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A climate change conundrum: Is there a sweet spot for natural gas in the energy transition?

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Highlights

- When burned, natural gas derived from methane emits far less CO_2 than coal. However, if released directly into the atmosphere, it has a far higher warming potential
- The concentration of methane in the atmosphere is higher now than at any time in at least 800,000 years, and this is due to human activity
- Leakage of methane from oil and gas infrastructure has dented the green credentials of natural gas, but those emissions are very often preventable
- We believe regulators should push for stricter policies, pushing oil and gas companies to adopt best practice in operations
- If inadvertent emissions can be brought under control, then we think methane can have a role in the energy transition, especially as an alternative to coal
- Care must be taken to ensure this does not slow the adoption and deployment of renewable energy to reduce absolute greenhouse gas emissions

The world has arrived at a scientific and political consensus. Climate change is being driven by human activity and we have the means and responsibility to create an energy transition that reduces our impact. Calls to reduce greenhouse gas emissions have become louder and more urgent, especially as we approach the crucial COP26 climate conference in Glasgow this November. Natural gas offers an intriguing dilemma at the heart of that debate. It may be a fossil fuel, but it is much cleaner than coal or crude oil. It also represents a potential 'climate bomb' if it leaks directly into the atmosphere. This paper attempts to disentangle the threads of this discussion, present the facts and reach a few conclusions.

For investors, this is an important consideration in the decarbonisation of portfolios. There is a delicate balancing act at play assessing of the role of natural gas in the energy transition and in the handling of methane/natural gas emissions. It demands a careful consideration of related corporate strategy, particularly in the oil and gas sector.

Methane is a simple molecule, one atom of carbon with four atoms of hydrogen attached (CH_4). It is the principal component of natural gas and is derived from the decomposition of organic matter. As a fossil fuel, it is the cleanest of them all. Burning methane generates 45% to 50% less carbon dioxide (CO_2) emissions than burning coal. This is why natural gas is often presented as a transition or bridge fuel as it can help decarbonise power generation and heat production by replacing coal before a fuller deployment of renewable energies. In the future, emissions from facilities burning natural gas could be captured and stored underground, further lowering the carbon footprint.

Methane, however, has an increasingly difficult reputation. Many non-governmental organisations (NGOs) highlight the environmental damage from natural gas, while cities in the US have begun to block new buildings from installing natural gas systems. As the European Union (EU) decided on a shared green taxonomy, the natural gas question became so heated that any definitive line on the issue was kicked down the road. This reputation stems from methane's very high global warming potential (GWP) as a greenhouse gas (GHG).

What makes a molecule warm the atmosphere?

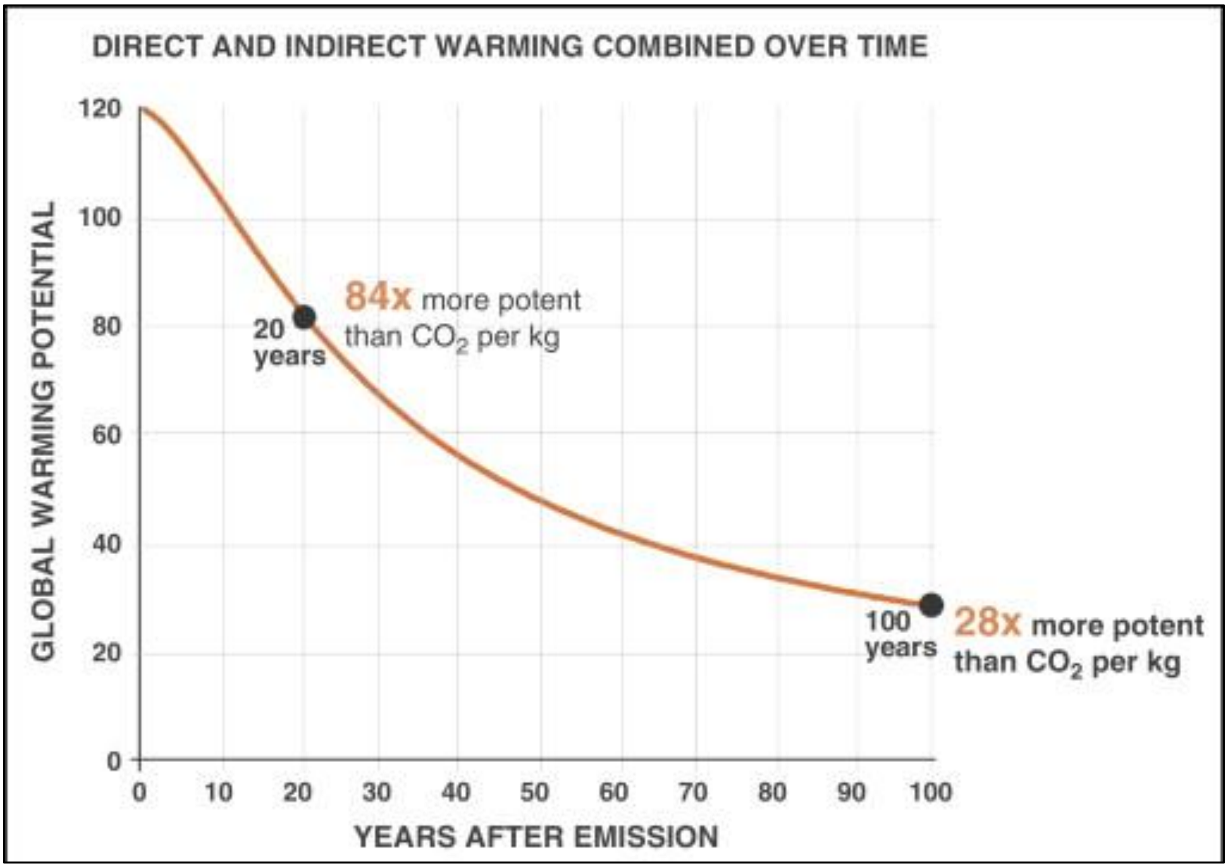
It's all about chemistry and physics. Sunlight reaches the surface of the Earth and some of it is radiated back as infrared waves, or heat. Molecules with two or three different atoms, such as CO_2 or CH_4, vibrate on a wavelength that intercepts a large part of this infrared energy, thereby stopping the escape of heat and warming the atmosphere. Oxygen and nitrogen – which make up 99% of the atmosphere – do not intercept infrared waves, but even a small relative volume of GHGs in this mix is enough to tip the balance towards excessive warming. By the same logic, CO_2 and CH_4 do not intercept the sunlight on its way in because visible light does not fall in the same wavelength range.

Click here for a short animation that explains this further.

Methane and climate change

Methane is a potent GHG. Compared to CO_2, it has a much shorter average life in the atmosphere (12 years compared to centuries for CO_2) as it is rapidly oxidised and turned into CO_2. After 20 years, 80% of the methane is gone. However, the CH_4 molecule is able to absorb more infrared waves, hence its warming potential is significantly higher.

This combination of a short life and high warming potential complicates investors' assessment of methane's role in the energy transition. Two ratios are widely used to compare CO_2 and CH_4, with different time horizons: x28 on a 100-year horizon and x84 on a 20-year horizon, often presented respectively as GWP100 and GWP20[1]. In other words, on a 100-year horizon, a molecule of CH_4 is equivalent to 28 molecules of CO_2 equivalent (CO_2e). As such, although methane accounts for 16% of GHG emissions, it accounts for 23% of the global warming produced by those GHGs.



Source: Methane emissions from natural gas production and use, Current Opinion in Chemical Engineering, 2014

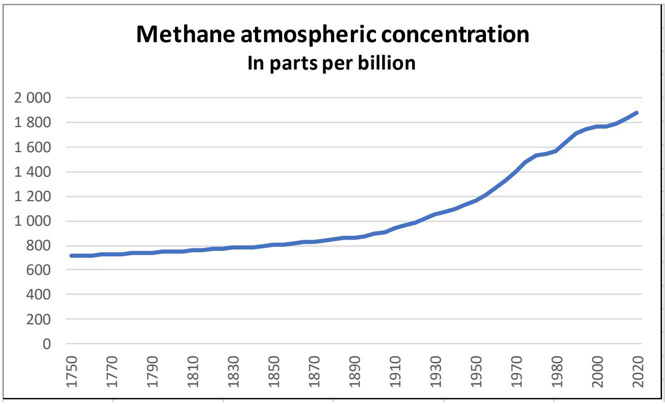
[1] Climate Change 2014. Synthesis Report, IPCC

The Paris Agreement goal is to limit the global rise in temperature to below 2°C and possibly as little as 1.5°C above pre-industrial times by 2050. On that basis, there is an argument that the higher ratio should be used to assess methane's impact as the time horizons are similar, but the controversy still rages (see here, here or here). This is not some academic, ivory-tower debate. Methodological decisions like this can have a powerful influence on the regulatory and political landscape.

It should also be noted that there is another debate on the merits and weaknesses of GWP as a measurement tool, and several alternatives have been proposed.

The origins of methane in the atmosphere

Methane concentration in the atmosphere has doubled since the early 20th century and, according to a recent IPCC report, is higher than at any time in at least 800,000 years.



Source: European Environment Agency, National Oceanic & Atmospheric Administration

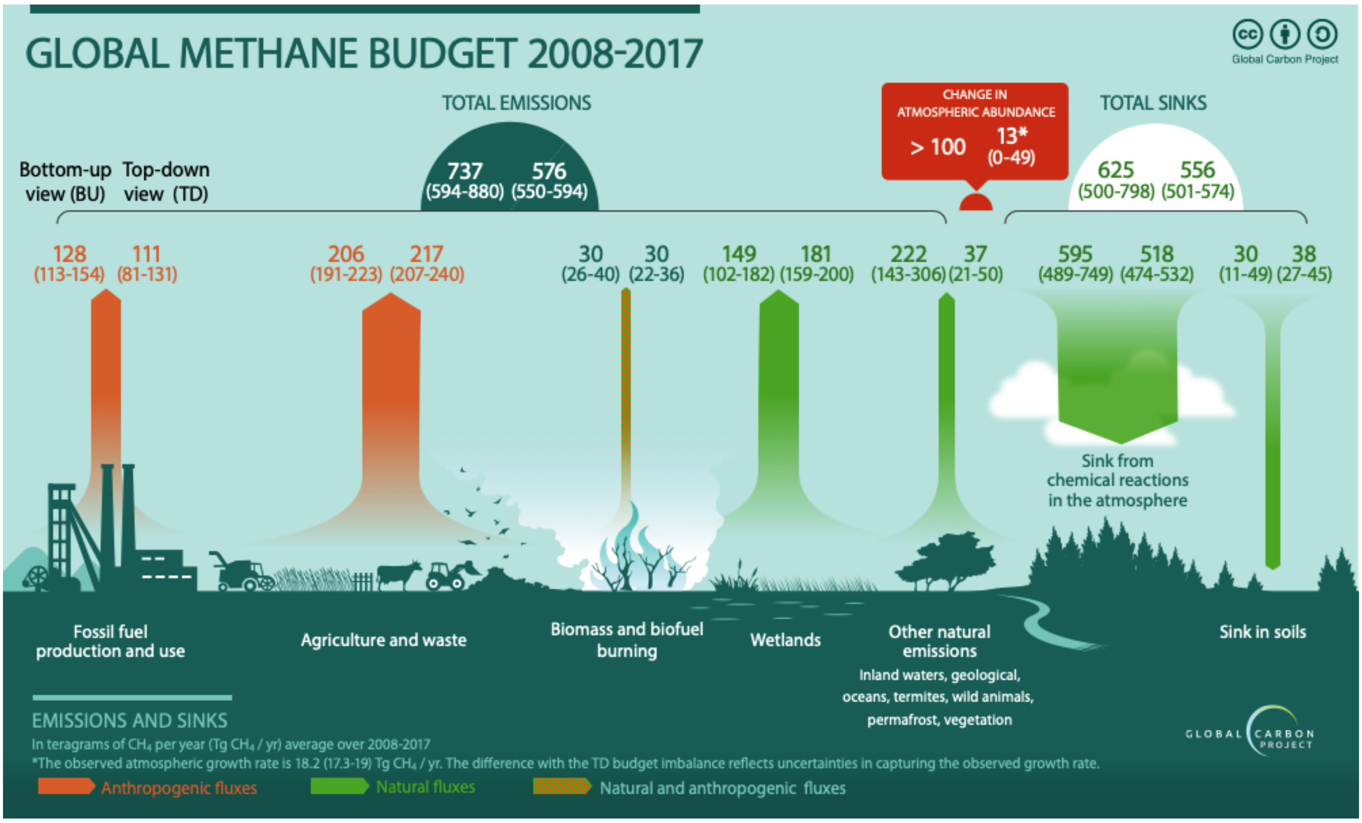
Anthropogenic emissions 2008-17 - Bottom up measures - MT per year	
Agriculture	**141**
Livestock	111
Rice cultivation	30
Fossil fuel	**128**
Coal	42
Oil & Gas	80
Waste Management	**65**
Biomass & biofuel burning	**30**

Source: The Global Methane Budget 2000-17, 2020

Measuring methane concentration is simple enough, but assessing its origin is more challenging. There are many sources of methane and several methods to allocate emissions to natural sources or human activities – broadly, bottom-up process-based measures, and top-down atmospheric inversion models. There are discrepancies between those two methods, and a sizeable uncertainty range.

Overall, it is estimated that 40% of methane emissions come from natural sources – mostly through organic matter fermentation in wetlands – and 60% from anthropogenic sources, i.e. human activities. For the latter, agriculture is the largest component due to livestock (enteric fermentation and manure) and rice cultivation, followed by fossil fuels and waste. It has also been shown that agriculture and fossil fuels are equally responsible for the rise in anthropogenic methane emissions.

US space agency NASA has published a very instructive visualisation showing the emission and flow of atmospheric methane. The graphic below from the Global Carbon Project describes the balance between methane emissions and methane sinks over 2008-2017.



Source: The Global Methane Budget 2000-17, 2020

Methane in the oil and gas industry

Natural gas accounts for 25% of the world's primary energy consumption. It has been the fastest growing fossil fuel over the past two decades, driven by its labelling as a relatively 'clean' alternative. This is undeniable at the combustion phase. However, on a life-cycle analysis, the picture is murkier as a not-insignificant share of production is lost between the well and the point of consumption. Given the GWP of unburned methane, this is impactful. The challenge, therefore, is to properly understand the nature of those methane emissions. In the vernacular of the oil and gas industry, it is about measuring venting, leakage, and fugitive emissions.

This is no simple task. There are millions of active and inactive wells, thousands of processing plants and hundreds of thousands of kilometres of pipelines. The potential sources of emissions are too numerous to be monitored individually. Ground-based studies are regularly carried out and, more recently, observations from satellites have complemented them. Methodological debates continue among scholars and experts. Some countries are less transparent on the state of their energy infrastructure; others, such as the US, are closely scrutinised. Overall, a wide range of estimates for emissions intensity can be found.

Looking at the US, the Environmental Protection Agency (EPA) estimates in its inventory of US GHG emissions that the methane leak rate is 1.4%. Scientists from the US National Energy Technology Laboratory in a 2017 report arrived at 1.7%. An article published in Science in 2018 reached a 2.3% rate.

On a global basis, the International Energy Agency (IEA) monitors methane emissions from the oil and gas industry. In its detailed and most recent analysis, it estimates that 72 million tonnes of methane are lost, or 1.7% of global gas production. That breaks down as 64% through venting (deliberate discharge, often for safety reasons) and 32% from leaks, with the balance from incomplete flaring – where gases are burned for discharge.

However, other studies have concluded that emissions are much higher than those levels. A satellite-based review of the US Permian basin – the largest oil producing region and the second largest natural gas region in the US – concluded that emissions represented 3.7% of gross gas production, in addition to 4.6% of the gas being flared. Another study, focusing on US natural gas distribution pipelines concluded than the emission rate was five times greater than the estimates made by the EPA. In addition, abandoned and shut-in wells often continue to emit methane and this is usually not reported. Finally, it does appear that many leaks or large venting events are not reported at the time and sometimes never disclosed. There is evidence of this from Russia, the world's second largest natural gas producer.

Many of the studies in this area are largely US focused, and they highlight the clear need for more transparency, a more global view, and greater monitoring – while still revealing the complexity of the analysis required.

One striking fact is that there is a huge discrepancy between the numbers reported by companies and official agencies and those measured by outside parties such as universities or NGOs.

Our tentative conclusion would be that real emissions are indeed higher than the sub-2% level. The emergence and rapid development of the shale industry in the US, where large methane emissions have been demonstrated, is one explanation. The use of methodologies with outdated assumptions is another. Poorly monitored large emissions events, caused by malfunctions or faulty equipment, are also likely to be inadequately reflected in overall methane emissions estimates.

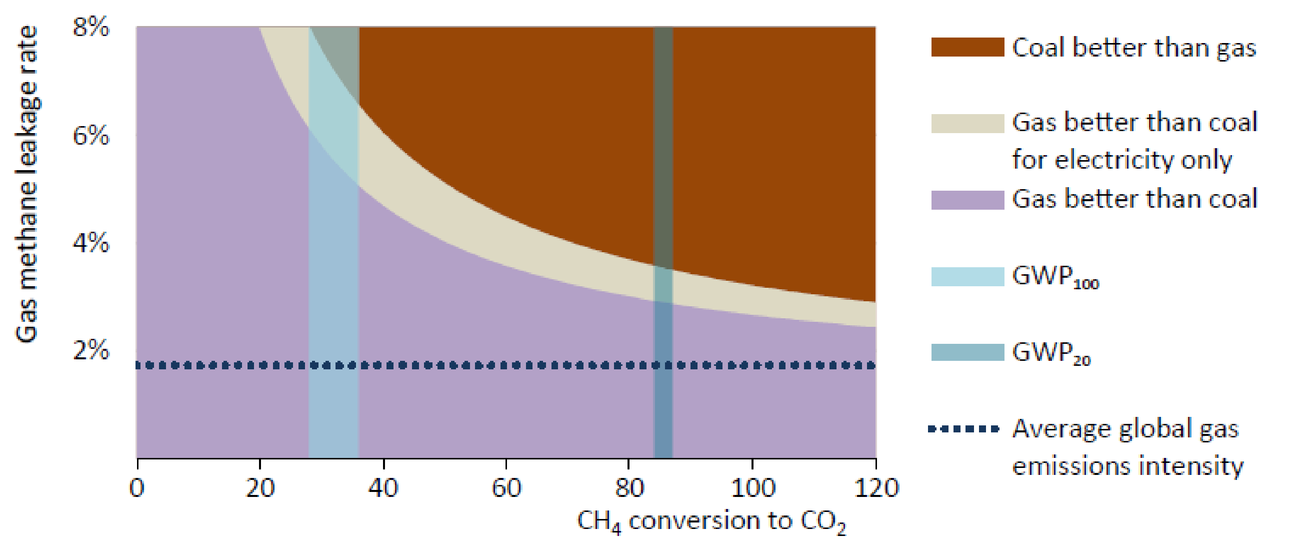
Another conclusion is that there is not one number for emissions, but many. A proper analysis ought to be made, production basin by production basin, with local or regional data points integrated into specific value chain analyses.

Striking a balance

What this amounts to is an acknowledgment that the benefits of natural gas as a cleaner fossil fuel depend on how much methane ends up in the atmosphere before it is used. If too much methane is lost, the advantage that natural gas holds against coal at the combustion phase can be eroded away. In certain scenarios it could even be deemed "dirtier" than coal. This plainly illustrates the difficulty for investors in assessing the carbon profile of portfolios exposed to natural gas, now and in the future. Our central view is that companies with the most effective pathways to reduce emissions over time could outperform, and so this debate over the role for natural gas offers an intriguing dilemma for investors and their portfolio managers.

Two key variables make or break the case for natural gas as a substitute: The leakage rate and the GWP. The IEA, in its World Energy Outlook 2017, published a chart illustrating this situation.

Greenhouse-gas emission intensity of natural gas compared with coal



Source: IEA, World Energy Outlook 2017

The key variable is the time horizon: The shorter it is, the higher the conversion ratio of CH_4 to CO_2:

- If GWP20 is used as the benchmark level, then a methane leak rate around 3.5%-4% makes natural gas as GHG intensive as coal. Several studies claim that this is the real level of methane emissions.
- If GWP100 is used, then the implied methane leak rate to make natural gas "dirty" is above all levels measured or estimated.

The IEA – using its own 1.7% number – concludes that "gas on average generates far fewer greenhouse-gas emissions than coal when generating heat or electricity, regardless of the timeframe or GWP in question". Clearly, this is a point of debate and several NGOs and academics challenge this conclusion, both on the leakage rate and the choice of GWP.

This again highlights the need for better data and the importance of methodological elements, most notably the time horizon selected for the analysis. And here as well, a regional analysis is necessary.

However, what really matters is that most of those emissions are preventable. They are largely linked to operational practices and can therefore be changed if management decides to act or if regulation requires it. Many examples show that it can be done quickly if there is a will, as illustrated by data shown below from EOG Resources, one of the largest US shale producers[2]. To achieve this 83% decline in methane emissions, EOG upgraded its equipment (most notably pneumatic controllers), systematically installed natural gas gathering pipelines to collect the gas and implemented a widespread leak detection and repair programme.

[2] This reference is included for illustrative purposes only and does not represent an investment recommendation.

EOG - Emissions of CH_4 equivalent per barrel of oil equivalent produced

2016	2017	2018	2019	2020
4.7	4.0	2.2	1.2	0.8

Source: IEA, World Energy Outlook 2017

The IEA has established a methane abatement cost curve showing that most technologies to prevent venting and leaks are well established and most often make economic sense. By and large, better planning, better equipment and better monitoring are the critical elements to reduce methane emissions. Natural gas associated with crude oil production must be incorporated into infrastructure planning to prevent flaring and encourage the use of better equipment to prevent venting. Pure natural gas production must also rely on improved equipment while the midstream part of the value chain must ensure the integrity of its assets. Throughout the process there should be a sustained momentum towards higher standards.

Encouragingly, technology is progressing fast. New satellite-based tools allow better monitoring of facilities and the identification of leaks and unplanned emissions. Digital tools, as in all industries, are very helpful to better manage and monitor facilities.

Regulation is crucial – a fact perhaps best shown when it is lacking. The divergence between Texas and Norway is striking, with stringent Norwegian rules a dramatic contrast to the more permissive approach in the US' largest oil and gas producing state.

Anyone concerned about climate change – investors, journalists, citizens – ought to question companies in the oil and gas value chain about their methane management policy. Likewise, regulators ought to be challenged when rules are too lax. Given the turbo-charged warming impact of the CH_4 molecule, controlling and reducing methane emissions is as urgent as it is doable.

It is not, of course, an excuse for companies and governments to deemphasise the reduction in CO_2 emissions. We should pursue both avenues at the same time. It is also critical to understand the possible CH_4-for-CO_2 trade-off in certain situations, when a reduction in emissions of short-lived methane could be at the cost of higher emissions of long-lived CO_2.

Does natural gas have a role to play in the energy transition? If the industry as a whole cannot or will not clean up its act and reduce fugitive emissions, then the answer is a resounding no.

If it can, then it could be a yes, although still a qualified one. Investors who are pursuing decarbonisation, whether to meet specific goals or as part of a broad commitment to a more sustainable global economy, will need a nuanced appreciation of where and why natural gas might have a role.

In regions where coal is a dominant source of electricity, a well-run natural gas system can help reduce GHG emissions from power generation, and allow time for the successful deployment of renewable electricity. Where coal is already on its way out or only a small part of the energy mix, then an acceleration in the use of renewable energy sources is a much better alternative.

In a nutshell, among the range of fossil fuels, well-managed natural gas should be favoured. However, it remains a fossil fuel and the ultimate goal is to decarbonise the energy ecosystem, hence, to reduce absolute consumption. Wherever and whenever possible, renewable energies should be prioritised and deployed.