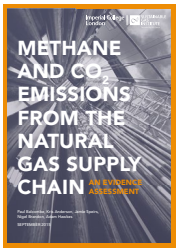
Imperial College London | SUSTAINABLE GAS INSTITUTE
Founded by BG Group

WHITE PAPER 1

Understanding methane and carbon dioxide emissions from the natural gas supply chain

24th September 2015



The words in **bold font** can be found in the glossary over the page.

BACKGROUND

When you compare natural gas to other fossil fuels such as coal, its combustion generates approximately half as much carbon dioxide (CO_2) emissions. However, natural gas is also mainly composed of methane, which is itself a strong greenhouse gas, and is emitted at different stages along the **natural gas supply chain**. While methane dissipates from the atmosphere more quickly than CO_2, it is considered to have a higher **global warming potential** and therefore a more potent short-term effect on climate change than carbon dioxide.

The big question is: do these methane emissions along the supply chain undermine natural gas's lower carbon credentials?

Over the last five years, a large number of studies have estimated how much methane is emitted through the whole natural gas supply chain from exploring, extracting, producing, processing and transporting natural gas. These studies have used a variety of methods to understand the issue, but so far have differed significantly in their findings.

EXPLORING THE ISSUE

The Sustainable Gas Institute (SGI) have undertaken a comprehensive review of all the available global data on both CO_2 and methane emissions from the natural gas supply chain to fully understand the scale of the issue. This briefing note summarises the main findings and recommendations of the Institute's first White Paper. By systematically assessing the literature in terms of transparency, relevance and accuracy, the paper assembles and analyses the current state of our knowledge on emissions globally.

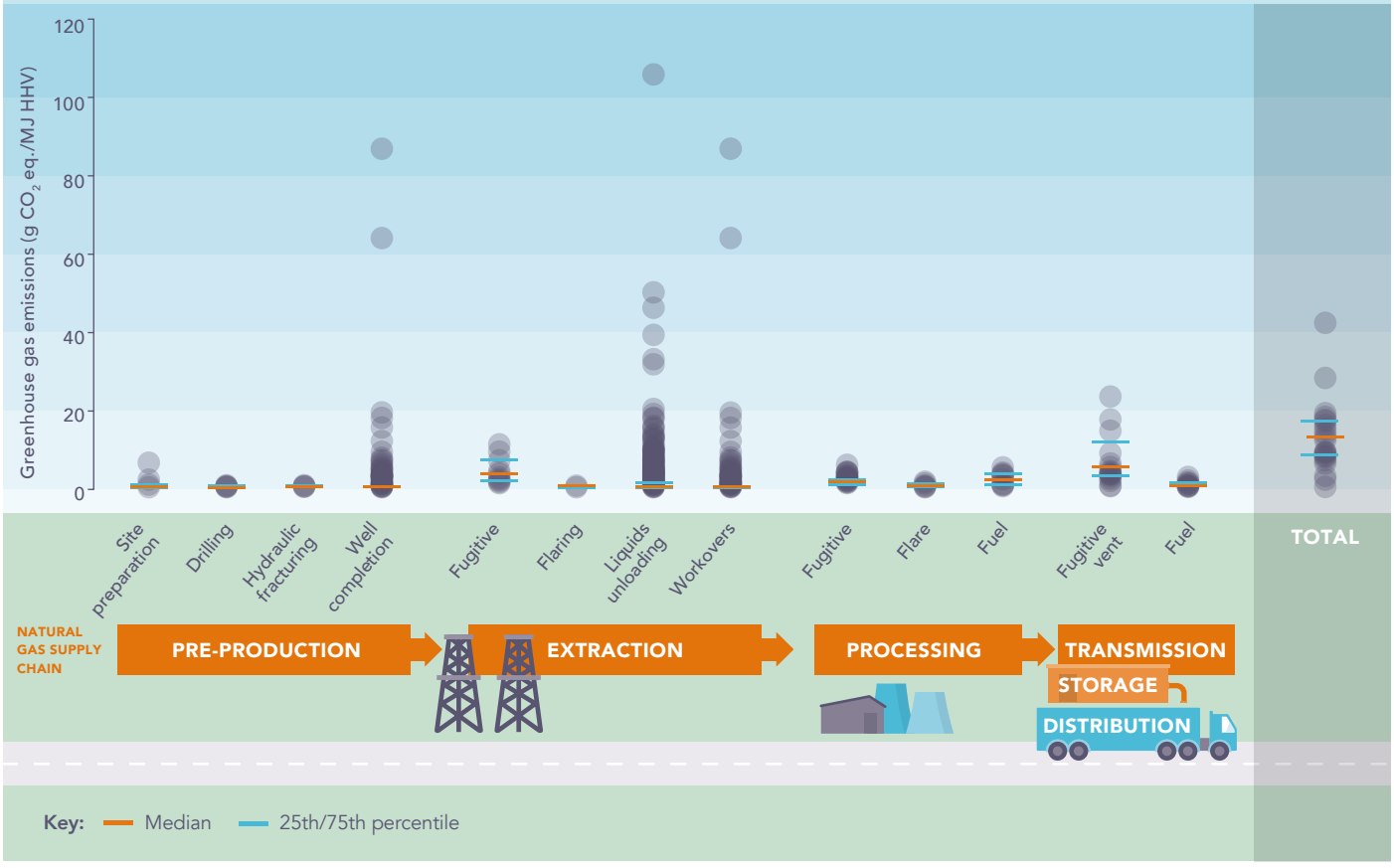
Key Questions

- How much methane and CO_2 emissions is released from the natural gas supply chain?
- What methods are being used to estimate these emissions?
- What factors affect emission ranges?
- Why do we see such a big range?

This review analysed over 250 studies and reports. These studies covered natural gas from both conventional wells and **unconventional** wells at every stage in the supply chain, as well as examining the **liquefied natural gas (LNG) process**.

FIGURE 1: Greenhouse gas emission estimates from the natural gas supply chain

Each grey circle indicates an estimate of total supply chain emissions from an individual study. The aggregated estimates from the literature have been shown with horizontal bars: median (orange) and 25th and 75th percentile values (blue).



KEY FINDINGS:

1 The range of estimated emissions across the supply chain is vast.

- Combined methane and CO_2 emissions from the supply chain are between 14 and 302 **gCO_2 eq/kWh**.
- A small number of studies estimate exceptionally high emissions from specific supply chain stages or facilities. However, the average estimates lie towards the lower end (see Figure 1).
- Methane emissions are estimated to be between 0.2% and 10% of total produced methane.

2 Key emissions sources are during well completions, liquids unloading, and the use of pneumatic devices and compressors.

- Studies show that the use of **Reduced Emission Completions (RECs)** equipment can significantly reduce methane emissions by over 75%. This technique is now compulsory in the United States.
- Emissions from both **unconventional** and conventional wells are comparable as long as methane is captured rather than flared during well completion.
- Gas venting and leakage from compressors and pneumatic devices across the supply chain contribute significantly to emissions.
- More research is needed to quantify the factors affecting the emissions from the liquids unloading process.

3 There is evidence of 'super emitter' facilities all along the supply chain.

- A small number of high-emitting facilities strongly impact the emissions profile at every stage in the production process.
- These may be a result of the use of ineffective process equipment and poor operational and maintenance strategies, and could be eliminated and reduced if the best available techniques were applied.

4 Some of the emissions estimates are considerable, but there is potential to reduce these emissions.

- If modern equipment with appropriate operation and maintenance regimes were to be used, the total supply chain emissions should lie within the range of 19–212 gCO_2 eq/kWh with a central estimate of 92 gCO_2 eq/kWh. If the natural gas was used in a power plant, these supply chain emissions would contribute between 4%–35% of the total greenhouse gas emissions per kWh of electricity generation.
- Methane emissions are expected to be 0.3%–2.4% of total produced methane, with a central estimate of 1.4%.
- Further reductions could be made, particularly for emissions from transport, storage and distribution, and also at the point when gas is extracted.

5 A wide variety of techniques are used to monitor emissions which means supply chain emissions estimates vary greatly in the literature.

- Many studies apply a top-down approach to measuring methane emissions which involves measuring or inferring the concentration of methane in the atmosphere within a region, and then attributing emissions to specific sources within that region. A more thorough approach would involve a bottom-up point measurement at specific places on the ground in combination with local leak detection.
- Methodological assumptions vary significantly across the literature and have a major effect on the estimated emissions (e.g. total production volume of a well and the assumed methane content of the extracted natural gas).

6 There is a significant lack of data, particularly for regions other than the US.

- More data is required globally for offshore extraction, coal bed methane extraction, liquids unloading, well completions with RECs, transmission and distribution pipelines, and methane emission measurement from all LNG stages.

7 Further research is needed to determine the potential role of natural gas in a low carbon energy mix.

- Research exploring the technological, operational or regulatory mechanisms is required to achieve emission reductions.
- Further studies are also necessary to quantify the potential reduction in supply chain emissions and to examine factors affecting different supply chain emissions in order to understand the mitigation potential at each stage and also to look at the impact of regional regulation (e.g. regulation for continuous monitoring of 'super-emitting' facilities).

GLOSSARY

Unconventional wells – This term refers to the methods that are used to extract natural gas, as well as the types of rock from which the oil and natural gas are produced. This may include shale rock.

Natural gas supply chain – The equipment and processes which bring natural gas from the field into power plants and homes.

Liquefied natural gas (LNG) – To move natural gas long distances, it must be cooled and converted into a liquid form, a process called liquefaction.

Well completion – This is the final process prior to production. For unconventional wells (e.g. shale gas extraction), this is where fluid flows to the surface, carrying gas.

Liquids unloading – This is a process to remove liquids that have collected at the bottom of a gas well.

Reduced Emission Completions (RECs) – This equipment captures natural gas before it escapes into the environment.

Global Warming Potential (GWP) – Is a measure created by the Environmental Protection Agency (EPA). It 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.

UNITS

gCO_2 eq/kWh units are grams of carbon dioxide equivalent per kilowatt hour of electricity generated. This unit is used to quantify greenhouse gas (GHG) emissions and global warming potential. GHGs other than CO_2, such as methane, are quantified as equivalent amounts of carbon dioxide. This is done by calculating their global warming potential relative to carbon dioxide over a particular period of time, usually 100 years.

For further information on this subject please contact the lead author at **SGI@imperial.ac.uk**

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The Sustainable Gas Institute at Imperial College London aims to explore the role of natural gas in the world energy mix.

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