

Equities

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Shale Gas Environmental Opportunities & Challenges

Presentation by Worldwatch Institute, Washington

Elaine Prior

+61-2-8225-4891

elaine.prior@citi.com

- **Key Takeaways** — Worldwatch Institute, a Washington-based environmental organization, presented to Citi's clients on the shale gas industry. The US industry has faced environmental opposition. Some of this criticism is flowing into the Australian Coal Seam Gas industry. Worldwatch highlighted some key environmental risks for shale gas, though it appears that best practice operations could substantially reduce some key risks. Worldwatch expressed the view that gas, including shale gas has a substantial advantage over coal from a greenhouse gas perspective, based on a preliminary Life Cycle Assessment of US operations (Figure 2). However, it sees a need for better data on methane emissions. *[This LCA does not directly translate to the Australian CSG / LNG industry.]*
- **Five Key Environmental Issues** — Worldwatch identified contamination danger to water supplies; water consumption quantities; whether operations trigger earthquakes; local air pollution; and whether shale gas produces lower emissions than coal on a "life cycle" basis when used for electricity.
- **Operating Practices Appears the Key Question** — It appears that technical solutions are available to significantly address many problem areas. Best practice well completions alleviate the risk of aquifer contamination via wellbores. Capture of fluids that "flow-back" to the surface after fracturing a well would allow methane to be captured and emissions reduced. The water could be treated for reuse at the operation. Minimizing fugitive leaks retains more product for sale, and reduces potential carbon liabilities. The key question is what practices companies are actually adopting.
- **Life Cycle Emissions** — Worldwatch opines that natural gas will have a greenhouse advantage over coal, when used in power generation. However, more robust data, particularly on methane leaks, is required and Worldwatch sees this as a priority.
- **How Relevant to Australian CSG is All This?** — The geology, and therefore some operating processes, are inherently different between shale gas and CSG. However, concerns like aquifer contamination and methane / life cycle emissions are applicable to both. In Australia, a carbon price will apply to leaked methane, providing an added incentive to reduce leaks and venting, and keep more product "in the pipe". Worldwatch commented that the relationship between industry and environmental advocates had turned hostile in the past two years, and we could make a similar observation in Australia. Public confidence may be regained by a combination of effective regulation, demonstration of appropriate operating practices and transparency. This may prove important to companies' and the industry's ongoing "licence to operate".
- **Slides and Replay Available** — CIRA's clients can contact us for replay details.

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Presentation by Worldwatch Institute

Today, CIRA hosted a well attended presentation for Australian clients on “Shale Gas: Environmental Opportunities & Challenges” by Saya Kitasei of Worldwatch Institute. Our invitation followed a similar very well received presentation by Worldwatch at Citi’s London Climate Change Conference in June.

This note outlines key points from the presentation, and some of our perspectives.

Why Investor Interest?

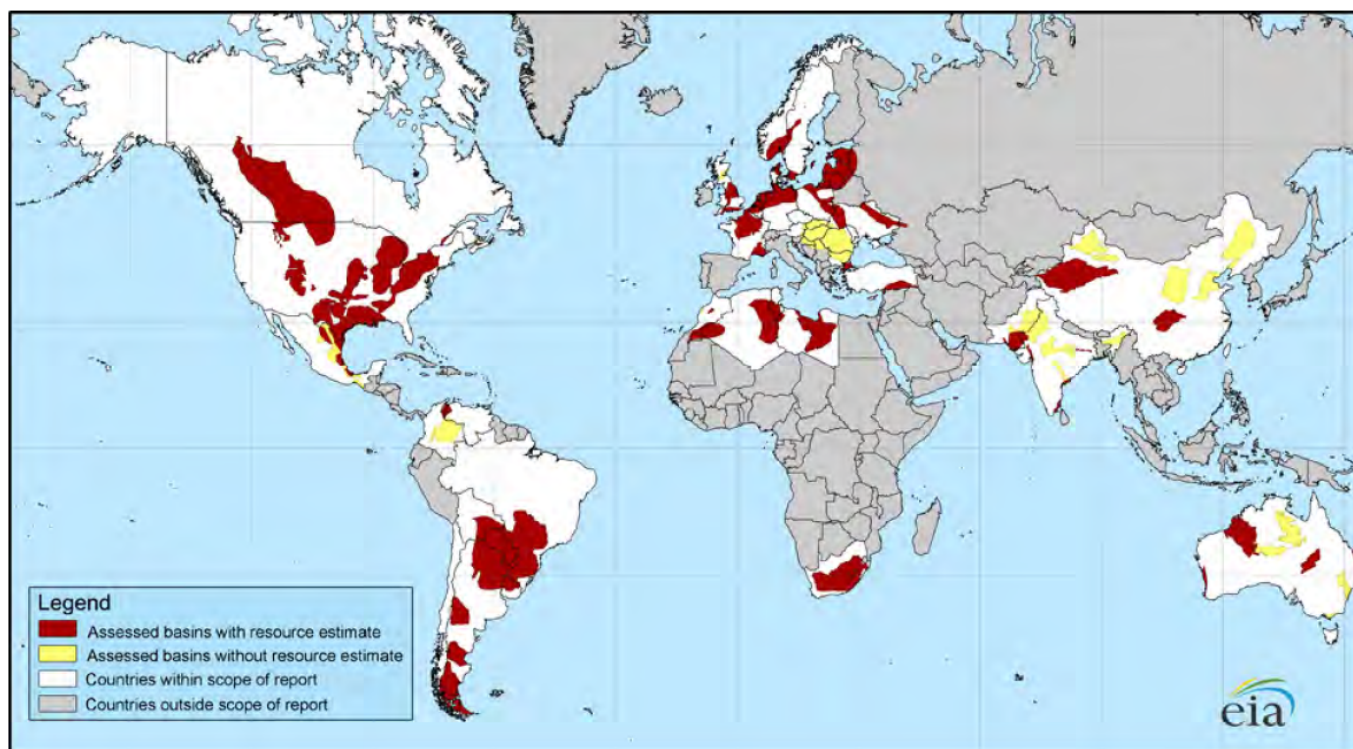
ASX-listed companies are now shale gas industry participants. For example, BHP has recently made two substantial US shale gas acquisitions, and Beach Energy is pursuing shale gas opportunities in Australia.

The shale gas industry, particularly in the US, has been subject to considerable opposition by environmental NGOs (Non Government Organizations) and affected communities.

Parallels are sometimes drawn between problems in the US shale gas industry and those that might occur in the Australian Coal Seam Gas industry, in which companies including Origin Energy, Santos and AGL Energy are participants.

US problems are regularly cited by groups opposing the Australian CSG industry.

Figure 1. Map of 48 Major Shale Gas Basins in 32 Countries



Source: U.S. Energy Information Administration (EIA)

Growth in Shale Gas

Shale gas appears poised to play a major role in energy supply in the US, and may assist transition to a low carbon economy. Advantages over coal for power generation include lower emissions of local pollutants (eg NO_x, SO_x, mercury and particulates), and lower use of cooling water.

However, there are environmental concerns.

Five Key Environmental Questions

Worldwatch has identified five environmental questions it believes are the most pressing ones facing the industry. These were addressed during the presentation.

1. Does hydraulic fracturing endanger water supplies?

Possible methods of contamination include: opening of pathways / fractures underground due to hydraulic fracturing (fracking); flow between formations within wellbores due to poor well completions (eg bad cement jobs); and surface contamination due to leaks of chemicals or release of toxins from the underground rocks.

“Flow back water” produced from drilling activities is sometimes injected into aquifers, or treated at water treatment facilities – though capacity is stretched in some areas. Water may be recycled and reused for subsequent fracturing jobs.

Worldwatch suggests that best technologies and practices have been developed that can significantly reduce the risk of groundwater contamination. However, regulation and oversight, a good safety culture, an effective compliance regime and remediation provisions would be required to effectively reduce these risks.

2. How much water does hydraulic fracturing consume?

Though the quantity of water used in fracturing appears high (eg 2-8 million gallons per well), on a lifecycle basis the quantity may be considered insignificant compared with the quantity of water used for power station cooling.

Water can be treated and recycled. Water availability may be an issue in water scarce areas.

3. Does hydraulic fracturing trigger earthquakes?

In the UK, fracturing operations were halted after a 1.5 magnitude earthquake occurred nearby. Small quakes have been felt near some US shale gas operations, linked to waste water injection.

Worldwatch comments that a lot remains unknown, and more widespread monitoring could alleviate public concerns.

4. How much air pollution does shale gas development generate?

Normal operations (eg trucks, compressors, pumps, drill rigs) can emit gasses and particulates. US legislators have introduced the “Breathe Act”, which would aggregate small sources so that they might become regulated by the Clean Air Act.

Technologies can greatly minimize these emissions, for example installing vapor recovery technology.

5. How much methane is emitted during shale gas development? Enough to undercut the greenhouse gas advantages of natural gas over coal?

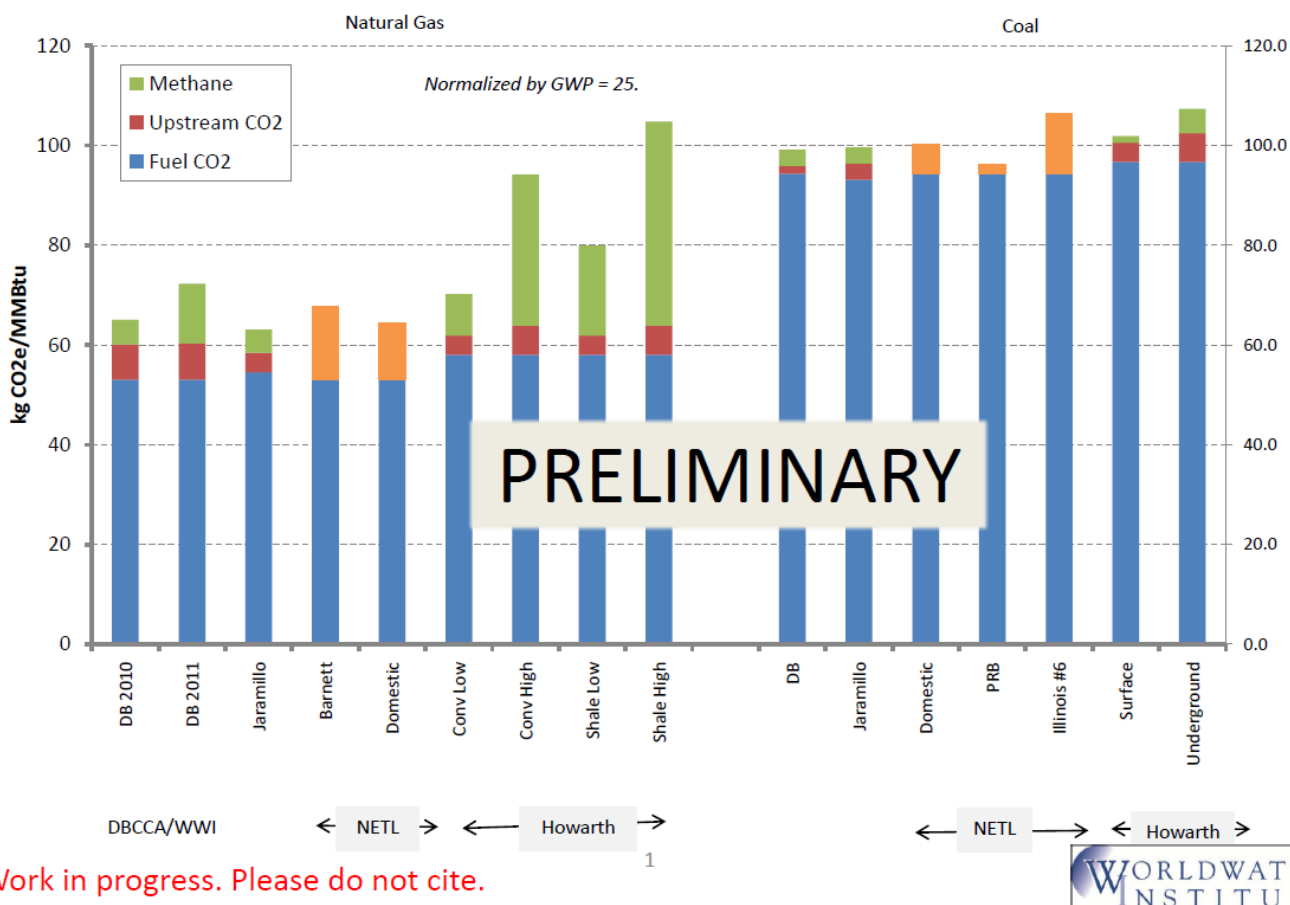
Life Cycle Assessment (LCA) of greenhouse gas emissions is a topical area. Gas is seen having benefits over coal as a transitional fuel towards a low carbon future, but various studies challenge this thinking.

A key variable is the amount of methane that escapes during shale gas operations. Methane is ~25 times as potent as CO₂ on a 100 year basis, 72x on a 20 year basis. *[Some studies use other factors.]*

In 2011, the US Environmental Protection Agency (EPA) revised upwards its estimate of methane vented and leaked by shale gas operations by 120%. A key issue is "liquids unloading" – ie when fracking water is produced back to the surface, accompanied by gas.

Worldwatch presented a preliminary comparison of various studies, based on scenarios for US domestic gas and coal operations (Figure 2).

Figure 2. Comparison of Natural Gas and Coal Burnertip Greenhouse Gas Emissions in Recent Life Cycle Assessments



■ Preliminary work by Worldwatch & DBCCA showed broadly similar results to the National Energy Technology Laboratory (NETL), with both datasets lying in the

range ~63-72 kg CO₂e / MMBtu of energy for shale gas. The highest number used the 2011 EPA factors mentioned above.

- Research by Howarth, Cornell University [*], showed ~80-105 kg CO₂e / MMBtu for shale gas, ie not much better than coal. Discrepancy with other studies appears to relate to estimates of methane emissions for transport, storage and distribution.
- Figures for coal were +/-100 kg CO₂e / MMBtu.

[] We observe that the Cornell Study is frequently referred to by opponents of the Australian Coal Seam Gas industry, particularly referring to the amount of methane that leaks. An apparent dearth of credible public emissions / LCA data for Australian CSG operations leaves a “void” which the Cornell study fills.*

These LCA figures are calculated per unit of energy content of the gas or coal (MMBtu – million British thermal unit), rather than per unit of electricity produced. Gas power stations tend to be more efficient than coal. Therefore, if the results were expressed per unit of electricity (eg per MWh), gas would become relatively more favourable.

Worldwatch opines that, based on the most robust data, natural gas has a substantial greenhouse gas advantage over coal.

However, Worldwatch notes shortcomings with data on methane leakage. It believes more robust data is needed, given the importance of the issue to greenhouse gas policy. Leaks can be vastly reduced via technology solutions, reducing loss of valuable product.

Appropriate Practices and Transparency Required to Create Public Confidence

Worldwatch observes that there has been a hostile turn in the relationship between the industry and environmental advocates over the past two years. It attributes this to the industry's resistance to additional federal regulation and a dismissive response to activists' concerns.

It suggests that industry can play a constructive role in many countries in the transition to a low carbon economy. However, it must create public confidence by demonstrating appropriate practices, safety records, and transparency, and must compromise on regulations.

LCA Comparisons Do Not Readily Translate to Australian LNG

We caution that the US shale gas Life Cycle Assessment does not readily translate to the Australian Coal Seam Gas industry.

The LCA path for Australian CSG to LNG, to ship, to power generation in China will have a number of different components. However, methane fugitives will remain a key consideration, and depend significantly on the operating practices adopted.

Similarly, the appropriate LCA comparison might be considered to be with coal produced in Australia, shipped to China and then used. Others might consider that the comparison should be against Chinese renewable energy.

Appendix A-1

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