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Gas as a replacement fossil fuel; Discussion paper on the health aspects of gas

Coal mining and combustion have significant health and environmental impacts. Natural gas has been promoted as a clean and green alternative, with significantly less greenhouse emissions than coal. This document presents an overview of these claims.

Impartial review of these claims is vital because Nobuo Tanaka, Executive Director of the International Energy Agency (IEA), has said, "While natural gas is the cleanest fossil fuel, it is still a fossil fuel. Its increased use could muscle out low-carbon fuels such as renewables and nuclear, particularly in the wake of Fukushima. An expansion of gas use alone is no panacea for climate change." Whilst in some respects gas is less polluting than coal, gas is in no way "clean". It is a mistake to proceed with gas combustion for electricity production unless a renewable energy option is unattainable. If its use is considered essential, it should be as an adjunct to tandem with wind and solar, which may have intermittent delivery.

Yet before the science of this issue has been fully explored an expedient worldwide boom in gas development is underway driven by the need for energy security and the wish to be independent from oil, and by the ease of production and modest capital costs compared to other energy sources.

In Australia government permissions have been rapid and expedient; the cost of financing gas-fired generation is much less than for example solar thermal with storage. The fact that solar thermal then provides a stable electricity cost in contrast to rising gas prices is something to be faced by future governments beyond short term electoral cycles.
Firstly some definitions:

Conventional and unconventional gas

Natural Gas is composed mainly of methane (CH_4) but there are other hydrocarbons. It may also contain significant amounts of carbon dioxide. Natural gas is categorized as conventional gas and unconventional gas.

Conventional gas exists in large offshore (example the Northwest shelf Australia) and onshore reservoirs and is often found when drilling for oil. It forms a layer within the reservoir rock overlying the oil. In oil production it is often vented or flared (burnt) giving the huge plumes that can be seen from space for example from the Nigerian oil fields. Alternatively it is captured,

compressed (forming LNG) and transported via pipelines or overseas by tankers.

Unconventional gas is natural gas that requires mining procedures over significant areas of land. It is extracted from coal deposits that are too deep to mine economically by the traditional methods.

The usual types of unconventional gas resources are

- Coal seam gas, which is trapped in coal seams. This is the predominant form in NSW and Queensland. (There are also extensive coal bed methane reserves in the USA)

- Shale gas, where the gas is trapped in shale formations; this is the predominant form in the US. In Australia it has been located in the Cooper Basin in Central Australia

- Tight sands gas. This gas is trapped in a rock/sandstone/limestone formation that is particularly "tight". This refers to the very small pore spaces and/or low permeability in the rock.

For both CSG and shale gas extraction, hydraulic fracturing or 'fracking' may be used. This involves pumping a mixture of water, sand and other additives at high pressure down the well and into the coal seam, fracturing the coal seam and providing a track for gas to flow back. In releasing the gas, coal seams are depressurised and underground water in the seams is released to the surface as a by-product. This can potentially affect interconnected aquifers above or below the coal seam.

The health and environmental risks and costs and therefore the externalities are different for each form. Conventional (offshore) gas has the risk of contamination of the marine environment and so the health risks relate to damage to food sources, and death and injury to workers due to storm or explosion. The health risks of unconventional gas are much more relevant to this discussion and will be described in this paper.

Approximately half of the gas currently produced in Australia is for domestic consumption, and half is exported. Eastern states' domestic consumption is projected to almost double by 2020 and almost triple by 2030.
(SKM MMA Gas Market Modelling 2011 p50)

Fugitive Emissions

These are emissions that escape into the atmosphere in the mining, transport and processing of gas.

Methane is a powerful greenhouse gas. Methane has 23 times the greenhouse warming potential of carbon dioxide over a 100 year period, and 72 times over a 20-year time frame[1]. Furthermore, Shindell et al. 2009[2], in taking into

account the reaction of methane with other chemical components of the atmosphere, showed that methane is actually 105 times more potent than carbon dioxide. The 20-year time horizon is important because it is increasingly likely that emissions must peak by 2020 if climate change has to have any chance of remaining with in a 2 degree rise.

Thus although combustion of gas produces much less carbon dioxide than coal, (a credential promoted by many petroleum industries) there is accumulating evidence that the fugitive emissions may bring near parity with coal as a greenhouse forcer. The US EPA/Gas Research Institute (2010) found that fugitive emissions for some parts of the extraction process for unconventional gas[3] are thousands of time greater than earlier estimates. Australian accounting of Greenhouse Gases under NGERS relies largely the American Petroleum Industry Compendium, which is based on US EPA/Gas Research Institute/GRI research that does not take these updated findings into account. Australian CSG/LNG projects have assumed very optimistic levels of fugitive emissions, of around 0.1%, while international experience in Wyoming US where the level of fugitives has been measured showed losses of up to 15% of total field yield[4]. Also significant energy is used in processes such as refrigeration and transport.

In addition to fugitive methane emissions, it must also be noted that mined gas often contains naturally-occurring carbon dioxide. This must be removed from the gas by the processor before it can be processed or sold. Longstanding practice is to vent this carbon dioxide into the atmosphere. Estimates have been made that this amounts to 5% of emissions from most conventional gas fields, but can be much higher and in the case of Moomba it is around 30%.

DEA has done a detailed analysis of fugitive emissions from coal seam gas and taking into account more recent evidence we believe there is little to choose between the greenhouse potential of coal seam gas and coal. When one considers the opinion of the IEA that the rise in the use of gas, with utilization of much available finance, is likely to delay the development of renewable energy sources, it is clear that humanity will deliver a dangerous rise in global temperature by pursuing. This opinion is supported by the work of Wigley which concludes that a greater reliance on natural gas would fail to significantly slow down climate change[5]. When exported it will displace renewable energy and not coal (Worley Parsons report)[6].

Thus, like coal, the use of fossil gas is a national and international health issue. According to the World Health Organization, climate change is one of the greatest threats to public health and it will affect, in profoundly adverse ways, some of the most fundamental pre-requisites for good health: clean air and water, sufficient food, adequate shelter and freedom from disease.

The health impacts from the full cycle of coal seam gas production, transport and combustion in Australia

DEA has presented evidence to two parliamentary committees that it considers the current level of assessment, monitoring and regulation of CSG exploration and mining activities to be inadequate to protect the health of current and future generations of Australians. There is the potential for public health to be affected directly and indirectly through CSG operations.[7,8]

Air Pollution from gas combustion

Although there is little research to date, the direct health impacts of coal seam gas are likely to be less than for coal mining and combustion, mainly because of the smaller burden from airborne particulate matter. However a range of air pollutants may be released to air from CSG mining and processing, including volatile organic compounds which contribute to ozone formation. It can been seen from table 2 from Markandya and Wilkinson (2007) that deaths and serious illness are of the order of 7 times less than for coal. However in this study from Europe it is pointed out that the power stations were state of the art and data would not reflect the recent upsurge in CSG development.

Table 2: Health effects of electricity generation in Europe by primary energy source (deaths/cases per TWh)

	Deaths from accidents		Air pollution-related effects		
	Among the public	Occupational	Deaths*	Serious illness†	Minor illness‡
Lignite[30]	0·02 (0·005–0·08)	0·10 (0·025–0·4)	32·6 (8·2–130)	298 (74·6–1193)	17676 (4419–70 704)
Coal[31]	0·02 (0·005–0·08)	0·10 (0·025–0·4)	24·5 (6·1–98·0)	225 (56·2–899)	13288 (3322–53 150)
Gas[31]	0·02 (0·005–0·08)	0·001 (0·0003–0·004)	2·8 (0·70–11·2)	30 (7·48–120)	703 (176–2813)
Oil[31]	0·03 (0·008–0·12)	..	18·4 (4·6–73·6)	161 (40·4–645·6)	9551 (2388–38 204)
Biomass[31]	..	..	4·63 (1·16–18·5)	43 (10·8–172·6)	2276 (569–9104)
Nuclear [31] [32]	0·003	0·019	0·052	0·22	..

Data are mean estimate (95% CI). *Includes acute and chronic effects. Chronic effect deaths are between 88% and 99% of total. For nuclear power, they include all cancer-related deaths. †Includes respiratory and cerebrovascular hospital admissions, congestive heart failure, and chronic bronchitis. For nuclear power, they include all non-fatal cancers and hereditary effects. ‡Includes restricted activity days, bronchodilator use cases, cough, and lower-respiratory symptom days in patients with asthma, and cases, cough, chronic cough episodes. TWh=1012 Watt hours.

In Australia there is an acceptance that air pollution from gas combustion is an issue, for example, in the regulations of the Queensland government (Operation Policy Queensland 2010)[9].

"As there is still a release of contaminants into the air environment, monitoring is considered necessary and desirable as it is the only means by which the Department of Environment and Resource Management (DERM) can assess or confirm the contamination load released into the environment and the contribution to, and the impacts of, the emissions on the surrounding environment".

In their discussion of the pollution effects of power stations, Markandya and Wilkinson (2007) note that "Long distance effects are a substantial proportion of total effects of air pollutants with the consequences that plants located away from centres of population can have health effects on people living quite far away". They support this with a review of epidemiological studies[10].

In conclusion, air pollution from gas combustion has health impacts. These are probably less than coal combustion, but nevertheless their cost is an important externality in the consideration of use of gas.

Water pollution and health

Contamination of drinking water supplies is the greatest concern with CSG operations, due to the chemical additives used during drilling and hydraulic fracturing, degradation products, and also the compounds that are mobilised from sediments during the mining process. These chemicals can include toxic, allergenic, mutagenic and carcinogenic substances as well as methane. Waste water coming to the surface may contain volatile organic compounds, high concentrations of ions, heavy metals and radioactive substances.

The effects on human health from chemicals, depends on many factors including the dose, the route and the duration of exposure. Health effects may be immediate in onset, with symptoms such as headache, dizziness and nausea, but can also develop later even with very low levels of chemical exposure. Concerns about long term effects include hormonal system disruption, fertility and reproductive effects, and the development of cancer.

There is insufficient information on the use and mobilisation of these chemicals to make adequate health risk assessments. One of the biggest problems is the lack of public transparency around the chemicals used, the majority of which have not been assessed for safety, and the lack of monitoring of their use.

Mining companies have misleadingly inferred safety of fracking chemicals, as some are components of household products. However, just because we may have hair bleach or antifreeze in the cupboard does not mean it is safe to drink it.

Some compounds, such as the BTEX chemicals, can present a risk to health even in minute concentrations. For example, the Australian drinking water guidelines for benzene (a known carcinogen) state; "no safe concentration for benzene in drinking water can be confidently set" so the guideline is set at below the level of detection, which is 1ppb, the equivalent to one drop of water in a swimming pool. BTEX chemicals are found in petrochemical deposits including coal and gas and can be liberated through extraction.

Lessons from impacts of unconventional gas mining in the United States suggest significant damage can occur to the natural systems upon which human life depends. There are significant health threats from loss of water security and good agricultural land needed for food security. Australia's ability

to feed other countries as well as itself, as the world moves to increasing food shortages is an emerging health issue.

Many of these concerns have been addressed in the recommendations in the interim report of the Federal Senate Committee for example:

that it be a requirement of all exploration or production approvals that the fluids extracted from wells after fracking are kept isolated in secure separate storages and prior to disposal are treated to the highest standards.

And

that all future CSG development approvals should be preceded by the development of "... a regional-scale, multi-state and multi-layer model of the cumulative effects of multiple developments" of ground and surface water as recommended by Geoscience Australia.

Yet under the regulation by the states, coal seam gas mining continues apace without proper analysis of public health risk.

Potential cost externalities are accruing in terms of human health which may have to be paid for by future generations with individual illness or loss of community resources.

Community health

Water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape, all have mental health consequences for communities living in a gas field. The CSG process can divide previously close-knit rural communities, increasing tension and disharmony, impact on local economies, and threaten other industries such as beef production, viticulture and tourism. These issues also apply to communities which have gas fired power stations imposed upon them.

These concerns are leading to widespread community protest over coal seam gas mining and their causes are discussed in the Appendix 1 of the DEA report to the NSW Parliament.[11]

However community impacts from the CSG gas industry are also national. The resource boom has the effect of driving up the Australian dollar making other export sectors of the Australian economy, particularly manufacturing, tourism and education, less competitive in international markets, so that for every percentage of GDP expansion in the resource sector, there is an equivalent contraction in these other sectors. Since the resource sector is a relatively low employer and has a low effective tax rate, the displacement of jobs, people and the loss of government revenue will be greater than its contribution.

Conclusions

The current world boom in gas production threatens human endeavours to control greenhouse emissions. Methane is a potent greenhouse forcer and full life cycle analysis of its impacts suggests that at best it may only be marginally better than coal, at best.

Gas combustion for electricity generation is promoted because it is thought to have fewer direct environmental and health impacts than coal combustion. However this avoids consideration of the many impacts from its mining and transport.

The development of CSG in Australia for electricity production can only be justified if non-fossil fuel alternatives cannot be found.

CSG mining also has serious potential impacts on water supplies for human consumption and is a threat to sustainable agriculture. The health impacts have not been adequately researched and the regulations to adequately protect public health are not in place.

A moratorium of CSG production is recommended until all scientific aspects have been researched and health impacts assessed.

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[1] As reported by the IPCC (Intergovernmental Panel on Climate Change (2007) IPCC fourth assessment report (AR4), Working Group 1, The Physical Science Basis.
[2] http://www.sciencemag.org/content/326/5953/716
[3] Greenhouse Gas emissions Reporting from the Petroleum and Natural Gas Industry, Technical Support Document , US Environmental Protection Agency Climate Change Division 2011 Table 1 p9
[4] http://www.hycapenergy.com/CBM_Separator.pdf
[5] http://www2.ucar.edu/news/5292/switching-coal-natural-gas-would-do-little-global-climate-study-indicates
[6] http://www.appea.com.au/images/stories/Policy_CSG/appea%20worley%20csg%20greenhouse%20emissions%20study%20final%20110411.pdf p26
[7] http://dea.org.au/images/uploads/submissions/MDB_CSG_Senate_submission_June_2011.pdf
[8] http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/f96d076732225603ca25791b00102098/$FILE/Submission%200412.pdf
[9] http://www.derm.qld.gov.au/register/p00650aa.pdf
[10] Energy and Health 2: Electricity generation and health, Anil Markandya; Paul Wilkinson
The Lancet; Sep 15-Sep 21, 2007; 370, 9591; Research Library (pg. 979)
[11] http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/f96d076732225603ca25791b00102098/$FILE/Submission%200412.pdf