GAS

A matter of urgency

Dr Paul Balcombe, Research Associate, Sustainable Gas Institute (SGI), looks at the impact of methane and carbon dioxide emissions from the natural gas supply chain.

The outcome of the United Nations Paris Climate Conference (COP21) in December was heralded a success by many, due to the reaffirmation of the goal to limit global temperature rises to 2°C above pre-industrial levels or, if possible, to 1.5°C (see p22). Given that we have already reached an increase of 1°C, the bar has been set extremely high and there is no doubt that a rapid change in energy systems is required in order to achieve such a target.

The role of fossil fuels will decline as we progress towards a net-zero carbon energy system. However, natural gas in particular may still serve two key purposes – as a replacement for coal electricity generation in the short term; and in providing a flexible complement to intermittent renewables as electricity from renewable generation increases.

So, what is the future role of natural gas in a lower carbon energy world? Natural gas is less carbon intensive than coal by approximately half and a global marketplace is forming as worldwide gas consumption has risen steadily over the last decade. The development of unconventional gas resources is spurring further interest, with the potential to contribute to lower energy system cost and increased energy system security.

Yet there is still much debate regarding the contribution that natural gas could or should make to meeting global climate change mitigation ambitions. Whilst natural gas may represent an improvement from coal for electricity generation, carbon dioxide (CO_2) emissions still may not be low enough to keep emissions within a demanding global carbon budget. Additionally, methane is a potent greenhouse gas (GHG) and it is unclear how much is released to the atmosphere through the gas supply chain. If methane emissions were high enough, any benefits associated with reduced end-use carbon intensity could be negated.

A number of recent studies have estimated methane emissions from the natural gas supply chain, resulting in a wide variation in conclusions, with some even suggesting that GHG from natural gas power generation may be worse than from coal. The areas of particular contention include the magnitude of methane emissions, the global warming potential of methane compared to CO_2 and also the estimation methods and assumptions used to define emissions. This has created a great degree of confusion, which a recent study from researchers at the Sustainable Gas Institute (SGI) at Imperial College has sought to clarify.

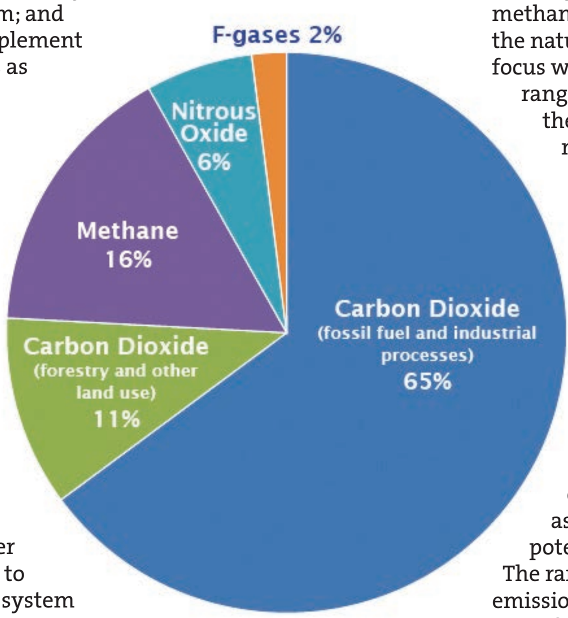

Figure 1: Global greenhouse gas emissions by gas
Source: IPCC, 2014

Seeking clarification

In September 2015, the SGI published a comprehensive review of a large body of studies on the methane and CO_2 emissions from the natural gas supply chain.* The focus was on determining the full range of emission estimates, the areas of uncertainty, methodological differences and any gaps in the evidence where further work is needed.

Overall, the range of estimated GHG emissions is vast, across a variety of supply chain routes, processes and regions – between 2 and 42g CO_2 eq/MJ HHV (higher heating value) of natural gas delivered to the end user, assuming a global warming potential of 34 for methane.**

The range of methane-only emission estimates is from 0.2% to 10% of the total produced methane. These values represent a wide range of extraction, processing and transport routes, reservoir conditions, regional regulation and estimation methodologies.

The key emission sources identified within the literature are from well completions and liquids unloading processes, as well as from pneumatic devices and compressors which are used all across the supply chain. During the well completion stage for unconventional wells, the hydraulic fracturing fluid returns to the surface whilst the gas flow increases to the high initial production rate.

Whilst some emissions estimates for this particular process are extremely high, data collected in recent years has shown that the use of reduced emission completions (RECs) capturing equipment can significantly reduce methane emissions to below 25,000 m^3/ completion. This is reasonably low and equivalent to around 0.3 g CO_2 eq/ MJ HHV depending on total well production. In the US, this equipment is now compulsory, indicating that this is no longer a significant source of emissions. This is an important finding as this process is the main differentiator between unconventional and conventional extraction, which means emissions are similar as long as methane is captured rather than flared.

Extremely variable emissions rates are also seen during the liquids unloading stage. As a well matures, liquids may accumulate at the bottom of the well. These must be removed in order to prevent 'choking' the gas flow. Emissions are so variable that whilst this may represent the greatest emission source for some wells, most wells do not vent at all during unloading.

Across the literature, the current understanding of the distribution of emissions across the global well population is extremely poor and further research is required to detail and quantify the factors affecting unloading emissions such as well age, reservoir properties, equipment used and operational strategies.

The study also found evidence of super emitters all across the gas supply chain. These are a small number of facilities or specific equipment that produce disproportionately high emissions. These large emissions are likely to occur due to the use of ineffective process equipment and poor operational and maintenance strategies. The review provides evidence to show that if best available techniques and more stringent maintenance and operation procedures are applied, these high emissions could largely be eliminated.

Methane versus carbon dioxide

One of the major variations in estimation methods is from the assumption about the warming potential of methane. The issue is that whilst methane is around 120 times more potent than CO_2, methane only lasts in the atmosphere for an average of 12 years, whereas CO_2 lasts for thousands of years. The vast majority of studies use a Global Warming Potential (GWP) value to say that methane is X times more potent than CO_2 as a greenhouse gas. However, this number varies depending on the timeframe considered. To make matters even more complicated, this value has changed over time as our understanding of direct and indirect climate warming has improved. Consequently, a large range of warming potential values are used across the literature, normally from 21 to 86 (g CO_2 eq). Unfortunately, there is no single correct value to use and some suggest a range of values or that even a different metric altogether would be more appropriate.

A number of other methodological differences also cause a big variation in estimates, such as top-down versus bottom-up measurements; the assumed total production volume of a well; the allocation of emissions to other co-products such as natural gas liquids; different boundary limits across different life cycle studies; and the assumed methane content of the extracted natural gas.

Future research

Determining how much supply chain emissions could feasibly be further reduced should be the subject of research, to understand the full potential for natural gas to contribute to a lower carbon energy mix. In particular, there is great potential to reduce fugitive emissions during extraction, transmission and distribution stages. A greater causal analysis of the factors affecting emissions is also needed to understand the mitigation potential at each stage. These factors include the selection of equipment, operational practices, the regulatory environment and reservoir properties. The use of emissions-minimising technology and operation may be limited by economic feasibility, whilst geological characteristics and regulation may also limit emissions minimisation. The impact of regional regulation on the emissions associated with the supply chain may also be large, in particular with respect to continuous monitoring and 'super-emitting' facilities. Targeting such facilities could yield the greatest environmental improvements and improve the contribution of natural gas towards a low carbon energy system.

Whilst there has been a recent drive to collect primary emissions data, there remains an incomplete and unrepresentative data set for a number of key emission sources. A lot more data is required in particular for regions other than North America, for offshore facilities and transmission and distribution pipelines.

Role for gas

Although some natural gas emissions are large, there will most likely be a significant role for gas in energy systems for the foreseeable future. In light of the strong COP21 climate targets, nations are searching for 'easy win' emissions reductions. Natural gas could represent this as a replacement for coal power generation. Even with the supply chain emissions described above, natural gas offers an improvement with respect to CO_2 emissions compared to coal.

The only way to stabilise the climate (no matter what temperature target is set) is to reduce net CO_2 emissions to almost zero. If we reduce methane emissions along the way, the peak temperature that we reach will be significantly reduced, minimising the dangerous effects of climate change.

The US is currently ahead of the curve on reducing methane emissions, with the Greenhouse Gas Reporting Program and the new updates to the New Source Performance Standards, with the aim of reducing methane emissions by 40% by 2025. It is now essential that other countries follow suit so supply chain methane emissions are understood and minimised, so that we do not replace one problem with another. ●

The full paper and a summary note on the paper's findings can be downloaded from* **www.sustainablegasinstitute.org

**The global warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval, usually 20, 100 or 500 years. GWP is expressed as a factor of carbon dioxide (whose GWP is standardised to 1). In the *Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, methane has a warming potential of 86 over 20 years and 34 over 100 years in response to emissions.