth in wind and rooftop solar (photovoltaic) energy generation.

The proportion of renewable energy generation has grown over the last decade, although the expansion of wind power has been offset by reduced capacity of hydro power generation from declining rainfall.[113]

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[107] ibid

[108] ibid; Department of Energy Resources and Tourism, *Energy White Paper 2012*, Australian Government.

[109] Geoscience Australia, *Coal Seam Gas Fact Sheet*, Australian Government. Available at http://www.australianminesatlas.gov.au/education/fact_sheets/coal_seam_gas.html Accessed 15 December 2012.

[110] Manning, P. Coal seam gas faces tax bill of billions, *The Age*, 19 November 2012.

[111] Carey. M. Coal Seam Gas: future bonanza or toxic legacy? *Viewpoint*, 23 January 2012, p.26-31; Lloyd-Smith, M. and Senjen, R. *Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment and Climate*, Briefing Paper, prepared for the National Toxics Network, February 2011..

[112] Climate Change Authority, *Renewable Energy Target Review: Issues Paper*, Australian Government, August 2012.

[113] ibid.

Energy policy in Australia

Energy policy in Australia is driven by a mix of state government decisions influenced by broader federal policy directions and legislation.

Onshore mining operations, including coal mining and coal seam gas extraction, are primarily licensed and regulated under relevant state or territory water, environment, mining and petroleum legislation.[114] If they are considered at all, human health matters related to energy projects are regulated by state and territory agencies.

The Council of Australian Governments plays a role in energy market oversight. The Australian Government's involvement is limited to matters protected under national environment law, such as nationally threatened and migratory species, wetlands of international importance, or national or world heritage places.[115] Issues relating to human health are considered under national environment law as 'social matters'.

The Australian Government's energy policy framework includes: the 2012 Energy White Paper; a range of subsidies for coal, oil and gas; the carbon pricing scheme; and the renewable energy target.

A National Harmonised Framework for CSG is being developed by the Council of Australian Governments (COAG) Standing Council on Energy and Resources (SCER) to "identify risks as well as achieve a balance between the rights and interests of different stakeholders".[116] An Independent Expert Scientific Committee on CSG and Large Coal Mining Developments was established in November 2012 to evaluate risks to water resources from intended developments.

[114] http://www.environment.gov.au/epbc/coal-seam-gas/index.html
[115] http://www.environment.gov.au/epbc
[116] Standing Council on Energy and Resources, Policy Statement, 9 December 2011.

Recommended Reading:

Australian Government, Energy White Paper, Executive Summary, 2012.

Butler, C. What will a four degree rise mean for world health? The Conversation, 2 June 2011.

Castelden, W. et al. The mining and burning of coal: effects on health and environment, Medical Journal of Australia, 195:6, 2011.

Gohlke, J. Estimating the global public health implications of electricity and coal consumption, Environmental Health Perspectives, 2011, 119:6, 821-826.

Lloyd-Smith, M. and Senjen, R. Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment and Climate, Briefing Paper, National Toxics Network, February 2011.

APPENDIX ONE:

Figure 1: Health aspects of energy sources

Energy source /type	Pollutants	Health Effects	Metrics ***
FOSSIL FUELS		Coal, gas, and oil extraction from underground or underwater stores, is the second most hazardous occupation in the US after agriculture.[1]	Annual US fatality: 27.5 deaths/100,000 cf 28.5 in agricultural workers and 3.4 deaths /100,000 for all US industries [1]
• Coal	Dust and particulates, especially $PM_{2.5}$, toxic gases eg methane, nitrous oxide, ozone, sulphur dioxide, ionizing radiation	Respiratory disease[,2,3,4, 5, 6, 7](asthma especially in children,[8,] pneumoconiosis, COPD, lung cancer[9])	Pneuomoconiosis US deaths 1996-2005: 10,000 deaths. [5, 6] US hospitalisations due to asthma as main diagnosis 2010 : 440,000.[8] US lung cancer diagnoses 2008: 208,493 - 111,886 men and 96,607 women.[9]
		Cardiovascular disease (coronary artery disease, congestive heart failure, arrythmias [4,10]	US suspected or confirmed myocardial infarction 2006: 7.9 million. [4] US prevalence congestive heart failure 2006: 5.7 million. [10]
		Cerebrovascular disease[10]	In US 1816 women had one or more fatal or nonfatal cardiovascular events including cerebrovascular disease and stroke coronary revascularization, myocardial infarction, and stroke correlated with levels of $PM_{2.5}$ in 2000 and varying between cities. [10]
	Carbon dioxide	Health issues of climate change[11]	Respiratory, disease; cancer; cardiovascular disease; food borne diseases and

			nutrition; human development; neurological disorders; mental health and stress; vector borne and zoonotic diseases; weather-related morbidity and mortality. [11]
	Mercury and other elements/metals particularly cadmium, lead and arsenic.	Kidney damage[2] Neurodevelopmental delay[4] Cancers[12]	16% US women of child-bearing age 1999-2000 had Hg levels high enough to disturb neurodevelopment of foetus.[4]
	Mining area expansion	Social and mental health problems [13]	Increase reports of depression and anxiety in mining areas of Australia where there has been disruption of the region's community cohesion.[13]
		Injury/accidents[14]	US data –2000-2004: 53 deaths, 536 injuries in vehicles licensed for coal transportation [14]
• Oil • Natural gas	Volatile organic compound (VOCs) such as benzene, toluene, ethylbenzene, xylene	Ground water contamination threatening food safety[15,16]	Increased cancer and non-cancer risks based on risk assessment. [17]
	Oil mists and vapours ie air pollutants generated by drilling fluids which are a complex mixture of solids, liquids and VOCs, including base oils and brine Groundwater	Headaches, vomiting, eye, skin and respiratory irritation, Very rarely concentrated oil vapors can cause lipoid pneumonia. [18] These problems are avoided by protective clothing.	

• Coal seam gas	contamination Toxic environmental VOCs including ozone	Food and water safety contamination pose risks to human and animal health[19] Toxic reactions to fraccing chemicals.[19] Respiratory irritation, depression of central nervous, cardiovascular and immune systems and kidney damage.[20]	
RENEWABLE ENERGY Solar Wind Wave Hydro Geothermal Biomass	 Pollutants from non-renewable resources used in plant construction, including particulates, toxic gases, heavy metals Hydrogen sulphide which breaks down to Sulphur dioxide, Carbon dioxide, benzene, Mercury, Radon, Arsenic Many low level	Less power-associated accidents because fuel extraction phase reduced, through a one-time extraction of raw materials is required to manufacture wind turbines and photovoltatic modules for wind and solar energy. [21] Psychogenic – anxiety, noise sensitivity, aesthetics [22] Safety concerns – to be clarified Pollution and water-associated disease, occupational exposures and accidents, community social and socio-economic economic change, including concern over noise and aesthetics [23] The concentration of these gases are low and unlikely to cause significant health risks, within occupational health controls. Accidents from hot liquids and volatalised gases are possible and should be carefully monitored. [24] Lower pollutant levels and	

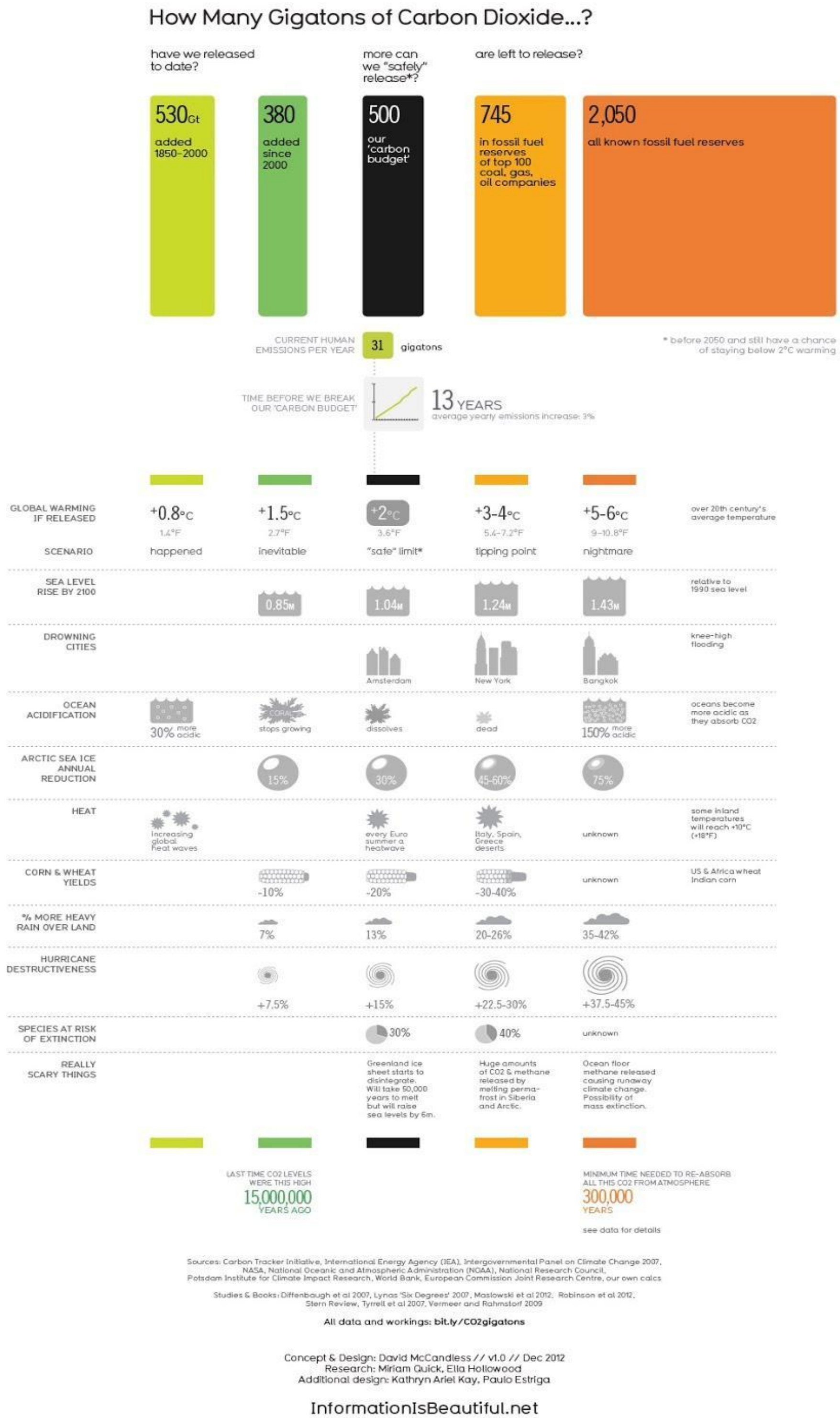
	products of incomplete combustion including, $PM_{2.5,}$ Carbon dioxide, nitrous oxide	effects than for coal. No reduction in power-associated accidents, because continuous extraction organic waste, wood derived fuels and crops such as corn for ethanol production and petroleum based fertilizers. [25]	
Electromagnetic	Non-ionising radiation and radio-frequency radiation	Evidence of health risks, particularly cancer is ambiguous and unproven. [26]	

*** There is a dearth of relevant data, especially in Australia. Best information is from descriptive, comparative studies between mining and non-mining areas. These measures are mostly of the burden of relevant diseases to which the human responses to sources of power contribute.

Nuclear power though debated for future power supply in Australia has been dismissed on public health grounds [27] and is not included in this summary.

APPENDIX TWO

Figure 3: How many gigatonnes of CO_2 can the world safely emit to stay within two degrees?



APPENDIX THREE: Case studies

Angelsea, Victoria

At Angelsea in Victoria, residents are facing the expansion of the open cut coal mine and ongoing pollution from an old coal-fired power plant on the outskirts of their town.

The pollution emissions from Anglesea Alcoa plant and mine exceed world health standards for emissions.

The National Environment Protection Council has recently reviewed the Ambient Air Quality National Environment Protection Measure (NEPM), which demonstrated that there are adverse health effects below the current NEPM standards.

The review found that there may be no safe level of exposure for sulphur dioxide (SO_2), especially for vulnerable groups including the elderly, children and those with asthma.

The current Victorian EPA standard for SO_2 is 200ppb, while the US EPA standard is a much lower 75ppb.

Monthly data released by Alcoa shows clearly Anglesea residents are frequently exposed to harmful levels of SO_2, according to the US standard.

Alcoa, an American owned company, is allowed to continue operating their coalmine and power station in Anglesea in Victoria when they would not legally be allowed not do so in the United States.

The Angelsea community are seeking that Alcoa invest in currently available technology to clean up their current operation and transition toward clean energy.

The community at Angelsea are also seeking a government funded independent study into air quality to establish level of pollutants in Anglesea, and asking for that Alcoa transition to renewable energy to power its operations at Point Henry.

Newcastle, NSW

A proposal to build a fourth coal export terminal (T4) to accommodate a planned expansion of coal exports from the city of Newcastle in NSW has raised health concerns for the local community in relation to the coal dust that increased coal transportation and storage will generate, as well as diesel exhaust emissions associated with coal transport and handling.

Between 1984 and 2012 coal exports from Newcastle increased six-fold from 21 million tonnes per annum (Mtpa) to 134 Mtpa. The proposed fourth terminal (T4) would add another

120Mt pa, which combined with the full extent of T3, would boost capacity to a total of 330 Mtpa, making Newcastle the world's largest coal port.

A survey of 580 Newcastle households found that fewer than 10% of residents support T4 and most are concerned about health impacts. Many Newcastle residents routinely wipe coal dust from every horizontal surface inside and outside their homes. T4 may mean as many as 100 additional uncovered coal trains passing by every day, exposing the community to even higher levels of particle pollution. There are 25,000 children attending schools within 500 metres of the coal corridor.

Intrusive day and night time noise levels will increase significantly by continuous movement of trains (108,000 coal train pass-bys per year at proposed full Port capacity of 330Mtpa – estimated to be one every 4.9 minutes). The anticipated noise pollution is expected to exceed WHO standards and is considered likely to disrupt sleep – which itself creates adverse health impacts.

Community members perceive that current levels of dust generated by coal transport and handling are causing significant and adverse health impacts, and are concerned these impacts will increase with the proposed near tripling of the volume of coal being transported from the Hunter Valley through Newcastle.

Air quality is monitored in the Hunter Valley and Newcastle by the NSW EPA, Newcastle City Council, PWCS, Orica and other licensed industries.

However the collected data from monitoring is not currently published in one accessible location, or in an integrated form, nor in a timely fashion, making it very difficult to evaluate risk, according to residents.

The T4 project's environmental assessment report does not present a comprehensive analysis of fine particle pollution levels or the associated health impacts. The report asserts that current levels of particle pollution are not of concern, that there are minimal health impacts and there particle pollution levels will not be significantly elevated if T4 is approved. Community groups do not accept these assertions. The development application environmental assessment reveals that long-term monitoring sites close to Hunter River have annual PM10 averages higher than the WHO standard of 20ug/m3.

Concerned Newcastle residents have formed a community coalition (Coal Terminal Action Group or CTAG) made up of 17 independent residential and environmental groups. CTAG is currently completing a mobile dust monitor study to assess the level of fine particle pollution along the rail corridor and in proximity to the coal loaders. Independent scientists will estimate the health implications of air quality risk found by the monitoring. The Dust and Health Study will provide the community with independent information and advice upon which to consider the T4 proposal and other port development projects.

APPENDIX FOUR: Definitions

This appendix provides definitions for some of the terms used in this paper and explains the relative size of some of these measures.

Gigawatt (GW): One thousand megawatts or one billion watts.

Megaton (Mt): Unit of one million tonnes.

Megawatt (MW): One million watts.

PM: Particulate matter produced by coal fired power stations, mining, wood and biomass combustion, industrial activity, and from motor vehicles. No level of particulate matter is safe, and the level of risk to health depends on the extent of exposure. Chronic exposure to particles contributes to cardiovascular and respiratory disease as well as lung cancer.

PM2.5: Fine particle pollution of up to 2.5 micrometers in diameter. These particles are fine enough to enter the bloodstream, and those produced from burning fossil fuels are the most hazardous to health.

PM10: Particulate matter of less than ten microns (micrometers) in diameter. A human hair is between50-70 microns in diameter.

Petajoules: A joule is a unit of energy. One joule is equivalent to one watt of power radiated or dissipated for one second. One petajoule is the heat energy content of about 43,000 tonnes of black coal or 29 million litres of petrol.[117]

Terrawatt (TW): Unit of power. Equivalent to 1,000 billion kilowatts or one million megawatts or one trillion watts. The average lightning strike peaks at 1 terrawatt.

Unconventional gas: gas trapped deep underground in rocks, such as coal seam gas, shale gas and tight gas.

[117] BREE, 2012, ibid.