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# Measuring Fugitive Emissions

## Is coal seam gas a viable bridging fuel?

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TAI

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## Summary

With increasing awareness of the dangers of climate change, the world is hunting for other forms of power generation that produce lower emissions of greenhouse gas. While gas is not a zero emissions energy source, it has come to be seen by some as a ‘bridging fuel’. In Australia an increasingly important source of gas has come in the form of coal seam gas (CSG).

While a number of concerns have been raised about the environmental impacts of CSG, including the process of fracking, in Australia most of these concerns centre on water. These include contamination of ground water, disposal of produced water, reduced availability of water for other consumers and the creation of hazardous waste resulting from either treatment of produced water or drilling mud. There is also concern about the chemical cocktail that can be used in the fracking process.

Most of the difficulties in confronting these concerns come from the lack of information that is available on the broader effects of CSG extraction. Very little measurement and research has been done in this area. While concerns about the effects of CSG on Australia’s water supply are widespread in the community, the focus of this paper is on fugitive emissions produced during the CSG extraction process.

Fugitive emissions occur when methane leaks during the extraction, processing and transportation of CSG. Leaking at the wellhead during extraction is the most significant source of fugitive emissions and is also the source for which the least amount of measurement has been done. The current default measurement technique for fugitive emissions at the wellhead is the same as that used for conventional natural gas, despite the fact that there is evidence to suggest that fugitive emissions from the extraction of CSG are significantly higher.

While conventional natural gas, particularly offshore production, comes from large reservoirs and so has only a relatively small number of wellheads which are very large and closely monitored, CSG is extracted from many small reservoirs. This means that for any given quantity of gas there are many small wellheads, rather than a few large ones. It also means that each of the wellheads is monitored less closely. For every tonne of natural gas produced from CSG, there is potential for more leakage to occur from the wellhead when compared with each tonne of gas produced from a conventional natural gas well.

Another reason why fugitive emissions from CSG would be expected to be significantly higher than conventional gas during extraction is that the amount of emissions that leak from the wellhead increases when fracking is used. Unlike conventional gas, fracking is likely to be used on 25 to 40 per cent of Australian CSG wells.

The consequences of underestimating fugitive emissions from CSG are two-fold: it blunts the efficacy of the recently introduced carbon price, as firms will not be paying the tax on all of their emissions; it also prevents us from correctly calculating Australia’s contribution to climate change. This underestimate may be inadvertently making it harder for the world to limit the warming effect of climate change below the environmental tipping point of two degrees.

Before we jump into the golden age of gas as a way of combating climate change, it is essential that we have a good understanding of the effect that switching from coal to gas will have on our emissions. We cannot do this until we can measure the fugitive emissions that occur in the coal seam gas extraction process.

The solution is to undertake better measurement of fugitive emissions, particularly at the CSG wellhead. With better information from more accurate measurement, we can more accurately calculate fugitive emissions and therefore better measure the impact that CSG extraction is having on Australia's greenhouse gas emissions.

Before the government approves more CSG production it would be prudent to allocate funding from the $200 million it has put aside from the Minerals Resource Rent Tax for scientific research on the effects of CSG extraction towards measuring fugitive emissions.

## Introduction

The International Energy Agency has said that we are entering a golden age of gas.[1] Many countries including Australia continue to rely heavily on coal for electricity generation. With increasing awareness of the dangers of climate change, the world is hunting for other forms of power generation that produce lower emissions of greenhouse gas. Burning natural gas in efficient gas fired power stations results in significantly less emissions at the power station than coal fired generation. While gas is not a zero emissions energy source, it has come to be seen by some as a ‘bridging fuel’. Generating power from gas is a way to reduce emissions using a method that has a similar cost to coal and is proven and commercially available.

As demand for gas rises worldwide there has been an expansion beyond conventional natural gas to unconventional natural gas. In Australia this has meant an increase in the extraction of coal seam gas (CSG). There are still many questions being asked about all the consequences of CSG extraction, along with calls for more research and measurement of its full effect on the environment. This paper will argue that there needs to be more measurement of the amount of fugitive emissions that occur when CSG is being extracted. The current methods of estimation, using fugitive emissions estimates for conventional natural gas, are inappropriate and are likely to underestimate CSG fugitive emissions.

The paper will also argue that the way we measure methane, the main fugitive emission from CSG extraction, may be inadvertently making it harder for the world to limit the warming effect of climate change to below the environmental tipping point of two degrees.

## Extracting CSG

Most of the world’s current gas supply consists of what is known as conventional natural gas, extracted from large gas reserves deep underground. Conventional natural gas is methane formed by rotted organic material in a low oxygen environment. Over geological time it migrates into large reservoirs and is stopped from escaping by a large impermeable layer, usually rock. It is then extracted by drilling through the rock layer, generally being forced out under its own pressure.[2]

In recent times there has been an increase in extraction of unconventional natural gas. Unconventional gas comes in two main forms: shale gas and coal seam gas. Unconventional gas is identical to conventional natural gas and forms in the same way. The difference is that unconventional gas is formed in coal seams or shale layers rather than large reservoirs. Shale gas is formed in layers of shale. CSG is held within the coal seam by adsorption and pressure from water in the seam.[3]

In Australia CSG is extracted in New South Wales and Queensland. CSG is extracted differently from conventional natural gas. Rather than coming out under its own pressure, CSG needs to be depressurised by removing water. If the gas still does not flow, the seam may need hydraulic fracturing, also known as fracking. This process involves pumping in large volumes of fluid, mainly water, at high pressure to fracture (break) the rock so the gas can escape. Estimates of the number of wells that require fracking in Australia vary, but it is likely to be around 25 to 40 per cent.[4] [5] Shale gas extraction is different to CSG, in that all

[1] International Energy Agency (2012)

[2] Rutovitz et al. (2011) p.3

[3] Rutovitz et al. (2011) p.3

[4] Rutovitz et al. (2011) p.4

[5] Senate Rural Affairs and Transport Reference Committee (2011) p. 5

shale gas wells require fracking. There is currently no shale gas production in Australia, although there are large reserves of shale gas in South Australia, Western Australia and the Northern Territory.

A number of concerns have been raised about the environmental impacts of unconventional gas, including the process of fracking. In Australia most of the concerns about CSG centre on water. They include contamination of ground water, disposal of produced water, reduced availability of water for other consumers and the creation of hazardous waste resulting from either treatment of produced water or drilling mud.[6] There is also concern about the chemical cocktail that can be used in the fracking process.

Most of the difficulties in confronting these concerns come from the lack of information that is available on the broader effects of CSG extraction. Very little measurement and research has been done in this area. The government has recognised this problem, and, to help overcome it, has put aside $200 million from the Minerals Resource Rent Tax for scientific research on the effects of CSG extraction.[7] While concerns about the effects of CSG on water are widespread in the community, the focus of this paper is on fugitive emissions produced during the CSG extraction process.

Fugitive emissions for the purpose of this paper are all leakage emissions from the extraction, processing and transportation of gas. This includes both accidental leakage as well as deliberate releases from, for example, venting or flaring. This is the definition that is used in the Intergovernmental Panel on Climate Change (IPCC) Guidelines for the reporting of national greenhouse gas inventories.

## CSG and the carbon price

From July 2012 the greenhouse gas emissions that are produced when natural gas is burned to generate electricity will be subject to the carbon price, which will start at $23 per tonne. It is the owner of the power station that is responsible for those emissions, not the company that extracted the gas. The company that extracts the gas is responsible for any emissions of greenhouse gases that are produced in the extraction and transportation of the gas.

The carbon price is designed to make it more expensive to release carbon emissions. As companies must now pay to dispose of their carbon emissions, they will treat them like other costs and try to find ways to reduce them. It is this cost that drives industry to be innovative and to come up with new ways of producing, in this case, energy that generates less greenhouse gas. In the case of CSG producers, making them pay a carbon price on fugitive emissions released during extraction is intended to drive them to produce in a way that minimises their fugitive emissions.

## Emission measurement

Emissions in Australia are recorded under National Greenhouse and Energy Reporting (NGER), governed by the *National Greenhouse and Energy Reporting Act 2007*. All firms that produce more than 25,000 tonnes of $CO_2e$ per annum are required to report annually under NGER. Since greenhouse gas emissions can come from many sources, the relevant regulation (the National Greenhouse and Energy Reporting (Measurement) Determination 2008) explains how to measure emissions. One of the ways to do this, known as 'method 1', provides a set default factor for calculating the amount of emissions that might be expected to be produced from doing a certain activity. So for example, if your business uses black coal

6 Rutovitz et al. (2011) p. 25

7 ABC Rural (2011)

to heat something, you simply take the quantity of coal you burn in a year and apply the method 1 factor, and that determines your emissions from burning coal.

Method 1 is not the only method that firms can use. They can measure the emissions that they produce from an activity and under certain circumstances can use that figure to report their emissions. So, for example, if a firm thought that the emissions from burning their coal were lower than the figure calculated using the method 1 factor, they could measure the emissions from their coal and use that figure instead. Of course if a firm thought that the emissions from burning their coal were greater than the figure produced by using the method 1 factor, then they would have no incentive to measure their own emissions, since this would increase their recorded emissions and mean they would have to pay more under the carbon price.

This is an important point. If the figure calculated using the method 1 factor is higher than the average emissions for a particular activity, then more firms will be encouraged to measure their own emissions and use that factor. If the figure obtained using the method 1 factor is lower than the average for conducting an activity, then fewer firms will be encouraged to measure their emissions. Instead they will use the method 1 factor.

## CSG emissions

The extraction process for coal seam gas produces emissions from a number of sources. One of those is fugitive emissions from the transportation of gas. Fugitive emissions are unintended emissions that leak out, usually from gas under pressure. Fugitive emissions escape during the transportation of CSG through pipelines because the gas is under pressure and some of it inevitably leaks out. The more kilometres of pipeline that the gas runs through, the higher the fugitive emissions will be.

Transport fugitive emissions from unconventional gas are essentially identical to transport fugitive emissions from conventional gas. NGER uses the same emissions factors for measuring emissions from transportation of CSG as those used for transporting conventional gas.

Another source of emissions is in the processing of the gas. While conventional gas sometimes contains significant quantities of other hydrocarbons including ethane, propane and butane, it may also have to be processed to remove excessive levels of $CO_2$. These processing activities can be emissions intensive. CSG differs from conventional gas in that it does not contain higher levels of hydrocarbons that need removing and rarely contains high levels of $CO_2$. Because of this difference, CSG requires very little processing.

The other main source of fugitive emissions from CSG is leaks at the wellhead. This is when emissions, in the form of methane, leak out as the gas is being extracted. Fugitive emissions from the wellhead occur for both conventional gas and CSG; however the wellheads for conventional gas and CSG are very different. Conventional natural gas, particularly offshore production, comes from large reservoirs and so only a relatively small number of wellheads are needed for a given quantity of gas. These wellheads are very large and are closely monitored.

CSG is extracted from many small reservoirs. This means that for any given quantity of gas there are many small wellheads, rather than a few large ones. It also means that each of the wellheads is monitored less closely. This means that for every tonne of natural gas produced from CSG, there is potential for more leakage to occur from the wellhead when compared with each tonne of gas produced from a conventional natural gas well.

The amount of emissions that leak from the wellhead increases when fracking is used.[8] This means that fugitive emissions from shale gas are far larger than those from conventional gas, since unlike conventional gas, shale gas extraction always uses fracking.

CSG extraction also uses fracking at some, but not all of its wells. So the combination of a higher number of wellheads per tonne of gas produced, and increased fugitive emissions (because some CSG wells use fracking) suggests that fugitive emissions from CSG are likely to be higher than those from conventional gas but lower than those for the extraction of shale gas.

## CSG method 1 factor

The NGER method 1 factor for fugitive wellhead emissions for CSG is 0.0012 tonnes of $CO_2$e per tonne of natural gas, or 0.12 per cent of gas production.[9] This is the same as the method 1 factor used for conventional gas. If the method 1 factor is used, this means that for every tonne of natural gas produced, 1.2 kg of $CO_2$e is produced. This means that no account is made for the fact that CSG extraction uses far more wellheads, and wellheads of a very different size. Also no account is made for the fact that fracking is used when extracting some of the CSG.

Conventional and unconventional natural gas have the same fugitive emission factors in significant part because there has been very little research done on emissions associated with unconventional natural gas, whereas a lot of research has been done on conventional natural gas. So the method 1 factor is not an average of conventional and unconventional natural gas fugitive emissions, but, rather, is just the emissions factor for conventional gas.

The research that does exist on unconventional gas is mostly on shale gas. This is in part because shale gas production has increased rapidly in the United States (US) and now accounts for about 15 per cent of US gas consumption.[10] In 2011 the United States Environmental Protection Agency (EPA) revised its estimates for fugitive emissions from natural gas operations, more than doubling it to 2.4 per cent of gas production, primarily because of emissions associated with unconventional gas.[11] A recent US study by the National Oceanic and Atmospheric Administration suggested that fugitive emissions were four per cent.[12] Some US studies have even suggested that when the full emissions from shale gas are measured they might be higher than those for coal, which they are supposed to be replacing.[13] While CSG fugitive emissions are not expected to be as high as those associated with shale gas, they are very likely to be higher than those of conventional gas.

As explained above, when the emissions figure calculated using the method 1 factor is likely to be lower than the actual emissions associated with an activity, it is in a firm’s interest not to measure emissions and to instead use the method 1 factor. If fugitive emissions from CSG are likely to be higher than for conventional gas, then the emissions calculated using the method 1 factor will be lower than actual emissions. This could create a situation where emissions estimates for firms producing CSG are an underestimate, which means that these firms are paying a lower carbon price. This creates a situation where there is no incentive for them to measure their fugitive emissions.

[8] Howarth et al. (2011)

[9] National Greenhouse and Energy Reporting (Measurement) Determination (2008)

[10] Rutovitz et al. (2011) p.3

[11] Environmental Protection Agency (2011)

[12] Tollesfson (2012)

[13] Howarth et al. (2011)

## Effect of underestimating CSG fugitive emissions

Underestimating CSG fugitive emissions is likely to have the effect of blunting the incentives created by the carbon price. Any efforts by firms to reduce their fugitive emissions will not result in a decrease in their carbon cost. This is of particular importance, since research into unconventional fugitive emissions has shown that introducing world's best practice can create emissions reductions of between 40 per cent and 90 per cent.[14] If the emissions calculated using the method 1 factor are significantly lower than actual emissions, then there is no incentive for CSG producers to introduce world's best practice.

The other significant effect this will have is that we will be failing to correctly measure Australia's greenhouse gas emissions. If the purpose of the carbon price is to help mitigate the effects of global warming, failing to measure emissions correctly, particularly underestimating emissions, will defeat that purpose. That is, our underestimate will have a cost; but rather than the gas producer bearing the cost, it will be borne by the environment.

## Methane as a greenhouse gas

There are a number of different gases that cause warming of the atmosphere. The Global Warming Potential (GWP) of a gas is the average amount of warming it causes over 100 years. By converting these gases into $CO_2$e, we can compare their GWP to that of a tonne of carbon dioxide over 100 years.

The main fugitive gas produced in extracting CSG is methane. The conversion rate that is used with the carbon price for methane is 25 times carbon dioxide over a 100 year period. Put simply, each tonne of methane emitted creates 25 tonnes of $CO_2$e. This is because methane is a particularly potent greenhouse gas, which creates more warming than carbon dioxide. Methane is also a relatively short-lived gas in the atmosphere when compared to carbon dioxide. Methane only lasts about 12 years, whereas carbon dioxide could last more than 1000 years. In the case of methane, it has broken down long before the 100 years are up, which drags down its average GWP. If methane is compared to carbon dioxide over 20 years instead of 100 years, however, then the conversion rate goes up almost threefold to 72 times.

Since global warming is a long-term issue, using a time frame of 100 years might seem sensible. But there are a number of reasons why this might not be the case for methane emissions. The first is that we are rapidly using up our budget of emissions in order to prevent more than two degrees of warming. Preventing two degrees of warming is important, because climate science is telling us that important tipping points are likely to be triggered if the globe warms more than two degrees. Tipping points cause feedback effects that in turn cause more warming, which once begun cannot be stopped. Once we pass two degrees of warming we may be unable to stop a further three or four degrees from occurring, even if we dramatically reduce our emissions.

Tipping points mean that preventing warming in the short term is very important, particularly as countries are slow to act. Countries have a greater capacity to change their behaviour in the longer term than in the short term. Because of the way we measure GWP, the larger short-term warming effect created by an increase in methane emissions may not have been properly considered.

The other major problem with using a GWP for methane over 100 years is that gas is being held up as a transition fuel to be used over a shorter period of time while we transfer to zero

[14] International Energy Agency (2012)

emission forms of energy. If gas is expected to be a transition fuel, then we expect to use it in the short to medium term, and not over a 100 year period. This also means that we expect to ramp up our use of gas, which will exacerbate the short-term effects of the fugitive methane emissions.

## Policy implications of an incorrect emissions factor

If the emissions factor for calculating fugitive emissions from CSG is underestimated, then there are a number of policy implications. The first is that there will be less incentive for CSG producers to reduce their fugitive emissions. A reduction in fugitive emissions will bring no financial reward to the producer, since the emissions figure calculated using the method 1 factor is already an underestimate.

The second policy implication is that less revenue will be collected from the scheme, since for gas producers, estimated emissions using the method 1 factor will be less than their actual emissions. This will come as a cost to other parts of the economy. Under a carbon price cap the emission reductions will still occur, but instead of gas producers reducing their fugitive emissions, the reduction will have to occur in another part of the economy at a potentially higher cost.

The final implication of underestimating emissions is that the environment will be forced to absorb more greenhouse gas than we would otherwise expect if emissions had been correctly estimated. This is particularly important if it changes the mix of greenhouse gases that is being released. If CSG replaces coal in electricity production, then methane will be replacing carbon dioxide; this will have important temporal effects. It may have the effect of bringing forward warming at a time when we are approaching major tipping points.

## The solution

The problem we have been discussing arises because of a lack of information on the amount of fugitive emissions that are occurring when CSG is produced. The solution is to undertake better measurement of fugitive emissions, particularly at the CSG wellhead. With better information from more accurate measurement, we can more accurately calculate fugitive emissions and therefore better measure the impact that CSG extraction is having on Australia’s greenhouse gas emissions.

Before we jump into the golden age of gas as a way of combating climate change, it is essential that we have a good understanding of the effect that switching from coal to gas will have on our emissions. We cannot do this until we can measure the fugitive emissions that occur in the CSG extraction process.

The government has set aside $200 million from the Minerals Resource Rent Tax for scientific research on the effects of CSG extraction. Accurate measurement of CSG fugitive emissions would seem like a good use of these funds.

Before the government approves more CSG production, we need to better understand the amount of fugitive emissions and the real carbon price of production. We need to be sure that we are actually reducing our emissions by switching from coal to coal seam gas. We need to make sure that we are not jumping from the frying pan into the fire.

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