FUEL CYCLE GREENHOUSE EMISSIONS FOR ELECTRICITY GENERATION FROM LNG AND COAL

BACKGROUND

The credentials of liquefied natural gas (LNG) as a means of reducing global emissions have been called into question given the emissions-intensive nature of its production. For example, Larissa Waters (Senator Elect and Environmental Lawyer) had a different view on CSG as a clean energy alternative, stating that CSG produces 97% as much emissions as coal. A comparison of emissions from the production and use (i.e. for electricity generation) of both coal and gas/LNG is required to examine these claims.

Analyses used in the comparison

Two main studies are used in the comparison:

- a 2009 analysis by consulting firm PACE for the Center for Liquefied Natural Gas; and
- a 1996 analysis by CSIRO for Woodside Petroleum

The CSIRO analysis, whilst fairly old, provides a comprehensive analysis and in general was consistent with the approach and outcomes of the PACE report. A further, high-level analysis was undertaken by DEEDI as a cross reference.

Emissions considered in the analysis

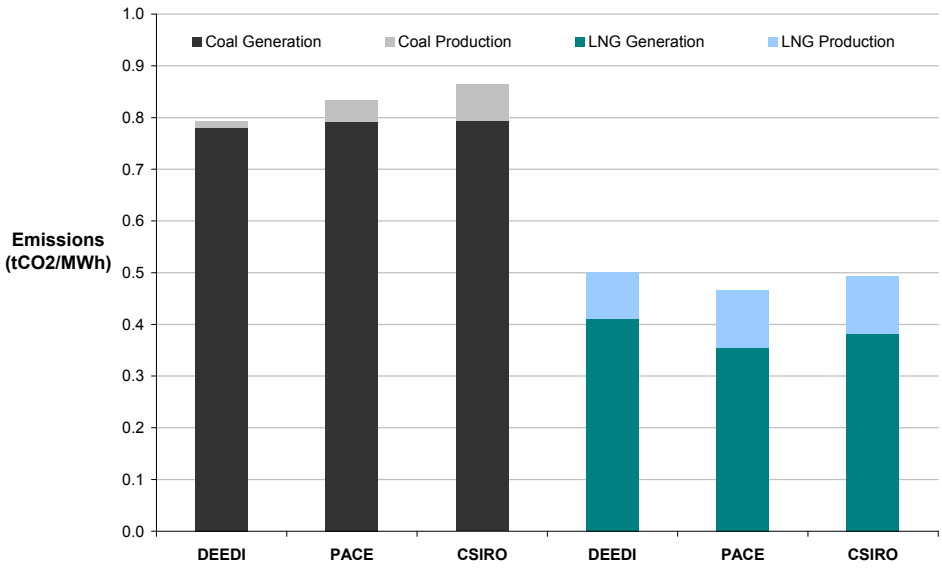
The comparison considers emissions resulting from the production and use in electricity generation of LNG and coal. Emissions associated with the construction of production facilities and generation facilities are not considered here. The PACE analysis does not consider these emissions, whilst the CSIRO analysis considered these emissions as negligible compared with production and generation (perhaps around 0.1% of emissions of these two stages of the life cycle).

RESULTS OF THE COMPARISON

Emissions associated with gas production were higher than coal, ranging between 0.09 and 0.11 tonnes of carbon dioxide equivalents (tCO2-e) per MWh in comparison with coal ranging from 0.01 to 0.07 tCO2-e per MWh. In contrast emissions associated with electricity generation from LNG were lower than coal, ranging from 0.36 to 0.4 tCO2-e per MWh, whilst coal was much higher at 0.78 to 0.79 tCO2-e per MWh.

As a result, overall emissions from LNG ranged from 0.47 to 0.5 tCO2-e per MWh whilst coal ranged from 0.79 to 0.86 tCO2-e per MWh (refer to Appendix A for greater detail). This means that coal produces between 59% and 85% greater emissions than gas for every MWh generated.

Figure 1 - Emissions associated with the generation 1 MWh of electricity from LNG and Coal



Sensitivity of results

All three studies assume that the most efficient generation technology is used to generate electricity from LNG, which is combined-cycle, gas turbine technology (CCGT). The rationale is that CCGT could be used as a substitute for coal in baseload applications. It is possible that LNG could be used in less efficient, open-cycle gas turbines (OCGT), reducing the emissions advantage of LNG. The result would be an emissions range 0.67 to 0.69 tCO2-e per MWh, with coal producing only 18% to 29% greater emissions per MWh.

Each analysis relies on the most-efficient coal-fired generation currently available, ensuring that the emissions outcomes for coal-fired generation are as low as possible. Comparisons with low emission coal technologies are not made. In a broad sense, it is likely that coal would become less emission intensive than gas should low emission technologies become commercially viable. This is unlikely in the short to medium term and as such it is more appropriate to focus on currently available coal and gas technologies.

The DEEDI analysis relies on a number of sources and generally takes a conservative approach. Overall, the DEEDI estimate for emissions from coal is the lowest of the three studies, whilst the DEEDI estimate for gas is the (equal) highest.

CONCLUSION

It is considered that the use of LNG for electricity generation would not be more emissions intensive than coal, given that

- the majority of emissions associated with both fuels are produced in the generation process; and
- emissions from the generation process for coal are significantly higher than for LNG.

The estimates of emissions from electricity generation are considered accurate. The estimates of emissions from coal and gas production are based on a number of variables and may be highly sensitive to changes in any variable. As such, they may be worthy of further investigation.

REFERENCES

Life Cycle Assessment of GHG Emissions from LNG and Coal Fired Generation Scenarios: Assumptions and Results Prepared for: Center for Liquefied Natural Gas (CLNG) February 2009
http://www.lngfacts.org/resources/LCA_Assumptions_LNG_and_Coal_Feb092.pdf

Lifecycle Emissions and Energy Analysis of LNG, Oil and Coal
Final Report to Woodside Petroleum Pty Ltd
http://premlib.govnet.qld.gov.au/downloads/reftracker/RT11349/Lifecycle_Emissions_and_Energy_Analysis_of_LNG_Oil_and_Coal_CSIRO_report.pdf

Sources for DEEDI Analysis

Electricity generation emissions intensities
ACIL Tasman (2009) Fuel resource, new entry and generation costs in the NEM
http://www.aemo.com.au/planning/419-0035.pdf

Emissions from coal production – Internal DEEDI analysis

Emissions from LNG production
MMA (2009) Queensland LNG Industry Viability and Economic Impact Study (confidential consultant report)

APPENDIX A – Detailed Results of Emissions Studies

NB: Scenarios shaded green and yellow are used for discussion in the paper

EMISSIONS FROM THE GENERATION OF 1 MWh OF ELECTRICITY

DEEDI ANALYSIS

Fuel	Production		Generation		Total	Emisions from Coal vs LNG
	tCO2/MWh	% of Total	tCO2/MWh	% of Total	tCO2/MWh	
Coal	0.01	2%	0.78	98%	0.79	159%
LNG	0.09	18%	0.41	82%	0.50	

Variable	Coal	Gas/LNG	Sources
Efficiency	43%	52%	ACIL Tasman Report to AEMO
Energy Content of Fuel (GJ/t)	27	54	Coal - National Greenhouse Accounts Factors, Gas/LNG - PACE Ana
Emissions Intensity of Production (tCO2/t)	0.04	0.7	Coal - DEEDI Analysis, Gas/LNG - MMA Analysis

PACE ANALYSIS

Fuel	Production		Generation		Total	Emisions from Coal vs LNG
	lbs CO2/MWh	% of Total	lbs CO2/MWh	% of Total	lbs CO2/MWh	
LNG	248	24%	797	76%	1,045	
Current US Coal Technology Mix	118	4%	2,614	96%	2,731	261%
Ultra Supercritical	94	5%	1,773	95%	1,868	179%
IGCC	94	5%	1,714	95%	1,808	173%

Fuel	Production		Generation		Total	Emisions from Coal vs LNG
	tCO2/MWh	% of Total	tCO2/MWh	% of Total	tCO2/MWh	
LNG	0.11	24%	0.36	76%	0.47	
Current US Coal Technology Mix	0.05	4%	1.17	96%	1.22	261%
Ultra Supercritical	0.04	5%	0.79	95%	0.83	179%
IGCC	0.04	5%	0.77	95%	0.81	173%

CSIRO ANALYSIS

Fuel	Production		Generation		Total	Emisions from Coal vs LNG
	tCO2/MWh	% of Total	tCO2/MWh	% of Total	tCO2/MWh	
LNG	0.11	23%	0.38	77%	0.49	
Coal	0.07	8%	0.79	92%	0.86	185%
Oil	0.13	18%	0.60	82%	0.73	156%

To: Ian Fletcher
Director-General, DEEDI

From: Dan Hunt
Associate Director-General, DEEDI

02 February 2011

DBN1727: Flawed Science fans doubts on gas Courier Mail 27 January 2011

Summary/Recommendation

It is recommended that the Director-General note:

- the evidence regarding methane leakage and greenhouse accounting that contradicts the claims in the Courier Mail article; and
- a separate briefing has been provided by the Office of Climate Change to Minister Robertson.

Timing

The article appeared on 27 January 2011.

Background

The article (refer to **Attachment 1**) raises doubts on the greenhouse emission benefits of electricity generation from gas compared with coal when the total carbon lifecycle is considered. The article cites research from Robert Howarth (a Professor in Ecology and Biology) from Cornell University and information published recently by the US Environmental Protection Agency, suggesting a significant underestimation of the greenhouse emissions from gas-fired electricity generation due to:

- the use of the 20 year Global Warming Potentials (GWP) for methane; and
- an underestimate of the volume of methane leakage.

Time-period for greenhouse emission accounting

Howarth contends that the conventional accounting methodology used to estimate emissions is inaccurate. Greenhouse gas emissions are estimated using individual GWP that estimate the long-term impact of greenhouse gases with reference to the impact of carbon dioxide (CO_2). The Intergovernmental Panel on Climate Change identifies 20 year and 100 year time horizon GWPs for each greenhouse gas. The GWPs for methane are 72 and 25 for the 20 and 100 year periods respectively.

Howarth argues that the 20 year figure is a more appropriate figure for methane (given its relatively short lifespan in the atmosphere) and as such, emissions from methane leakage should be around three times greater than currently reported. The Australian Department of Climate Change and Energy Efficiency confirmed that it has been internationally agreed under the Kyoto Protocol that 100 years is the reference time frame over which cumulative radiative forcing is to be measured. The converse argument is that, as methane decays more quickly from the atmosphere it may initially have a large effect, but in terms of total atmospheric concentrations, it is more quickly removed and becomes less important.

Methane leakage from gas production

Howarth argues that methane leakage during extraction from shale, transportation and production processes in the USA has previously been underestimated. In the Australian context, the *Australian National Greenhouse Accounts- accounting for the Kyoto target (May 2010)* is the definitive source on emissions data from all sectors. The Accounts state (page 11) that there has been a reduction in methane emissions from Australian oil and gas production between 1990 and 2008, largely through improved production and transportation processes.

Life-cycle emissions from gas vs coal

A full life cycle emissions analysis for Australian coal seam gas to electricity generation (including production, pipeline transport, liquefaction, shipping, regasification, transportation and generation) has yet to be completed. APPEA has commissioned a study which is expected to be completed by late March 2011.

Other studies (refer to **Attachment 2**) have estimated life-cycle emissions associated with liquefied natural gas (LNG) from conventional gas fields with coal and other fuels. These studies include emissions associated with off-shore activities (LNG tanker transport and regasification). These indicate that emissions associated with electricity from LNG are around 40 per cent lower than the coal over the lifecycle.

In addition, based on the Australian Government's National Greenhouse Accounts Factors (Tables 1 and 2, Pages 11 and 13 respectively), the average Australian full fuel cycle emission factor of energy consumption (including production, processing and transportation) is around 38 per cent lower for natural gas than for black coal.

The clear conclusion from these studies is that the majority of emissions over the life-cycle from coal or gas are produced in the combustion of the fuel and gas has a distinct advantage over current coal technologies. A report commissioned by the Australian Energy Market Operator shows that the emissions intensity of new entrant combined cycle gas turbine generators in Queensland is half that of black coal generators based on a 'like-for-like' comparison of natural gas and coal used for base-load generation. Given the magnitude of the emissions advantage of gas over coal-fired generation, arguments that the underestimation of up-stream emissions from extraction and production of gas erode its attractiveness are not credible.

Consultation

The Office of Climate Change (OCC) was consulted in the preparation of this briefing note and provided details of advice from the Federal Department of Climate Change. OCC has prepared a briefing note to Minister Robertson as Minister for Natural Resources, which has been provided for comments and was endorsed by Sue Ryan (DDG – Energy). The Energy Industry Policy Division provided information regarding the emissions from electricity generation for the OCC briefing note.

Attachments

Attachment 1: Courier Mail article, 'Flawed science fans doubts on gas plan', 27 January 2011.
Attachment 2: Analysis of Fuel Cycle Greenhouse Emissions for Electricity Generation from LNG and Coal (November 2010).
Attachment 3 Office of Climate Change briefing note to Minister Robertson.

Next steps

Energy Industry Policy will prepare a further brief when the APPEA report on Coal Seam Gas LNG used for electricity generation is finalised at the end of March 2011.

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Flawed science fans doubts on gas plan

John McCarthy

QUEENSLAND'S multibillion-dollar plunge into the gas industry could be based on a major flaw in the science, with doubts raised in the US this week over its greenhouse gas emissions.

Reports from Cornell University and the US Government's Environmental Protection Agency said there had been a dramatic underestimate of emissions and gas could be similar to coal as a greenhouse polluter.

The apparent environmental benefits from gas have been a major selling point for the coal seam gas industry and the $30 billion it is ploughing into the state over the next four years to build export facilities in Gladstone.

Gas has long been considered to have about half the greenhouse gas emissions of coal and therefore an ideal stopgap as the world attempts to make renewable energy, such as solar and wind, more viable.

But the EPA said previous estimates of gas emissions had not included a significant number of issues, had left out the effect of methane and that emissions were about double what they were considered in 2006.

The Australian gas industry said it stood by a number of reports, including those by the CSIRO and Worley, that backed gas as a low-polluting alternative and said the US EPA report did not relate to the local industry.

The EPA's analysis said worn and loose fittings on equipment meant about double the previous estimates of methane gas leaks into the atmosphere. But even with the new analysis, gas remains a better alternative to coal.

In a second report, a professor of ecology and environmental biology at America's Cornell University, David Aktinson, said the combustion emissions were only part of the story and the favourable comparison to coal was "quite misleading".

"A complete consideration of all emissions from using natural gas seems likely to make natural gas far less attractive than other fossil fuels," he said.

"Until better estimates are generated and rigorously reviewed, society should be wary of claims that natural gas is a desirable fuel in terms of the consequences on global warming.

"Far better would be to rapidly move towards an economy based on renewable fuels."

Pages 8 through 23 redacted for the following reasons:
- -
sch3(1) Cabinet matter - brought into existence before commencement
sch3(6)(c)(i) Infringe the privileges of Parliament