Shale gas: will it undermine progress on tackling climate change?

Martin Quick critically examines the rapidly expanding shale gas industry, in particular its claimed role in helping to reduce carbon emissions.

The discovery of huge global reserves of shale gas has been hailed by many as a solution to energy security problems. Some also see it as a significant part of a strategy to mitigate climate change by substituting low-carbon gas for high-carbon coal, especially if it can used in conjunction with Carbon Capture and Storage (CCS) technologies to deposit the carbon emissions underground.

However, shale gas has its downsides, not least the significant levels of methane leakage that occur during extraction. This could critically undermine the claim that it is a low-carbon fuel.

Shale gas and climate change

Shale gas (comprising mainly methane, CH_4) is extracted from shale rock formations by hydraulic fracturing ('fracking'), using large quantities of water and various chemicals (many of them toxic) injected into the rock under high pressure. While the problem of local water pollution has received a lot of attention, in this article the focus is on methane leakage into the atmosphere. The nature of the extraction process means that it is difficult to prevent such leakage, so there could be serious implications for climate change.

Methane has a global warming potential (GWP) of about 25 times that of CO_2, assessed on the basis of the cumulative effect on the climate system over a 100-year timeframe.[1] CO_2 stays in the atmosphere throughout this timescale, but methane has a much shorter 'life' – thus its warming effect is much greater in the short term than that of CO_2.

Methane also leaks from conventional gas and coal extraction and there is considerable uncertainly associated with estimates of all methane leakages. Robert Howarth and colleagues at Cornell University[2] have compiled ranges for the percentage of gas leaking into the atmosphere through extraction, transport and distribution. These are 3.6%—7.9% for shale gas and 1.7%— 6% for conventional gas.

Assuming that, in the longer term, best practice measures minimise gas escapes, and taking Howarth's lower values in assessing climate change implications, methane leakage from shale gas production is about twice that from conventional gas. We can use these figures to compare the total greenhouse gas emissions (adjusting for different GWPs) for shale gas, conventional gas and coal.[3] This calculation reveals that the total greenhouse gas emissions of shale gas are about 70% of that of coal, compared with the figure of 50% generally claimed for conventional gas.[4]

The effects of methane leakage are most noticeable on a 20-year time frame, so the warming effect of this leakage will be felt earlier than the effects of CO_2 emissions. Oceans warmed by this front-loaded methane in effect absorb less CO_2 and so result in a positive feedback loop that exacerbates the effects of the CO_2 emissions. The result is an increased time-integrated temperature rise.

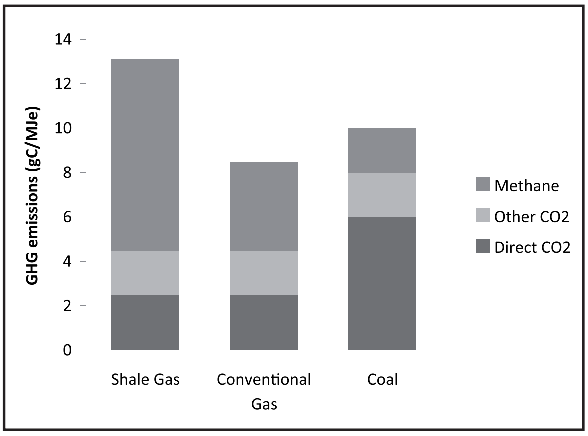

Figure 1: Total (direct and indirect) greenhouse gas emissions per unit of electricity output from power stations burning shale gas, conventional gas and coal, all incorporating CCS.

Shale gas and CCS

Deploying CCS at the point of combustion is often presented as a major component of an energy portfolio that includes fossil fuels yet enables suppliers to deliver large greenhouse gas emission reductions. So far, the main emphasis has been on CCS for coal combustion, but gas-fired plants incorporating CCS are also now being considered, including one in the UK. Although many of the individual components and systems have been tested, no large-scale experience of CCS in practice yet exists.

In any case, significant methane leakage in the extraction and transport of the fuel before it reaches the power station or plant will significantly reduce the effectiveness of CCS in minimising greenhouse gas emissions. Assuming CCS captures 90% of the CO_2 emissions from the plant, and accounting for emissions from leaks before that point, the total greenhouse gas emissions from shale gas electricity generation with CCS would be about three times greater than from the CO_2 emissions alone and around 30% greater than for coal,[5] even allowing for the greater efficiency (approximately 20% lower heat input) of gas-fired power stations. For conventional gas, the equivalent calculation gives total emissions slightly less than those from coal generation with CCS. These are shown in Figure 1.

Implications for future energy policy

The indications are that huge quantities of shale gas could be available globally. However, analysis suggests that methane leakage from shale gas between extraction and combustion is significant enough almost to negate the claimed advantages of shale gas using CCS and could even make the climate change impact of shale gas comparable with that of coal.

The oil and gas industry is currently lobbying heavily to greatly expand the exploitation of shale gas in many places around the world, including the UK. While using relatively small amounts of gas could assist in (for example) improving energy security, major reliance on shale gas would be counterproductive, especially as it could squeeze out further development of renewable energy technologies.

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References

1. Intergovernmental Panel on Climate Change (2007). Climate Change 2007: The Physical Science Basis. Fourth Assessment Report (Working Group I). http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
2. Howarth R, Santoro R, Ingraffea A (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. Climatic Change, vol. 106 (4), pp.679-690.
3. Ideally we would take account of the energy used in gas transport operations, but for simplicity we assume a relatively local gas source. For coal, an average of the emissions values for deep and surface mined coal is taken.
4. Derived using figures from Howarth et al (2011) – see note 2.
5. As note 4.