SENATE ENVIRONMENT AND COMMUNICATIONS LEGISLATION COMMITTEE

Inquiry into the Landholders' Right to Refuse (Gas and Coal) Bill 2015

Questions on Notice

CSIRO

Senator WATERS asked:

Methane as GHG fugitive emissions from CSG

1. When is stage 2 of the research into CSG fugitive emissions (stage one being the publication called *Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities*) due to be published? (In Budget Estimates the CSIRO stated that the research would be published in June 2015).

   As advised in our answer to Question on Notice BI-11 arising from the June 2015 Budget Estimates Hearing, coordinating the deployment of measurement equipment at the same time and in the correct location as well completion has been difficult to achieve and as a consequence field measurements have been delayed. The contract for this work has thus been extended until December 2015 with the approval of the Department of the Environment. The final report will be released before the end of the contract.

2. What is the rough sample size (in number of wells) of that new research?

   CSIRO is aiming to make detailed measurements at up to six well sites where completion operations are occurring. Multiple measurements covering different stages of completion will be taken at each well site. The final sample size will at least partly depend on the ability to deploy measurement equipment at the same time and in the correct location as well completion, which is not always easy to achieve logistically.

3. Does CSIRO have any funding for further stages of this project?

   No.

4. Combined with CSIRO's previous study funded by the Department of Environment and published in August 2014, will the current study (stage 2) cover all the stages of production?

   No.

5. Which stages of production will be outstanding?

   Gas and water gathering networks, water treatment facilities, gas processing and compression facilities, and all other downstream operations including distribution.

Methane from water bores

6. On Monday 27 July 2015 the Committee has heard from a landholder called George Bender who has two water bores on a property which have been rendered useless by water drawdown. The bores are unusable, and the gas company has agreed to decommission them because they are a safety risk because they are leaking methane. The Committee heard that the methane was measured at 35% by volume at the bore head. Does the CSIRO's work on fugitive emissions take account of emissions from bores like that, or even old drill holes which might be similarly affected?

   CSIRO cannot comment on this particular situation as it does not have all the information. However, the current GISERA project *Characterising the regional fluxes of methane seepage in the Surat Basin, Queensland* aims to quantify background methane fluxes from a variety of sources, including any potential flux from agricultural wells and bores, regardless of the cause of these emissions.

7. Would the CSIRO classify emissions of methane like those of George's property caused by water drawdown as fugitive emissions?

   The Australian Government, not CSIRO, is responsible for the classification of fugitive emissions. Please see the definition provided by the Australian Greenhouse Emissions Information System http://ageis.climatechange.gov.au/Help/PublicTutorialGlossary.aspx. "Fugitive emissions involve the release of non-combustion, greenhouse gases arising from the production and delivery of fossil fuels. Fugitive emissions from oil and gas extraction, production and transport involve venting, flaring, leakage, evaporation and storage losses."

8. Could you please explain why, or why not?

   The Australian Government, not CSIRO, is responsible for the classification of fugitive emissions. Please see the answer to question 7.

9. Would such emissions fall under NGERS?

   The Australian Government, not CSIRO, is responsible for the classification of fugitive emissions. Please refer all questions related to NGERS to the Department of the Environment.

10. Is the CSIRO aware of any other agency or body in Australia studying emissions of methane from water bores or disused bore holes or other sources caused by water drawdown?

    CSIRO is not able to give a comprehensive list of all other research organisations in Australia active in this area. We are aware that there are some groups (e.g. the University of Southern Queensland) with an interest in this area but CSIRO is not able to comment on their current research projects.

11. In estimates in June 2015, CSIRO stated that the study would not examine emissions other than those measured near to the well pad "… because those emissions will not be coming to the surface in the soil around that region; they will be following a line of least resistance back towards the wellhead…" (Link in footnote below[1]- page 136). Does that mean that the CSIRO considers that no fugitive emissions are likely to be occurring from other places than the CSG infrastructure?

    The quote refers to a discussion about measuring emissions associated with hydraulic fracturing and whether there was potential for methane to escape from these fractures to the surface. CSIRO stated that any flow of gas induced by hydraulic fracturing would most likely be back towards the well head. As noted in the answers to questions 7-9, the term fugitive emissions as defined by the federal government refers to emissions associated with infrastructure. However, CSIRO is also conducting work to understand the broad picture of methane emissions, e.g., the GISERA study aims to identify and quantify sources of methane emissions in the Surat Basin, and a study with the NSW Environmental Protection Agency (EPA) is monitoring fugitive methane air emissions across a range of different natural and industrial sources over the four different seasons.

12. Does the CSIRO consider that it is impossible that examples such as the Condamine River seepage of methane were caused by the CSG industry?

    CSIRO considers that it is unlikely that the Condamine River seepage of methane was caused by the CSG industry.

13. Has the CSIRO done any literature reviews, or fieldwork, or other work to determine whether fugitive emissions may be likely to occur otherwise than at the well pad?

[1] http://parlinfo.aph.gov.au/parlInfo/download/committees/estimate/fef16def-3d6b-4f2a-b0dd-45eb9db6fe8f/toc_pdf/Economics%20Legislation%20Committee_2015_06_03_3514_Official.pdf;fileType=application%2Fpdf#search=%22committees/estimate/fef16def-3d6b-4f2a-b0dd-45eb9db6fe8f/0005%22

Yes. The phase 2 report from the GISERA study released in April 2015 located and estimated emissions from some gas compression plants. CSIRO's work with the NSW EPA is also looking at fugitive emissions from different aspects of CSG operations than the well pad.

Flawed methane equipment

14. A news article surfaced in early May 2015 (link below[2]) about a US study which found potentially very serious flaws in a very commonly used piece of equipment used to measure the level of methane gas emissions from gas wells in the CSG and shale gas industries. The equipment is called a "Bacharach". Is the CSIRO aware of that study?

    As advised in our answer to Question on Notice BI-69 arising from the June 2015 Budget Estimates Hearing, CSIRO is aware of this study.

15. The article says: "In one instance, the authors found that two separate Bacharach samplers recorded natural gas concentrations in the air of 1 to 6 per cent, when the actual concentrations were between 7 and 73 per cent" – is the CSIRO aware whether that equipment is widely used in Australia?

    As advised in our answer to Question on Notice BI-69 arising from the June 2015 Budget Estimates Hearing, CSIRO does not use these sensors and to the best of our knowledge they are not used widely in Australia.

Methane from shale and tight gas

16. Does the CSIRO have any funding or staff time allocated for work on shale or tight gas since there is a large volume of such development planned across SA and WA?

    As at 30 June 2015, CSIRO had a portfolio of unconventional gas projects worth $11.3 million and involving 52 people, including research on tight and shale gas.

17. Would CSIRO expect, given the experience overseas and what is known already about geology and the technology - that fugitives from shale and tight gas would be higher or lower than for CSG?

    The likely fugitive emissions from shale and tight gas have not yet been determined in the Australian context.

BTEX and other pollutants from fugitive emissions

18. The Committee has heard rather disturbing evidence on Monday 27 July 2015 about the presence of Volatile Organic Compounds or VOCs in CSG fugitive emissions in Queensland. VOCs have been recorded by community members emanating from CSG facilities. Does that fit with the CSIRO's understanding of the composition of fugitives from CSG?

    CSIRO is not able to comment on this particular situation as it does not have all the information. Speaking generally, CSIRO's knowledge of the relevant literature suggests that there are very low levels of non-methane VOCs in the coal seam gas of the Surat Basin, Queensland.

19. Do you have a clear idea of how much of these compounds would be in each m3 of fugitive emissions?

    No. Non-methane VOCs are being investigated as part of the NSW EPA study.

20. Is there anyone in CSIRO studying that question?

    Yes. Non-methane VOCs are being investigated as part of the NSW EPA study.

[2] http://www.smh.com.au/environment/climate-change/flawed-methane-monitor-underestimates-leaks-at-us-oil-and-gas-sites-20150506-ggvuj5.html

21. Is that question beyond scope for your current work on fugitive emissions funded by the Department of Environment?

    Yes.

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Prof. Barrett: The Great Artesian Basin Water Resource Assessment…

Senator URQUHART: When was that report done?

Prof. Barrett: My recollection is that it was released in 2012, but I can get the exact report for you, if you would like.

Answer:

The study was released in 2012, and is available online at

http://www.ga.gov.au/scientific-topics/water/groundwater/gabwra

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Senator WATERS: Just explain for me: you are talking about when they are being drilled. In my head, I am conceiving of it as: after they have been drilled, once the casing has been put in and once it has been sealed—so in years to come—then there might be the degradation of that casing. Is that a potential connectivity pathway?

Prof. Barrett: During well construction, those techniques are applied to ensure integrity. The engineering standards that apply are such that the casing and the cement that is used has a lifetime that exists for the productivity period of the well. When the well is finished, shut in and abandoned, there is a set of processes—involving closing off the well, isolating aquifers and filling the well—that are controlled by state government regulations that aim to isolate that well from the freshwater aquifers and the agricultural aquifers that it is penetrating through.

Senator WATERS: What are those processes?

Prof. Barrett: Again, using barriers to isolate and protect those aquifers that have been drilled through and then cement is used to backfill that well to the surface.

Senator WATERS: When you say barriers, what is the content of those? Is that cement or something else?

Prof. Barrett: They may be steel barriers.

Senator WATERS: Can you provide us a bit more information on notice and perhaps some pictorial representations? I am interested in how on earth you would get that into place.

Answer:

In relation to well integrity and abandonment, CSIRO notes that the NSW Chief Scientist and Engineer report published in 2014, the *Independent Review of Coal Seam Gas Activities in NSW Information paper: Abandoned wells,* covers this issues of well abandonment. The references referred to in the text below are available from the report (available online at http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/56925/141002-Final-Abandoned-Well-report.pdf).

Well abandonment refers to the decommissioning of a well. In modern practice this generally means a well ceases production, equipment is removed from the well, the well is plugged with cement, cut and capped below the surface level, surface equipment is removed, and the land is rehabilitated and reclaimed.

Table 1.2: Well status in relation to decommissioning

Well Status Terminology	Description
Shut in	A well that has had its valves closed to stop it from flowing
Suspended or Temporarily abandoned	A well that has temporarily discontinued operations
Abandoned or Plugged and abandoned	A well that is filled with cement and decommissioned, after cessation of function
Decommissioned	A well that is removed from service
Orphaned or Derelict	A historical well for which an operator cannot be located
Legacy	A historical well, potentially constructed or abandoned under less stringent conditions

From Section 2:

Well design

The aim of well design is to ensure environmentally sound, safe production from the well, enabling the protection of groundwater resources, and isolating the productive formations from other formations (API, 2009). Poorly completed wells with compromised integrity or where the bond to the surrounding geology is weak, can cause movement of water and gas along the well annulus.

Modern well designs include contingency planning where multiple barriers, both physical and operational, are designed into the system to mitigate and eliminate the risk of failure due to unplanned events, for the protection of people and the environment (API, 2009). There are a range of different well log tests that can be used to confirm integrity and cement bonding and thickness. In the event that one barrier should fail, additional barriers are in place to prevent total well integrity failure and leaks to the environment.

In addition to this, the introduction of improvements in well tubing and pipes, cementing design and practices, couplings, pressure controls, and plugging design and practices have all worked to sustain the integrity of a well during its active life and after abandonment (Banchu & Valencia, 2014).

Well cementing

Cement is a critical component of well construction and thus cementing is a fully designed and engineered process. Cement is used in casing at the time of well construction, in addition to plugging at the time of well abandonment, and less commonly to address production or perforation issues. Cement used for plugging has the purpose of providing zonal isolation, preventing fluid from flowing within the well. Cementing a well casing has two main purposes: to provide zonal isolation between formations and to provide structural support to the well. According to the API, "*cement is fundamental in maintaining integrity throughout the life of the well*" (2009).

Cementing practice and design has decades of research to underpin it. Special formulations and additives are available to customise cement to individual well conditions, including increased resistance to gas migration, naturally occurring chemical ions, low pH environments, carbon dioxide (CO_2), high temperatures, sulphate, and mineral acids (King, 2012). Designs may call for using different cements for casing than for plugging a well.

Poor cement jobs, which may result in well integrity failure and potential leaks, are influenced by three main problems: failure to bring the cement top high enough, failure to surround the casing completely with cement, and gas migration in the cement during cement setting. All of these problems can be mitigated through proper cement design and competent execution. "*Cement is a strong, durable, very long-lasting barrier as long as it is mixed and placed properly*" (King, 2012).

As a high quality cement seal is critical to well integrity, various methods are available to test this. First, cements are pressure tested to ensure zonal isolation. Secondary confirmation steps include cement bond logs and other tools designed to test the bond strength between the cement, the pipe and the formation wall. "*A single cement inspection tool is not appropriate for every cemented* *string, but the tools are a broadly applied technique for assessing cement seal in a manner beyond that of a pressure test after cementing*" (King, 2012). Numerous tools and technologies exist for cement evaluation, with improvements being developed regularly (GE, 2013; Halliburton, 2014; Schlumberger, 2014).

Given its importance to well integrity, numerous standards exist around cementing, which are frequently referenced in petroleum regulations and rules.

Competencies and compliance

Significant expertise goes into the design of wells to ensure long lasting safety and integrity. To maintain well integrity, this expertise relies on proper execution of these designs. The NSW Code acknowledges this by stating, "*Worker training and certification is central to good practice and the mitigation of safety and environmental risks. Workers must have the knowledge and skills necessary to perform their work safely and to the highest possible standard*" (2012b).

Also key to ensuring well integrity is maintaining stringent compliance and enforcement programs. These not only ensure the protection of the environment and other resources but simultaneously work towards gaining public acceptance and support (Groat & Grimshaw, 2012).

Long-term durability of abandoned wells

Despite the abundance of information and research on petroleum well integrity (including design and cements), very little data exists about the long-term (100-1000 years) durability of abandoned petroleum wells.

Although no long-term studies could be found dealing specifically with deterioration of CSG wells, other studies have been undertaken into the degradation of comparable wells. Yamaguchi, Shimoda, Kato, Stenhouse, Zhou, Papafotiou, Yamashita, Miyashiro & Saito (2013) have investigated the long-term corrosion behaviour of cement in abandoned wells under CO_2 geological storage conditions by simulating the geochemical reactions between the cement seals over a simulated period of 1,000 years. While alteration of the cement seals was found after a period of time, the alteration length after 1,000 years was approximately one meter, leading to the conclusion that cement would be able to isolate CO_2 and upper aquifers over the long-term.

Cement plug integrity in CO_2 subsurface storage was also looked at by Van der Kuip, Benefictus, Wildgust & Aiken (2011). Using estimates for degradation after 10,000 years they likewise came to similar conclusions stating that "*mechanical integrity of cement plugs and the quality of its placement probably is of more significance than chemical degradation of properly placed abandonment plugs*".

It is important to note in the foregoing, that the literature on corrosion and cement degradation considers CO_2 stored at high pressure to be more aggressive than methane (Popoola, Grema, Latinwo, Gutti, & Balogun, 2013). Therefore, a conclusion can be drawn that if wells are properly designed, installed and maintained, the risk of long-term leakage from CSG wells from both the casing and cement can be considered to be minimal, although there is scope for additional research specifically to assess the impact of abandoned CSG over extended timeframes.

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Prof. Barrett: The research that is undertaken in relation to depressurisation of coal seams—in particular in eastern Australia, where for example we are doing bioregional assessments or other work in coal seam gas fields—looks at the depressurisation and the propagation of that depressurisation wave, if you like, through the coal seam over a period of more than 100 years. It could be up to 200 years. We can examine the behaviour of that coal seam and surrounding aquifers over a period of at least a couple of hundred years.

Senator WATERS: Is our knowledge sufficient to have modelling that can predict that far? I thought that we really did not know that much.

Prof. Barrett: This is world-standard, highest quality numerical modelling for groundwater impacts. It is world's best standard.

Senator WATERS: What are the confidence parameters for that modelling?

Prof. Barrett: I cannot give you an exact figure in relation to the uncertainty around those impacts. The quantification of that uncertainty is a key part of the research that CSIRO does. Quite sophisticated numerical methods are used to examine various scenarios, if you like. Perhaps we have got parameters wrong by five, 10, 20 or 30 per cent. That is factored in and the impact of that on the output from the models is examined.

Senator WATERS: If you could just take on notice what level of confidence we can have in the model's ability to predict and how we get to that level of confidence. Thank you.

Answer:

It is not currently possible to give a definitive figure on the uncertainty of impacts of dewatering for coal seam gas production covering all regions and all aquifers. The CSIRO is undertaking research on quantifying these uncertainties.

For gas production in the Surat Basin, the Queensland State Government Office of Groundwater Impacts Assessment (formerly the Queensland Water Commission) quantified uncertainties for the Surat Basin groundwater model. This work was undertaken by Watermark Consulting[1].

The following table gives representative percentage lower and upper uncertainty estimates relative to the median of the 5th and 95th percentiles for maximum drawdown in pressure head in the Gubberamunda, Springbok, Hutton, and Precipice confined aquifers. It provides an indication of the range of relative uncertainties in groundwater models used to quantify impacts of dewatering for CSG operations.

% uncertainty in the impact of dewatering Walloons on overlying aquifers
• Gubberamunda Sandstone Lower bound 100% Upper bound 60%
• Springbok Sandstone Lower bound 67% Upper bound 67%
% uncertainty in the impact of dewatering Walloons on underlying aquifers
• Hutton Sandstone Lower bound 88% Upper bound 50%
• Precipice Sandstone Lower bound 25% Upper bound 25%

[1] Watermark Consulting, (2012) 'Predictive Uncertainty of the Regional-Scale Groundwater Flow Model for the Surat Cumulative Management Area’