Health and Energy Choices:
Background Briefing Paper

This Background Briefing Paper supports the Health and Energy Choices Position Paper. It is provided by a collaboration of health sector organisations concerned that the health impacts associated with fossil fuel energy projects are not being considered in public policy decision-making.
Background to Position Paper: Health and Energy Choices

All sources of energy to support human activity have implications for health. We, as a society, need to choose how we harvest energy so that we use the ones with the least overall adverse impacts on health. This paper on Health and Energy Choices is to open this discussion for Australia, and to provide a background for the Joint Position statement on Health and Energy Choices.

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1 Introduction

In Australia, it is estimated that the adverse health impacts from pollutants produced from coal fired electricity generation cost A$2.6 billion annually. The production of petroleum poses risks to health through exposure to chemical carcinogens and its combustion for transport is a major source of air pollution that causes respiratory, cardiovascular disease and cancer.

Air pollution costs from power generation, industry and transport in NSW are estimated at $4.7 billion annually. A 2005 estimate of the health costs associated with air pollution from transport put the national cost at $3.3 billion annually. The economic costs of adverse health impacts associated with other energy resources and from climate change in Australia are as yet unquantified.

However the global costs to human health associated with the carbon intensive energy systems of the global economy is $540 billion each year, excluding health impacts resulting from climate change. If climate impacts on health are included, the total current cost to the global economy is estimated to be $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 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 continue to increase, with damages accelerating throughout this century.

Communities across Australia are being affected by coal mining, transportation and combustion, and unconventional gas exploration and production. Communities living near proposed coal mines, coal mine expansions, coal seam and shale gas extraction potentially face displacement, water insecurity, air and noise pollution, risks to water quality, loss of amenity and social capital, and serious physiological and psychological health risks. Those being exposed to coal transport face unacceptable levels of noise and air pollution that regularly breach air quality standards. Those living in proximity to coal fired power stations face risks of respiratory, cardiovascular, neurological disease and developmental effects. Air pollution from transport kills more people each year than the road toll.

The evidence of harm to human health directly related to fossil fuels documented in this paper reinforces the imperative extolled by scientific experts around the world - that shifting away from fossil fuels is urgent and necessary to reduce widespread risks to human health and wellbeing and help prevent further climate change.

In contrast, renewable energy, including solar and wind, present clean, safe and reliable energy alternatives. Australia must, for reasons related to global warming and the protection of the health and wellbeing of the community, transition as quickly as possible to 100% renewable energy systems for electricity generation, heating and cooling systems, and transport.
2 Current energy sector

This report addresses industries involved in the production of energy for electricity, heating and cooling, and transport either through mining, extraction or utilisation of resources domestically, or internationally following export. The discussion is set out in four sections: firstly an overview of the health effects of energy choices to society and health at a broad and general level, and then a more specific review of local direct effects by energy source sector; third, it looks at the way forward; and then at the role of health professionals.

The initial sections look at the mining, transportation and combustion of coal; the extraction and distribution of gas (conventional eg liquified natural gas, and unconventional eg coal seam gas, shale and tight gas), and the exploration, production and combustion of oil.

The energy sector in Australia is heavily based on fossil fuels, including coal, gas (conventional and unconventional) and oil (petroleum, diesel). The energy sector accounts for

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Figure 1.1

Hunter Valley coal mines near Muswellbrook, NSW. Many mines are in close proximity to houses and farms and leave huge scars on the landscape. Photograph: © Greenpeace/Chris Daley
around 75% of Australia’s greenhouse gas emissions. 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.

The bulk of Australia’s energy resources are exported. Coal dominates energy production (60%; 80% of coal is exported), followed by uranium (20% - all of which is exported), and gas (13%; of which 48% is exported).

There is no nuclear power produced in Australia. While there is exploration of geothermal energy, there is no commercial production in Australia.

The renewable energy sector is increasingly significant, and includes wind, solar and hydro power. Despite abundant renewable energy resources in Australia, renewable energy currently contributes just 8% to national energy supply. Other countries with far fewer renewable energy resources are producing far more energy from renewables than Australia. In Austria, 65.8% of electricity is supplied by renewables; Latvia 50.5%; Denmark 40.3% (50% of which is wind power); Italy 27.6%; Ireland 19.7%; and in Germany 20.4%.

Australia’s energy sector is heavily dependent on fossil fuels, with 75% of total electricity in the National Electricity Market supplied by black and brown coal–fired power stations. Most coal fired power stations in Qld, NSW and WA are owned by state governments or government–owned corporations.

Of the total energy produced in Australia, gas supplies 16%; hydro provides 6.5%; while wind provides 1.5%, and solar 0.1%. Both wind and solar are growing rapidly: wind is expected to grow to 12% by 2030, while solar is expected to increase by 6% a year to 2030.

Australia is one of the world’s largest coal exporters, responsible for 300 megatonnes (Mt) of coal exports in 2010. The largest markets for Australian coal are Japan, Republic of Korea, Taiwan and India. Japan is the largest buyer of thermal coal (47.3%), followed by the Republic of Korea (18.7%) and China (12.7%). The bulk of Australian metallurgical coal exports (used in steel–making) also go to Japan (29.8%), followed by India (22.9%), and the European Union (EU at 14.7%).

If proposed exports of coal were included in total national emissions accounts, Australia would be the source of 4.8% of global emissions.

National and state energy policy continues to favour coal over renewables with the national 2012 Energy White Paper declaring reserves of thermal coal “can sustain current production levels beyond 2100”.

Government support for coal–fired electricity was $3.6 billion per year in 2012–13, compared to $1.4 billion for renewable energy.
3 Energy choices and health effects

The first section summarises the broad domains of harm to society and health from fossil fuel use. The following section will detail the harms associated with particular fossil energy sources. Nuclear energy will be addressed as well.

3.1 Health risks from fossil fuel energy production and use

This section describes the broad social, economic and environmental aspects of fossil fuel energy use on health and wellbeing.

Figure 3.1 Australian energy production (for local consumption and export) is largely from fossil fuel resources. Source: BREE 2012, Australian Energy Statistics
Background to Position Paper: Health and Energy Choices

3.1.1 Localised pollutants

Fossil fuel energy production exposes communities to air, water and soil pollution from gases and other chemicals that are directly harmful to health. Local pollutants such as coal dust, particulate matter, and other toxins (e.g., arsenic, sulphuric and nitric acids, boron, fluorides and mercury) are produced from the mining and combustion of coal, while the combustion of fossil fuels for transport is associated with the production of particulates, nitrogen dioxide, ground level ozone and carbon monoxide.

In 2004, Australian government scientists estimated that 2,400 of the 140,000 Australian deaths each year were linked to air quality – a number they say would be much greater if the longer term contribution of air toxins to cancer mortality were included.

There have been few scientific studies on the direct health impacts of fossil fuel energy production on communities living in Australia. The international literature however clearly demonstrates that serious harms to health can be associated with exposures to pollutants from coal mining and coal-fired power stations.

There are also localised pollutants associated with the mining and production of unconventional gas (e.g., coal seam gas). The process of hydraulic fracturing (also known as hydraulic stimulation and more commonly as fraccing/fracking) used in unconventional gas mining involves the use of many chemicals, some of which are associated with short and long term health effects.

These chemicals are associated with detrimental health effects, including increased cardiovascular, respiratory, neurological, reproductive, cancer, endocrine and kidney disorders, cancer and birth defects.

3.1.2 Risks to water security and water quality

The production of coal and unconventional gas threatens water supplies which also pose risk to health. The mining of coal and coal seam gas both pose a risk of contamination of underground aquifers and adjacent waterways with pollutants, as well as a risk to water security, since both require huge amounts of water.

Coal dust can pollute the surrounding environment, including waterways, as can waste water from coal mines when disposed of. Coal seam gas mining involves the removal of vast amounts of water which can affect the level of underground aquifers and may deplete them completely or leave them contaminated with chemicals. This has serious implications for the agricultural industries and rural communities that rely on this source of water.

The National Water Commission reports that the Australian CSG industry could extract in the order of 7,500 gigalitres of
produce water* from groundwater systems over the next 25 years, equivalent to approximately 300 gigalitres per year. In comparison, the current total extraction from the Great Artesian Basin is approximately 540 gigalitres per year.34

The National Water Commission has identified the following risks to sustainable water management in relation to coal seam gas:

- Extraction of large volumes of water will impact on surface and groundwater systems, including the Great Artesian Basin and Murray-Darling Basin.
- Dramatic depressurisation of the coal seam can lead to changes in pressures of adjacent aquifers; reductions in surface water flows; and land subsidence over large areas, affecting surface water systems, ecosystems, irrigation and grazing lands.
- The release of large volumes of treated waste water from CSG mining could alter natural flow patterns and have significant impacts on water quality, and river and wetland health.
- Fracking and discharge of wastewater can cause cross-contamination between aquifers, with impacts on aquifer and groundwater quality.

* “Produce water” is a by-product of the gas drilling process. It is considered hazardous waste and requires special disposal and handling.
Discharge water from coal seam gas wells has a high saline content and may contain fracking chemicals which can pollute adjacent waterways. Coal seam gas operations in Queensland are associated with incidents in which groundwater has become polluted with the chemicals benzene, toluene, ethylbenzene and xylene (BTEX).36 The levels of benzene found in bores at the Arrow Energy fracking operation was between six and 15 times the levels allowable in the Australian drinking water guidelines.37

Methane from unconventional gas operations involving shale gas in the USA has been found to contaminate drinking water in Pennsylvania and New York, with water wells near active drilling sites contaminated with methane at levels 17 times higher than wells in areas without drilling.38

These risks to water require greater consideration within unconventional gas project approval processes, according to the National Water Commission, which urges a precautionary approach, saying:

“CSG development represents a substantial risk to sustainable water management given the combination of material uncertainty about water impacts, the significance of potential impacts, and the long time period over which they may emerge and continue to have effect”.39

### 3.1.3 Social harms

Communities in proximity to coal and coal seam gas exploration and production and coal transport in Australia are experiencing significant social and economic impacts that affect individual and community health and wellbeing.40, 41, 42, 43

These include:

- distress related to concerns about adverse health impacts;
- costs associated with environmental damage and declining land values;
- concerns regarding noise and air pollution;
- social divisions and inequalities between those benefiting from the industry and those who do not, including those due to adverse economic impacts on other industries;
- reduced affordability and access to accommodation;
- distress and disempowerment related to asymmetries of power and influence between mining companies and individuals and communities over access to information and resources;
- increased road traffic accidents due to sudden and significant increases in vehicular transport; and
- increased demands on local services without corresponding investment in infrastructure or human capital.44, 45

In communities exposed to coal seam gas exploration and extraction, there is emerging evidence of severe psychological distress associated with disempowerment and grief as individuals and families are forced to accept the industrialisation of their landscape with gas wells, or
are obliged to leave their family farm when the level of industrialisation and pollution makes it untenable to live there any longer.\textsuperscript{46,47}

The Australian National Water Commission also holds concerns regarding adverse social impacts associated with CSG development by “disrupting current land-use practices and the local environment through infrastructure construction and access”.\textsuperscript{48}

One component of the harm to mental health being experienced by communities in coal mining regions is ‘solastalgia’, a term coined by environmental philosopher Glenn Albrecht to describe the distress associated with the destruction or loss of ‘place’.\textsuperscript{49}

### 3.1.4 Regulatory failures

Increasingly, reports are emerging that document a failure of the current system of regulation with respect to energy projects in Australia. An independent medical evaluation of the health impacts associated with a coal seam gas development in Queensland found no baseline air or water monitoring occurred prior to the Queensland Government permitting widespread development of coal seam gas in proximity to family homes.\textsuperscript{50} No ongoing health study or surveillance is in place or any ongoing testing to monitor exposure to health risks. The investigation of local health complaints by the Queensland Department of Health was unable to confirm reasons for the symptoms experienced but relied on industry commissioned data, self presentation for medical review and involved no site visits by any medically trained staff.

According to a recent report by Doctors for the Environment Australia, there is no adequate evaluation of the implications for human health occurring during the approvals process for energy resource projects.\textsuperscript{51} While there is an expectation that health impacts be addressed during mandatory Environmental Impacts Assessments, the evaluation of potential health risks by state governments is often rudimentary and fails to adequately protect the health of the community.

Further regulatory failures are leading to excessive exposures to pollutants such as coal dust among communities in Brisbane,\textsuperscript{52} and Newcastle, where national air quality standards are failing to be enforced and communities are being exposed to levels of air pollution that frequently exceed national air quality standards. The standard for PM10 was exceeded more than 115 times in the Hunter during 2012.\textsuperscript{53}

### 3.1.5 Economic risks

The economic benefits to Australians from the energy sector, particularly from mining, appear to be overstated. The entire mining industry employs 269,700 people, or around 2% of the total workforce.\textsuperscript{54} Over 80% of the mining
industry in Australia is foreign owned.\textsuperscript{55} Mining companies in Australia pay much less tax than other companies: 13.9\% compared to the 30\% corporate tax rate.\textsuperscript{56} Mining also receives far more subsidies than other industries with miners the recipients of over $4 billion in annual subsidies from the federal government,\textsuperscript{57} while the total subsidies provided to the fossil fuel sector amount to over $10 billion annually.\textsuperscript{58}

Fossil fuel mining and export contributes to the recent rapid expansion in mining which has brought broader economic disadvantages: it drives up the value of the Australian dollar and makes Australian exports more expensive, thereby reducing demand for other exports.\textsuperscript{59} The mining boom has also driven up labour costs, making it increasingly difficult to attract and retain staff in non-mining industries. This is impacting important service industries including health and education and policing, where shortages put health, safety and future economic security at risk.

A recent paper by Economists at Large and the Australia Institute\textsuperscript{60} evaluated the economics of coal and coal seam gas projects in NSW and found that:

\begin{itemize}
  \item the economic benefits of projects were routinely overstated;
  \item the environmental harms were downplayed;
  \item the volumes of greenhouse gases produced were seriously under-reported;
  \item the employment benefits including potential jobs created were overstated;
  \item the costs to other industries from taking workers away and effects on the exchange rate were ignored; and
  \item the health costs were not considered, despite evidence of increased health costs from increased morbidity and mortality and reduced productivity.
\end{itemize}

The flawed and overinflated estimation of economic costs of energy projects and failure to account for adverse social, health and environmental impacts as well as greenhouse gas implications reveals that many energy projects in Australia are more likely to impose a significant economic cost on communities and taxpayers. These costs may outweigh the value of the projects; however the international companies, that are the proponents of these projects and recipient of their profits, bear none of these costs.
3.1.6 Greenhouse gas emissions

The interrelationship between health and well-being and the energy sector is writ large in the adverse impacts for human health from the enhanced greenhouse effect: global warming, sea level rise, other ocean changes and climate change.

Greenhouse gas emissions arising from the energy sector in Australia and globally are amongst the most powerful drivers of climate change. Climate change has been described by the prestigious medical journal The Lancet as “the biggest threat to human health of the 21st century” and is already contributing to increased global morbidity and mortality, with Australia amongst the most vulnerable of all developed countries.

The per capita greenhouse gas emissions from the energy sector in Australia are amongst the highest in the world – the third highest of any OECD country.

Climate change impacts health in many ways. With less than one degree of average global temperature warming, climate change is already responsible for the deaths of more than 400,000 people each year. Continued intensive use of fossil fuel energy sources is estimated to cause six million deaths each year by 2030.

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**Figure 3.3**

Climate change affects our health and wellbeing in many ways, through both direct physical impacts and flow-on social and economic changes. Infographic © Climate Commission *The Critical Decade: Climate Change And Health*
The text below summarises the main health impacts of climate change that are expected to affect the Australian population as outlined by the Climate Commission’s 2011 report on climate change and health:66

Direct risks include:

- more frequent and intense heat waves resulting in more heart attacks, strokes, accidents, heat exhaustion and death;
- more frequent or intense extreme weather events – particularly storms, floods and cyclones – resulting in more injuries, deaths and post-traumatic stress; and
- more fires increasing the number of cases of smoke-induced asthma attacks, burns and death.

Risks of flow-on effects, although more complex and harder to predict in timing and extent, include:

- more exposure to some air pollutants and air-borne allergens, such as pollens and moulds, exacerbating respiratory illnesses, such as asthma, hay fever and longer-term heart and lung diseases;
- changed rainfall patterns – increases in rainfall in some regions and decreases in others – and hotter temperatures increasing the spread and activity of disease transmitting mosquitoes and increasing the chances of food-borne infections;
- warming and drying in some regions leading to a higher prevalence of mental health problems and lower morale in rural communities;
- changed rainfall patterns and hotter temperatures leading to reduced supply and increased prices of some foods, resulting in reduced nutrition;
- changes, such as rising sea levels, hotter conditions and changed rainfall patterns, causing displacement of people from within and outside of Australia and community-wide negative effects on social and economic wellbeing; and
- increased pressure on health systems and emergency responses delaying effective delivery of health care.

Climate change also affects human health by influencing the rate of mobilisation of chemicals that persist in the environment, with higher temperatures increasing chemical releases from soil, water and ice.

Climate change is also altering patterns of use of chemicals through increasing demand for disease vector control, as well as increasing exposure through extreme weather. Climate-related factors such as salinity, water temperature and acidification are increasing the toxicity and bioaccumulation of persistent chemicals and impacting on the ability of species including humans to cope with exposure to toxic chemicals.57

Australia’s contribution to climate change through its production of greenhouse gas emissions is already among the highest per capita in the world, and these are set to dramatically increase if proposed coal and unconventional gas projects go ahead.68, 69

The coal mining industry in Australia is undergoing a massive and rapid expansion. A total of 107 new coal mines or mine expansions are in the pipeline that, if built, would extract 801Mt of coal per annum and a total of 22,476 Mt of coal over their lifetime.70
If the expected expansions of Australia’s coal exports occur, global carbon dioxide emissions could rise by 1.2 billion metric tons a year.\(^{71}\)

Exploration for unconventional gas is also undergoing rapid expansion, with over 40,000 wells said to be proposed for Queensland alone.\(^{72}\)

Geoscience Australia (2012) estimates there is 716,540 petajoules (PJ) of unconventional gas reserves across Australia\(^{73}\) – more than five times what would be required to meet current demand for another 70 years.\(^{74}\)

Another source suggests Australia has resources of more than 150 trillion cubic feet of coal seam gas, almost 400 trillion cubic feet of shale gas and 20 trillion cubic feet of tight gas.\(^{75}\) To provide some perspective, the gas industry suggests 250 trillion cubic feet of gas is enough to power a city of 1 million people for 5000 years.\(^{76}\)

The proposed utilisation of the continent’s land mass for energy exploration is vast: licences for further coal and gas exploration cover 437 million hectares of land – more than half of Australia’s land mass.\(^{77}\)

These proposals to further exploit Australia’s fossil fuel reserves are however sharply at odds with what is known about the implications for global warming from any further fossil fuel production.

Climate science suggests there is a maximum amount of carbon (fossil fuels) that can be burned if the world is to stay beneath the two degrees maximum warming agreed to by over 100 countries in Copenhagen in 2009.\(^{78}\)

Scientists warn that allowing warming to exceed this level could unleash irreversible, and (for humans and much of biodiversity) catastrophic climate conditions.\(^{79}\)

Two important papers published in the journal Nature in 2009 by scientists Myles Allen and Malte Meinhausen and colleagues calculated the volume of CO2 emissions that can be emitted into the atmosphere between now and 2050 to have a 75% chance of staying below the 2°C guardrail.\(^{80}\)
More recent work to determine the ‘global carbon budget’ shows that having emitted 321 Gt CO2 so far this century, we can only contribute another 565 Gt. Therefore there is only around 500 billion tonnes left in the global carbon budget. However the proven fossil fuel reserves available globally amount to five times that amount. This means we can only safely burn about 20% of the world’s listed fossil fuel stocks, if we are to give ourselves a better than even chance of not breaching the two degrees guardrail.

The Climate Commission’s Critical Decade 2013 report sets out the updated scientific basis for action and concludes:

“The carbon budget is clear and compelling. To stay within the 2°C limit, the trend of increasing global emissions must be slowed and halted in the next few years and emissions must be trending downwards by 2020 at the latest. Investments in and installations of renewable energy must therefore increase rapidly. And, critically, most of the known fossil fuel reserves must remain in the ground.”

Australian coal export expansion was listed as one of 14 “carbon bombs” potentially risking the lock-in of catastrophic and irreversible global warming in a Greenpeace report.

The latest report from the Carbon Tracker Initiative (CTI) suggests that the coal likely to be developed in Australia could account for 42–75% of the total global carbon budget.

Australia’s total direct and indirect domestic greenhouse gas emissions in 2008–09 were 759 million tonnes (Mt), CO2-e (NB This figure accounts for domestic use, imports and exports). Both major political parties are committed to a five per cent net GHG reduction on 2000 levels by 2020. This is considerably less than the 19% by 2020 emissions reduction target recommended by the federal government’s scientific advisory.

However, with a coal mining boom now underway, depending on assumptions such as the number of mines that open, by 2025 annual emissions from Australia’s coal exports are expected to reach somewhere between 1300 and 1700 Mt CO2-e. In addition, Australian governments are pushing to expand gas exports. Increases in gas consumption and exports will also contribute significantly to national and global emissions.

This points to a national (and global) energy policy and investment environment that is failing to recognise the implications of climate science and failing to reflect the predicted profound risks in decision-making.
4. Fossil fuel energy choices — implications for health

The international literature suggests there are significant risks to human health and well-being from the mining, transportation and combustion of fossil fuels. There is a dearth of literature on the risks to health in Australia. Because differences in the mineral and contaminant content of energy resources vary according to location, as do regulations and industry practices, further research is needed to better understand the specific threats to Australian communities living in proximity to fossil fuel extraction, production and transportation.

4.1 Coal

4.1.1 Direct health effects

Australia’s coal contributes to climate change and its global health impacts as well as to direct and localised adverse health effects in populations living and working in proximity to coal-fired power stations, coal mines and coal transportation (see above).

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. A recent review of data from 41 countries evaluated the public health implications of electricity and coal consumption and found the consumption of coal for electricity has “significant detrimental health impacts”, which outstrip the benefits afforded by access to electricity.

Communities located where coal mining or burning occurs have been shown to suffer significant health impacts. 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. Based on the international and available Australian literature it is likely that there are direct health costs to Australia from the coal industry, being borne largely by the communities that live and work in proximity to coal mines and coal-fired power stations.

A review of this literature found serious health and social harms can be associated with coal mining and coal fired power stations for people living in proximity to them. While aspects of the examples given here may not be able to be directly extrapolated to the Australian setting, they do
illustrate the potential for harm from coal mining activity, and other aspects of the international evidence may apply.

In people living in communities close to mountain top removal coal mining in the Appalachians in the USA these impacts include:

- higher rates of mortality from lung cancer, chronic heart, respiratory and kidney diseases;
- higher rates of cardiopulmonary diseases, kidney disease, and heart attack;
- increased likelihood of hospitalisation for chronic obstructive lung disease and hypertension;
- poorer self rated health and quality of life; and
- increased incidence of birth defects, including neural tube defects.

In other coal mining communities in the UK and Europe, health and medical researchers have found:

- increased incidence of asthma;
- increased respiratory disease in children; and
- possible links to high blood levels of heavy metals including lead and cadmium.

Coal combustion also carries serious health risks for communities in proximity to as well as distant from power plants - pollutants emitted from burning coal can travel long distances and affect populations living remote from power plants.

Other European studies of communities living close to coal fired power have found other adverse impacts including:

- increased risk of dying from lung, laryngeal and bladder cancer; and
- increased risk of skin cancer.

European studies have found higher rates of preterm birth, low birth weight, miscarriages and still births in women living near coal plants.

Children’s exposure to pollutants released from coal fired power plants in China has been linked to:

- impaired neurological development in children living close to a coal fired power station; and
- impaired foetal and child growth.

In Australia, the few studies that have been conducted support the international evidence on exposure to air pollution from coal fired power stations, finding:

- increased rates of asthma and respiratory symptoms; and
- poorer lung function and increased asthma symptoms in children; and
- increased respiratory morbidity.

Coal in Australia is mainly extracted by open cut mining. The destruction of the landscape caused by this type of mining poses risk to human health through environmental degradation and subsequent loss of ecosystem services from forests, waterways and biodiversity. The dust generated by mining is harmful to miners and those living and working in proximity to coal mines.

Coal mining is inherently dangerous to the health of workers in both open cut and underground mining. Explosions
and mine collapses are significant risks associated with underground mining. Toxic gases such as carbon monoxide produced during mining pose serious health risks to miners.\textsuperscript{120}

Long term exposure to coal dust produced by mining contributes to ischaemic heart disease\textsuperscript{121} and can lead to pneumoconiosis, lung fibrosis, emphysema and chronic bronchitis among coal miners.\textsuperscript{122} If coal dust contains silica, exposure can lead to silicosis and lung cancer.\textsuperscript{123} A recent study shows the incidence of pneumoconiosis is increasing among young US coal miners and that their progression to an advanced stage of the disease is occurring much more rapidly than in the past.\textsuperscript{124} Without research to evaluate the effects of coal dust on Australian coal miners, it is hard to know whether they face similar risks.

Mining uses large quantities of water, a precious resource in Australia, and can pollute nearby waterways, potentially contaminating drinking water supplies. Coal mining waste is harmful to health as it contains many toxic substances,\textsuperscript{125} including chemicals and heavy metals that are rarely disposed of safely.\textsuperscript{126}

Coal combustion produces harmful air pollution, including particulate matter (PM) and emissions that can contain (depending on the composition of the coal and the level of emissions controls in place) arsenic, mercury, fluorides,
boron, cadmium, sulphuric and nitric acids, lead, selenium and zinc. Particulate matter (PM), particularly the fine particles – PM2.5, contributes to cardiovascular disease, respiratory disease and lung cancer. Coal-fired power stations also produce sulphur dioxide (SO2) and nitrogen dioxide (NO2), the level of which varies depending on the power station. Even exposure to low levels of sulphur dioxide for periods as brief as ten minutes can adversely affect pulmonary function; while exposure to nitrogen dioxide reduces lung function and contributes to increased asthma and can cause permanent lung damage.

Mercury emissions from coal combustion are converted into methylmercury, which dissolves in the sediment of waterways, and enters the human food chain through fish. 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. Uncertainty exists as to the mercury content of coal burnt in Australian power stations and the efficiency of mercury capture devices.

A 2013 review of the scientific evidence of health effects of coal-fired power conducted by environmental health experts at the University of Illinois at Chicago (UIC), reveals pollutants generated from coal combustion have profound effects on the health of local communities but can also travel long distances, affecting communities remote from power plants.

According to co-author Dr. Susan Buchanan, Director of the University of Illinois Pediatric Environmental Health Unit: “Every step of the lifecycle of coal generates pollution that is harmful to human health, but the bulk of the health burden is associated with pollutants from combustion for electricity.”

The review found air pollution from coal combustion was responsible for over 200,000 deaths globally each year, and caused almost two million serious illnesses, and 151 million minor illnesses. These figures do not include the health burden from climate change, to which coal is a significant contributor.

Research from Europe published in The Lancet estimates that 24 people die and there are 225 occurrences of serious illnesses including respiratory and cerebrovascular hospital admissions, congestive heart failure and chronic bronchitis for every terawatt hour (TWh) of coal combusted, from the harmful effects of the airborne particulates, nitrogen oxide, and toxic metals such as mercury and lead released.

The International Energy Agency estimates that more than 7,500TWh of electricity was generated by burning coal in 2009. According to this and other estimates, the toll from coal-fired power generation globally may exceed over 200,000 deaths per annum. However, the health and environmental costs associated with coal are 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.

### 4.1.2 Financial cost of adverse health impacts

The Health and Environment Alliance (Europe) report, ‘The unpaid health bill: How coal power plants make us sick’ provides the first-ever calculation of the effects of coal-fired power generation on chronic lung disease and some
heart conditions in the European Union.\textsuperscript{140} It shows that the EU-wide impacts amount to more than 18,200 premature deaths, about 8,500 new cases of chronic bronchitis, and over 4 million lost working days each year. The economic costs of the health impacts from coal combustion in Europe are estimated at up to €42.8 billion per year. Adding emissions from coal power plants in Croatia, Serbia and Turkey, the figures for mortality increase to 23,300 premature deaths, or 250,600 life years lost, while the total costs are up to €54.7 billion annually.

A recent review of broad health indicators across 40 years in 41 countries revealed large unaccounted for costs associated with coal consumption.\textsuperscript{141} 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.\textsuperscript{142} 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 half a trillion dollars annually.\textsuperscript{143} Accounting for these damages would “conservatively double to triple” the price of electricity from coal.\textsuperscript{144}

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.\textsuperscript{145} This study 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 unaccounted for total climate and health costs are considered (including greenhouse gas effects) the estimate rises to $8.3 billion annually.146

Given the evidence above, it is clear that every tonne of coal Australia exports causes damage to the wellbeing of current and future generations both in Australia and internationally.

### 4.1.3 Examples of health impacts in local communities

The impacts of coal are also being borne by communities in Australia, with the adverse impacts of coal mining being felt by many communities; examples from Angelsea in Victoria, Newcastle, the Hunter Valley and the Gunnedah Basin in NSW, and Mackay in Queensland are given.

In regions in proximity to coal fired power stations or where there is establishment or expansion of coal mining activities, particularly open cut, there are particularly high levels of concern about toxic air pollution associated with these activities. Concerns are also raised about coal dust along coal transport corridors.

In Anglesea in Victoria, residents are seeking an independent study into air quality to establish level of pollutants associated with the expansion of an open cut coal mine and ongoing pollution from a 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, and the community experience frequent exposure to harmful levels of SO2.

Communities such as those in the Upper Hunter in NSW have been calling for years for research to evaluate the cumulative impacts of coal mining and coal fired power generation, including the impact on health from associated particulate matter, and for continuous dust monitoring. Their calls have been repeatedly ignored by state government, and mining industry groups have sought to discredit the concerns of residents.147

In the Gunnedah Basin in NSW, communities are facing large scale developments of coal mines and coal seam gas development. The local community is seeking a health impact assessment to evaluate the potential cumulative impacts of current and potential coal and coal seam gas exploration and other extractive industries on the health of the people living and working in the region.

In Newcastle in NSW, an expansion of coal export facilities is anticipated to double the volume of coal being transported from the Hunter Valley through Newcastle. Around 25,000 children attend schools within 500 metres of the coal corridor. The project’s environmental assessment report does not provide a comprehensive analysis of fine particle pollution levels or the associated health impacts, and the community is seeking an independent assessment of the associated air pollution and its likely impacts on their health.

In Dungeon Point near Mackay in Qld, where a significant expansion of coal export facilities is proposed, the community is seeking an evaluation of the health impacts of dust emissions from coal ports. There is no monitoring of coal dust in the region, with the nearest monitor for PM10 only being 19 kilometres away from the port.148
4.2 Natural Gas – Conventional and Unconventional

What is referred to in Australia as ‘natural’ gas comprises gas mainly composed of methane but which may also contain other hydrocarbons such as ethane, butane, and propane.\textsuperscript{148} When found in easily accessed subsurface reservoirs or associated with oil, it is known as ‘conventional’ gas.

Gas from coal seams (CSG), shale beds, basin-centered gas and tight gas are collectively known as ‘unconventional’ gas because unconventional means are required to extract it.

4.2.1 Conventional gas

Conventional gas exploration and drilling carries risks for human health, but these are considerably less than coal and oil\textsuperscript{150} The main public health risk associated with conventional gas electricity generation is associated with air pollution from power plant operations\textsuperscript{151} and by contributing to climate change from its high emissions of the powerful greenhouse gas methane.

National emission data from the US indicates conventional gas exploration and production is the largest anthropogenic source category of CH$_4$ (methane) emissions\textsuperscript{152} A 2011 study from the Center for Atmospheric Research (NCAR), concluded that the substitution of gas for coal as an energy source results in increased rather than decreased global warming for many decades\textsuperscript{153}

4.2.2 Unconventional gas

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) is predominantly methane found in coal seams. Exploration and extraction of CSG potentially carries significant human health and environmental impacts, as well as risks to animal health\textsuperscript{154} However, concerningly, many of these health risks remain unquantified.

There are serious concerns being raised in Australia and overseas with regard to the safety of chemicals used in the unconventional gas extraction process. Chemicals used include ethylene glycol, formamide, naphthalene, ethoxylated nonylphenol and sodium persulfate. Drilling chemicals include calcium sulphate, anionic surfactants, ethylene glycol, monobutyl ether, polyacrylamide polymers and petroleum distillate flocculants\textsuperscript{155}

Very few of the chemicals used in coal seam gas mining have been evaluated for their health effects when used for this purpose\textsuperscript{156} Exposure to these chemicals either from spills pre-use or from poor management of the water used
in the fracking process, carries potential risks to virtually all systems of the body, including risks of neurological, respiratory, reproductive, cardiovascular, endocrine and kidney disease. Some of the chemicals used in coal seam gas mining are associated with hormonal disruption, affect fertility and reproductive health, and are potentially carcinogenic. Other chemicals such as BTEX and volatile organic compounds which can be released from the coal seam are associated with damage to kidneys and nervous system and are harmful to respiratory health.

The gaseous 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 around US gas operations, including acrylonitrile, methylene chloride, benzene and hydrogen sulphide. These emissions increase the risk of cancer and may cause nervous system and respiratory damage.

A study in rural Colorado where unconventional gas exploration is occurring in close proximity to communities found concentrations of non-methane hydrocarbons (NMHCs) at levels that may pose risks to endocrine systems, and polycyclic aromatic hydrocarbons (PAHs) concentrations greater than those at which prenatally exposed children had lower developmental and IQ scores.

An independent health survey of the residents in the rural estates at Tara in Queensland living in close proximity to intensive coal seam gas developments recorded a range of symptoms, including respiratory symptoms, headaches, fatigue, skin and eye irritation, and spontaneous nose bleeds.

‘Tight gas’ is another form of unconventional gas which involves fracking. This technique has been found to cause contamination of groundwater in Wyoming, USA, and the source of health concerns, with local farmers reporting neurological symptoms. Coal seam gas exploration and extraction threatens food and water security. Fracking operations use millions of litres of water for each well and raises serious concerns about risks to water quality and harm to underground aquifers. These threats to surface and groundwater and the displacement of food production from fertile agricultural land, mean that unconventional gas operations have significant implications for food security. Reliable access to clean and safe food and water are amongst the most basic fundamentals of ensuring good population health.

Unconventional gas extraction also drives climate change and the associated negative health impacts. Firstly this is because large quantities of “fugitive” methane emissions are released during unconventional gas extraction. Methane is one of the most powerful of the short term greenhouse gases. Over a 20 year period, methane is 72 times as powerful at greenhouse forcing as CO2, making its containment as a greenhouse gas urgent. There is emerging evidence that suggests the climate impacts of gas mining and burning have been underestimated and the emissions from gas, particularly unconventional gas, may be much higher than currently reported levels.

In addition, gas from shale deposits (currently rapidly replacing conventional gas in the US and beginning to be developed in Western Australia) is estimated to have a higher greenhouse signature than coal, with the footprint of shale gas is at least 20% greater and perhaps more than twice as great over a 20 year period. The risks for environmental harm and to health are similar to those from CSG fracking.
Underground Coal Gasification is a technique which involves burning the coal seam in situ to produce energy. This process has proven to pose a risk to water quality in Australia, with pilot projects shut down in Queensland following the appearance of benzene and toluene in bore water.171, 172

The United Nations Environment Program issued a global environmental alert in 2012 about unconventional gas production, saying:

“UG has the potential to generate considerable GHG emissions, can strain water resources, result in water contamination, may have negative impacts on public health (through air and soil contaminants; noise pollution), on biodiversity (through land clearance), food supply (through competition for land and water resources), as well as on soil (pollution, crusting).”

- UNEP Global Environmental Alert System 2012

Another consequence of developing unconventional gas as a fuel source is that this maintains the lock-in of fossil fuel energy systems and delays adoption of renewable technologies.173

### 4.3 Petroleum

Petroleum is the major source of transport energy in Australia. The combustion of oil, petrol and diesel creates harmful air pollutants that cause respiratory disease, heart disease and lung cancer.

Air pollution from transport contains particulates, nitrogen dioxide, ground level ozone and carbon monoxide.174 These pollutants are associated with cardiovascular disease and heart attacks, respiratory illnesses such as asthma and bronchitis, and lung cancer.175, 176, 177

Motor vehicle-related air pollution is believed to be responsible for between 900 and 4,500 cases of cardiovascular and respiratory diseases (eg bronchitis) each year in Australia, and between 900 and 2,000 early deaths.178

An Australian study on the health effects of air pollution in Brisbane, Melbourne, Perth and Sydney in 2005 found a 10 mg/m3 elevation in PM2.5 concentration was associated with a 1% increase in the daily total number of deaths.179 There is increasing evidence of an association between lung cancer and transport emissions, thought to be caused by exposure to fine particle pollution and carcinogenic gases such as benzene.180

Diesel emissions are particularly toxic and have been classified by the World Health Organization as carcinogenic.181 The health costs of diesel particle emissions have been estimated at $257,000 per tonne. In Sydney, over 1500 tonnes of diesel particles are emitted each year, resulting in a potential health cost of over $400 million.182
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. 183

The combination of pollution from transport and rising temperatures from global warming is also associated with the production of ground level ozone, a serious respiratory irritant. 184, 185

A report from the Union of Concerned Scientists in the US in 2011 suggests the health impact costs of the projected increase in ozone will cost the US $5.4 billion each year by 2020, lead to one million missed school days, and almost three million additional acute respiratory attacks. 186

Figure 4.3 Photo © Peter Rae, 2014 Sydney Traffic

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Ozone affects the airways and lungs, causing inflammation and reduced function. Exposure to increased levels of ozone is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma and other respiratory diseases, and with premature mortality. As well as affecting people who are particularly sensitive to air pollution, such as children, asthmatics and the elderly, ozone can also affect the lungs of healthy people. 184, 185
5. Nuclear - implications for health

The major health risk associated with nuclear power is cancer from radiation, either for workers in underground uranium mines from exposure to radon gas, or from radioactive emissions from nuclear reactors. Uranium exposure may be linked to endocrine disruption. Large studies of nuclear power workers demonstrate a link to the development of solid cancers as well as leukemia. Uranium mining also poses risk to health through the contamination of drinking water and food chains in nearby communities.\(^{187}\)

Children living near nuclear facilities have been found to have a higher incidence of some cancers, including leukaemia.\(^{188}\) A 2008 German study found a 60% increase in solid cancers and a 120% increase in leukemia in children living within 5km of nuclear reactors.\(^{189}\)

Accidents from nuclear reactors whilst relatively rare have potentially catastrophic health impacts. The Chernobyl nuclear disaster in 1986 is estimated to be responsible for several thousand premature deaths from cancer, substantial mental health burdens that persisted for decades, as well as requiring the resettlement of 400,000 people.\(^{190}\) While little is yet known about the health effects that will result from the Fukushima nuclear disaster in Japan in 2011, around 150,000 people were displaced by the disaster with serious health impacts associated with displacement and environmental contamination.\(^{191}\)

High level nuclear waste also presents a threat to health if it is not managed safely. No country has a strategy for the storage or disposal of high level radioactive waste that matches the lifespan of the waste – the half life of some chemical constituents (eg of iodine isotope 129) is 16 million years.\(^{192}\) However even the 1000 years required for radiation to return to the equivalent to base line is a long time over which to guarantee safety.\(^{193}\)
6. Renewable energy – implications for health

6.1 Solar power

Figure 6.1 Solar thermal power uses mirrors to heat up a tower containing molten salt, allowing for ‘on demand’ electricity dispatch — day or night. Location: Gemasolar, Fuentes de Andalucía (Seville, Spain). Photograph © Beyond Zero Emissions.

Australia receives an average of 58 million petajoules (PJ) of solar radiation per year, approximately 10,000 times larger than its total energy consumption. However, Australia’s current use of solar energy is low, accounting for only about 0.1 per cent of Australia’s total consumption. The main forms of solar power currently in operation in Australia are solar thermal water heating and photovoltaic (PV) technology, with over one million households now with installed solar PV.

Lifecycle assessments of wind, water and solar energy options demonstrate lower emissions and better air quality compared to coal and gas. The health risks associated with the manufacture and production of photovoltaic cells relate to exposure to silica, compounds such as cadmium and chromium, and some gases. Unprotected exposure to dust produced during mining and processing of silica can cause silicosis.

A recent international review of the health impacts of energy sources concludes: “the health impact of solar power is likely to be far less than any of the fossil fuels.”
6.2 Wind and health

Wind power is Australia’s fastest growing energy source, with 1634 wind turbines spread across 51 operating wind farms, as well as one small wind farm located in the Australian Antarctic Territory. The amount of wind power in Australia has doubled in the past five years. Wind now accounts for 3.4% of total energy production, although in some states such as South Australia, where there are 15 wind farms with an installed capacity of 1,203MW, wind energy supplies up to 26% of the total electricity supply. Public support for wind power in Australia is high, including in both urban and rural communities.

Adverse health effects from wind turbines have been reported in Australia and internationally. There are claims about health effects resulting from exposure to infrasound (low frequency sound, in the range less than 200Hz), and about the character of the noise and associated reports of sleep disturbance and annoyance, which have the potential to contribute to stress related disorders. Differences of opinion exist among acousticians regarding the specific characteristics of the sound, and of the physiological mechanism underlying those complaints.

The available Australian and international evidence does not support the view that the infrasound or low frequency sound generated by wind farms causes adverse health effects for people living or working in proximity to them.

While audible noise from wind turbines has been demonstrated to be much lower than many other sources of environmental noise, this component is associated with annoyance. Noise levels, including infrasound, diminish with distance from the source wind farm. It has been argued that wind farm noise is too low to be audible, whereas reports suggest that under certain conditions, sound can be heard at a distance of several kilometres. The variable tonal or fluctuating swish from wind turbines has been suggested as the prime contributor to annoyance in susceptible people, which they find more annoying than transportation or industrial noise at comparable levels.

At distances beyond 500 metres, infrasound and low frequency sound generated by wind farms in Australia is thought to be below the level capable of causing health effects to occur, and there is no accepted physiological mechanism where sub-audible infrasound from wind farms could cause health effects. A number of mechanisms additional to noise have been suggested that may account for complaints attributed to the operation of wind turbines. These include the ‘nocebo’ effect, in which expectations of symptoms can become self-fulfilling; misattribution of pre-existing or new symptoms to a novel technology; worry about the technology increases the chances of someone attributing symptoms to it; and social factors, including negative media reporting and interaction with lobby groups, which can increase symptom reporting.

A systematic review commissioned by the National Health and Medical Research, investigated the scientific literature for evidence of a causal link between wind farms and human health outcomes. Human health impacts arising from proximity to wind turbines from audible, infrasound, low frequency noise, electromagnetic radiation and shadow flicker effect were considered. These reviews also examined parallel evidence. The purpose of this step was to identify potential physiological mechanisms, or evidence of direct health effects arising from characteristics affiliated with wind turbines yet derived from other (non-wind farm) sources. These reviews found an absence of reliable or
consistent evidence to demonstrate these characteristics directly cause health effects. On the other hand, no evidence was identified in the dual reviews to conclusively demonstrate that there is no health effect, although none were designed to test the impossibility of an effect. The NHMRC’s Systematic Review findings concurred with previous reviews, in finding a paucity of rigorous, well designed studies exists. Several studies reported symptoms among people living near wind farms, but these failed to eliminate potential for confounding and bias. \(^ {216}\) Hence conclusions could not be drawn that a causative relationship exists.

Several studies demonstrated anxiety about the sound source elevates negative responses, and this underpins a potential source of tension. The association between expectations and health outcomes dates back to Hippocrates\(^ {217}\) and is well established in the health psychology literature. The influence of pre-intervention expectations upon positive or negative outcomes is consistently demonstrated across a range of health endpoints, including weight loss,\(^ {218}\) smoking cessation,\(^ {219}\) and post-operative recovery.\(^ {220}\) Indeed the pervasive power of expectations is responsible for the double-blind design becoming a universal standard for evaluation studies\(^ {221}\) and the “power of positive thinking” is used therapeutically.\(^ {222}\)

Negative expectations potentiate adverse effects if patients are informed that the therapy (or exposure) they are about to receive is “dangerous”, “unsafe”, “ineffective”, “limited”, or has “potential side-effects”.\(^ {223}\) “Nocebo response” is the term to describe new or worsening symptoms that are caused

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**Figure 6.2**

Wind farms such as the one in Portland, Victoria, produces enough energy for several towns and exports electricity to the national grid. Photograph © Greenpeace / Dean Sewell
only by negative expectations on the part of the patient and/or negative verbal and nonverbal communications on the part of the treating person, without any treatment or intervention. People who have higher levels of concern about how various aspects of modern life, such as exposures potentially harming their health, report higher levels of physical symptoms than people with lower levels of concern. The nocebo response can also be powerfully elicited through news reports and social media. Recent studies have specifically tested attitudes and reported symptomatology in response to wind farm noise. Crichton et al. demonstrated response differentials between pre-exposure positive and negative information and post exposure symptomatology.

In Australia, an audit of all known complaints using wind company records, news media reports and searches of public submissions to three government enquiries found that there are large historical and geographical variations in wind farm complaints. This suggests that social factors in addition to the noise are potentially at play.

Annoyance can contribute to physiological or psychological stress responses, and can cause sleep disturbance and sleep deprivation, which can negatively impact on wellbeing. Influential factors that can enhance or mitigate the annoyance levels in those exposed to the noise include prior attitudes to wind farms, their visibility and receiving financial recompense (or not).

Studying of quality of life is an inexact science. Perception of quality of life varies between individuals and is dynamic within them, and people with different expectations will report that they have a different quality of life even when they have the same clinical condition. Additionally, people whose health has changed may report the same level of quality of life when measures are repeated. It is also apparent that current measures do not take account of expectations and cannot distinguish between changes in the experience of disease and changes in expectations of health. This provides little comfort for people who report symptomatology, and it contributes to the complexity in characterizing the relationship between wind farms and human health.

The point remains that research into the potential health effects of proximity to wind farms has been limited, and is generally of insufficient quality to generate evidence of a causal link. Conclusions therefore cannot be made that health effects do exist. Differentiation between nocebo responses and health responses that are not induced by pre-existing negative attitudes or negative messaging is difficult. Hence the necessity for studies designed to exclude the possibility of pre-loading expectations of health harm. Complaints however, cannot be ignored. Research is clearly needed in order to assess whether potential health effects are in fact occurring or not.

However, with respect to Australia’s energy future, broader consideration of energy choices and health is required. Consecutive wind farm reviews have found no evidence of health harm meanwhile extensive international literature consistently links fossil fuels with far reaching direct health harms.

The balance of evidence clearly suggests that wind turbines are likely to be considerably less damaging to human health in the short and long term at a population level than fossil fuel alternatives. The problems associated with annoyance, while unfortunate for those affected, are relatively minor when considered in relation to the significant adverse effects associated with the use of fossil fuels, and the millions affected. The net harm potential is on a vastly different scale.
6.3 Hydroelectricity

Hydroelectricity provides 10% of electrical power in Australia\textsuperscript{237} The major hydro schemes in Australia are in Tasmania, the Snowy Mountains, north east Victoria, Queensland and the Ord River in Western Australia, and provide around 8,000 megawatts or 5.5% of Australia’s total energy production.\textsuperscript{238} Due to predicted declines in water availability, this is predicted to decline to around 3.5% by 2030.\textsuperscript{239}

The health risks from hydroelectricity are largely associated with environmental disruption requiring population displacement, disasters related to dam burst, and infectious disease risk associated with stagnation of water in dams leading to increases in infectious organism and disease vectors.\textsuperscript{240} Occupational health risks to hydropower workers are low.\textsuperscript{241}

In terms of its contribution to greenhouse gas emissions, hydropower is considered the only electricity generating option that has the capacity to bring about a net sequestration of carbon.\textsuperscript{242}

\textbf{Figure 6.3} Using native forests for biomass threatens Australia’s surviving forest heritage and may exacerbate climate change. Photograph ©: Rob Blakers.
6.4 Biomass

Energy from biomass is produced directly from combustion of crop or suitable urban waste or when biofuels such as ethanol are produced from food crops such as sugar cane, animal fats or algae. Biofuels (e.g., dried manure, charcoal and wood) are the source of energy for a major proportion of humanity.

Risks to health associated with biofuels include the “food-versus-fuel” dilemma, where productive farmland is used for fuel production instead of food production. There is also potential for pollution and depletion of water sources, and loss of biodiversity and ecosystem services associated with land clearing for plantations cultivated specifically for biofuels. Other health risks include exposure to dust, endotoxins, fungi and aspergillus, putting workers in the biofuels industry at a higher risk of asthma and respiratory symptoms.

One of the principal health benefits claimed in relation to biofuels is a reduction in greenhouse gas emissions, however the climate advantage of biofuels is described in a 2013 international review of energy options as “marginal.”

There may be health benefits associated biodiesel vehicles from reduced air pollution with much lower emissions of particulate matter, carbon monoxide, volatile organic compounds and sulphur oxides than from conventional diesel vehicles.
7. The way forward

7.1 Energy efficiency

Reducing energy use from changing behaviour and improving the energy efficiency of appliances and buildings can reduce demand for energy. This is an important component of an energy transition plan away from fossil fuels. Improving the energy efficiency of buildings can reduce health risks through minimising fluctuations in temperature, reducing the incidence of heart disease, asthma, respiratory disease and strokes.\textsuperscript{247, 248} The enhanced housing comfort associated with more consistent temperatures provided by energy efficiency measures is also associated with improved mental health.\textsuperscript{249, 250}

Reducing the use of energy, or energy conservation, brings health and climate co-benefits.\textsuperscript{251} Reduction in the consumption of energy can reduce greenhouse gas emissions through declines in production of energy generated from fossil fuel combustion. This also contributes to reduced air pollution, with improvements to population health as already described.

Decreasing emissions from coal fired power would save many lives by avoiding the problems listed above, and provide substantial productivity and economic benefits through avoided ill health.\textsuperscript{252, 253}

7.2 Introducing energy alternatives

At present, Australia is failing to take advantage of the nation’s abundant renewable energy resources. Renewable energy resources generate just 8% of Australian electricity, 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 demand declining 4% since 2008. Increasing rates of adoption of energy efficiency measures is another contributor.

Australia boasts the best solar resources in the world and among the world’s best wind resources with higher average solar radiation per square metre than any other continent.\textsuperscript{254} 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.\textsuperscript{255}

The rollout of renewable energy technologies in Australia has been slow due to uncertainty and volatility in the policy environment\textsuperscript{256} and historical differences in costs of renewable technologies and fossil fuel generation.\textsuperscript{257}

The Zero Carbon Australia 2020 Plan developed by the Melbourne Energy Institute (MEI), University of Melbourne
and research consultancy Beyond Zero Emissions 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 decade or so; that is, 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.

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. This modelling suggests there needs 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.

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. Like the UNSW modelling and the MEI/BZE report, the Stanford modelling uses wind, water 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.

Evaluations of Australians’ attitudes towards renewable energy suggest Australians “overwhelmingly support renewable energy”, with the strongest support for solar, wind and hydro power. The benefits cited by people in both rural and urban areas include: reduced pollution, improved health, and economic benefits.

Figure 7.1 Royal Children’s Hospital. ‘Main Street’ uses passive ventilation and non-mechanical air pre-heating/cooling. Rising warm air draws outdoor air through a sub-floor labyrinth. Photograph © Shannon McGrath Photography
reduced electricity costs, and increased jobs.\textsuperscript{265} 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.\textsuperscript{266}

There are positive implications for jobs in an expanding renewable energy sector. Compared with fossil fuel technologies, the renewable energy industry is more labour-intensive, with more jobs created for each unit of electricity generated from renewable sources than from fossil fuels.\textsuperscript{267}
Royal Children's Hospital. Bates Smart (Architect), Norman Linsay Young (Engineer). Patient ward bathroom facilities employ evacuated tube solar hot water. Sun blockers reflect the hot summer sun’s heat away. Photos ©John Gollings Photography
7.3 Recognising and responding to risks and opportunities

The complexity of energy systems in terms of variety in energy sources, range of technologies, and diversity of associated regulatory measures means a range of measures need to be employed to ensure energy systems in Australia do not pose a risk to health directly or by contributing to climate change.

It is important for us as a society to acknowledge that continuing to invest in and subsidise fossil fuels for energy generation is harmful to the health of Australians. In order to protect health from climate change and the pollutants associated with fossil fuels energy generation we need to move away from coal, gas and oil, to less polluting, healthier and safer renewable energy systems.

Australia possesses abundant renewable energy resources. A range of policy measures and strategies must be employed to drive a rapid transition to renewable energy and therefore reduce risks to health associated with carbon intensive energy systems, both from global warming, regional systemic threats to water and agriculture and from localised direct, immediate threats.

The health sector has a vital role in bringing its expertise to inform public policy decisions. It is imperative that decisions about energy choices, and all major public policy decisions, are subject to a comprehensive health impact assessment and quality research by appropriately qualified independent health professionals.

The influence of the fossil fuel sector in decisions regarding energy choices is evident in the development of federal policy and in the failure of state governments to regulate to protect health and environmental concerns. Industry proponents routinely overstate the economic benefits of mining and gas projects; downplay the greenhouse gas emissions and other environmental costs; ignore the costs to other industries; and ignore the health costs.
8. Conclusion

The evidence of harm to human health directly related to fossil fuels documented above reinforces the imperative extolled by scientific experts around the world – that shifting away from fossil fuels is urgent and necessary to prevent further climate change as well as reduce considerable detriment to human health and wellbeing.

Australian and international modelling demonstrates renewable energy technology is available to achieve a 100% renewable energy system for Australia. This is affordable with estimates ranging from $42 billion a year for ten years to complete (BZE), to estimates that suggest a modest carbon price ($50-$100 per tonne) would could deliver a 100% renewable electricity system that would be cheaper than reliance on fossil fuels.271

Renewable energy developments offer significant economic benefits as well as health benefits and can bring much needed investment to rural and regional economies, many of which are struggling with the effects of climate change on agricultural productivity, declining availability of services, and increasing mental and physical health issues.

Australia must, for reasons related to global warming and the protection of the health and wellbeing of the community, develop evidence based policy to transition as quickly as possible away from fossil fuels to 100% renewable energy systems for electricity generation, heating and cooling systems, and transport.

The choices we make as a society have significant implications for health and wellbeing and these impacts must be taken into account in our energy policy choices.
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32. ibid


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94. This particular form of coal mining involves considerable blasting and production of dust. The mountaintop nature of the mining also enables further dispersion of mining–related dust than mining elsewhere. While these results may not be able to be extrapolated to the Australian setting, they are worth considering as they illustrate the potential toxicity of dust generated by coal mining.


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