Industry Trends Brief

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Unmasking the Hidden Culprit Beyond CO2: Methane

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- **South Korea is a member state to the Global Methane Pledge (GMP) and therefore has committed to lowering methane emissions by 30% by 2030. However, the Korean energy sector has yet to demonstrate how it will address methane emissions - a potent greenhouse gas which significantly contributes to short-term climate change.**
- **Methane is emitted or leaked throughout the entire gas industry value chain; from gas exploration, production to transportation and distribution.**
- **The economic impact of methane leaks from gas upstream and downstream sectors is estimated to be significant. This affects not only corporations but should be addressed as a national energy efficiency issue.**
- **The gas industry can reduce methane emissions by adopting Leak Detection and Repair (LDAR) programs and by joining global reduction initiatives with government policy playing a crucial role.**

° Unmasking the Hidden Culprit Beyond CO_2: Methane

Methane (CH_4) is a potent greenhouse gas that significantly contributes to climate change by rapidly increasing global temperatures in the short term. Its Global Warming Potential (GWP) is approximately 80 times greater than CO_2 over two decades and 28 times greater over a century.[1] According to the Intergovernmental Panel on Climate Change (IPCC), to limit global warming at 1.5 degrees by 2050, we need to reduce methane emissions by more than 30% by 2030, in addition to the reduction in CO_2 emissions.

In 2021, the Republic of Korea (South Korea) joined the Global Methane Pledge (GMP), thereby making a commitment to reduce its methane emissions by 30% by 2030. South Korea's recent National Basic Plans for Carbon Neutrality and Green Growth, however, mainly targets reduction measures in waste, agriculture, and livestock sectors, with a notable absence of measures for the energy sector [1].

The energy sector, according to the International Energy Agency (IEA), presents a promising opportunity for reducing methane emissions, because the cost of mitigation in the energy sector is less compared to agriculture, livestock, and waste sectors. According to the IEA's report, it is technologically

[1] Global Warming Potential (GWP) refers to a simple metric of energy absorption capacity grounded on radiative characteristics for a given period such as GWP100 means GWP over a hundred years. This index is used to estimate the relative impact of varying greenhouse gas emissions on the climate. A larger GWP means that a given gas can absorb more heat than CO_2. For more detail, please refer to https://archive.ipcc.ch/ipccreports/tar/wg1/247.htm

feasible to reduce 70% of current emissions in the oil and gas sector, and nearly 45% can be typically achieved without any net cost.[2]

Other GMP member states such as the United States (U.S.) intends to impose a methane emissions charge on the energy industry starting in 2024, under the *Inflation Reduction Act*, and the European Union (EU) has implemented a policy that requires gas importers to measure and curtail methane emissions from gas production, starting in 2026 [11].

° Methane Leakage Across the Gas Industry Value Chain

Methane, which composes 80-95% of natural gas, is emitted across the entire value chain of the gas industry. The gas industry, globally, has been found to leak considerable amounts of methane, especially from gas pipelines, utilities, and during venting processes in gas extraction.

According to the IEA Methane Tracker report, about 34 million tons of methane equivalent is globally released by the gas sector. Onshore and offshore gas field venting contributes to roughly 57% of this total, while nearly 43% originates from fugitive emissions during gas production, and from pipelines and facilities [14].[3]

Primary fugitive emissions sources are storage tanks, equipment leaks, and pneumatics. While equipment leaks and pneumatic devices like compressors are typically identified as the main contributors to methane emissions, storage tanks are also significant sources of fugitive methane emissions [19].

During the production process, between 1.2-6% of gas production is leaked as methane according to estimated satellite measures (the methane leakage rate varies per gas producing area or basin) [13].[4] Liquefied Natural Gas (LNG) facilities experience methane losses during both liquefaction at LNG export and regasification at LNG import accounting for roughly 0.07% and 0.02% respectively [15]. As LNG is transported to import countries such as South Korea, boil-off gas from LNG storage tanks is injected into engines. This process results in substantial methane leakage, representing about 0.1% of the LNG volume during the shipping process [9].

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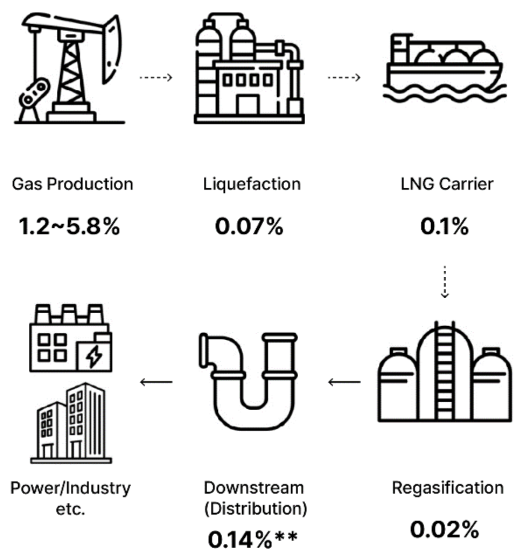
[2] For general introduction of methane emissions, please refer to https://www.iea.org/reports/curtailing-methane-emissions-from-fossil-fuel-operations/executive-summary

[3] Fugitive emissions denote greenhouse gases such as methane that leak from equipment like air compressors, valves, and flanges during the extraction, transportation, and storage stages of oil, gas, and coal.

[4] Appalachian (1.2%), Eagle Ford Shale (3.5%), Permian Shale (3.7%), Anadarko Shale (5.8%)

[Figure 1] Methane Leakage throughout the Gas Industry Value Chain*[5]



[Table 1] Equipment/Process-level Methane Emissions in U.S. Gas Production

CH_4 Emission Source	Share [%]
Tanks	17%
Equipment Leaks***	42%
Pneumatic Devices	29%
Liquid Unloading	7%
Methane Flare	1%
Completions & Workovers	1%
Methane Slip	3%
Total	**100%**

*Methane leak rate from gas (LNG) production, transportation, liquefaction, regasification, and distribution
**The value for distribution is derived from 26.8 g of methane per million BTU
***Equipment Leak: Leaks from separators, dehydrators, meters, reciprocating compressors, heaters, chemical injection pumps, etc.

Sources: [Figure 1] Balcombe et al. 2022 [9], Howarth R.W. 2022 [13], Innocenti et al. 2023 [16]
[Table 1] Rutherford et al. 2021 [19]

Methane emission statistics in South Korea present discrepancies depending on the source, making it challenging to fully determine methane emissions across the entire gas import process. *The National GHG Inventory Report* states that methane emissions from the energy sector in 2020 reached approximately 280,000 CH_4 tons (equivalent to 6 million tons of CO_2e), with the lion's share attributed to fugitive emissions of natural gas at about 177,000 CH_4 tons (equivalent to 3.7 million tons of CO_2e) [4].[6] The IEA, however, places South Korea's energy sector methane emissions to be even higher, at roughly 400,000 CH_4 tons (8.4 million tons of CO_2e based on IPCC AR2 GWP100), with an additional 72,000 CH_4 tons leaked from gas pipelines [14]. According to the IEA, then, the national methane emissions from the energy sector can be reported to be notably greater than the government's official reporting.

It is important to highlight that these estimates do not account for methane emissions linked to the production and transportation of LNG from overseas. South Korea ranks among the top three LNG importers globally. Given this context, South Korean energy companies should consider quantifying and

[5] LNG carriers refer to specialized vessels exclusively used for LNG transportation.
[6] The carbon dioxide equivalent for methane emissions (CO_2e) is calculated by multiplying the CH_4 tons by GWP value, 21, for 100-year time horizon, based on the IPCC's Second Assessment Report (AR2). In 2020, methane accounted for just around 4.1% of South Korea's total greenhouse gas emissions in CO_2e under current standards. However, this could rise to roughly 16% if we apply the GWP20 standard outlined in the IPCC's Sixth Assessment Report (AR6).

disclosing methane emissions, which may increase further from their ongoing overseas oil and gas production projects.

For example, according to recent studies, it is estimated that at least about 500,000 CH_4 tons leaked during the production and transportation of the 45.4 million CH_4 tons of LNG imported to South Korea in 2022 [2]. This translates to about 10.5 million tons of CO_2e when applying the current GWP100 standard. However, this figure magnifies nearly four times to reach 40 million tons of CO_2e when assessed under the GWP20 standard.

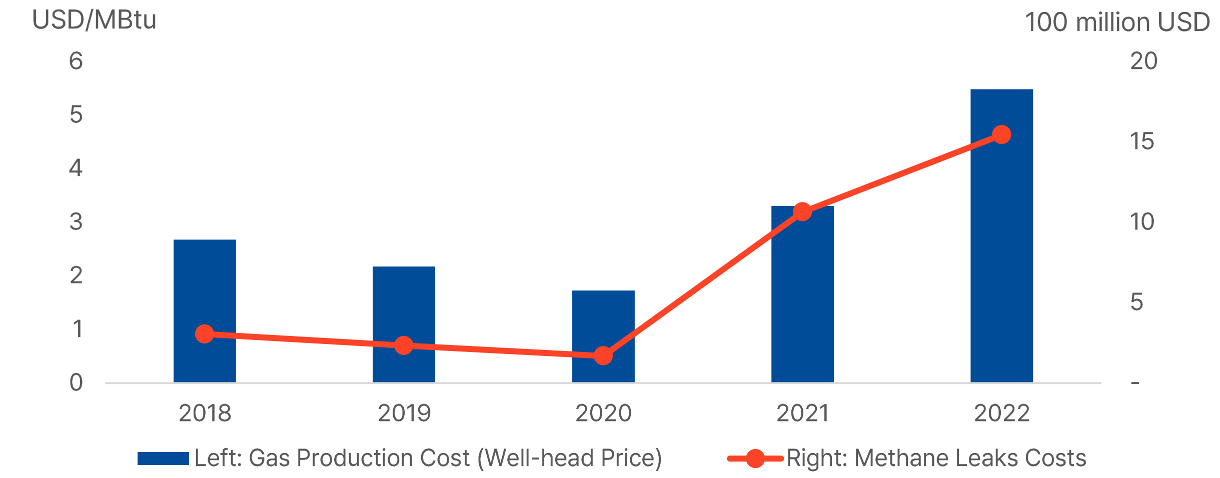
° The Costs of Methane Leakage

The economic value of methane can be assessed based on fluctuating gas prices at production stage and the volume of methane emissions (both fugitive and venting) during onshore and offshore production [14].

Figure 2 uses the U.S. as a reference point, taking into account the well-head price, which is taken as the Henry Hub Price minus 15% to cover local gas transportation costs and fees [14].[7] Due to the conflict in Ukraine, gas prices in the U.S. are roughly double what they were in the period preceding COVID-19, which has correspondingly increased the cost of methane losses. For example, although 2022 saw a slight downturn in methane emissions from gas production compared to the previous year, the total economic cost of methane leakage is approximated to be about USD1.5 billion, a jump of nearly 50% from 2021.[8]

[7] Henry Hub Price, the US benchmark price for natural gas, serves as a gauge of the natural gas supply and demand in the country.
[8] Methane emissions from U.S. gas production: 5.73 million CH_4 tons in 2021, and 5.61 million CH_4 tons in 2022

[Figure 2] Comparison of U.S. Gas Production Costs and Methane Leaks Costs



Source: Estimates are made and modified based on methane emissions data from EIA [10], EPA [12], and IEA [14]

In South Korea's energy sector, substantial fugitive methane emissions predominantly originate from the city gas pipelines and power generation processes. The situation in importing nations like South Korea is different from gas-producing nations, with a significant proportion of methane losses coming from gas distribution and power generation stages.[9]

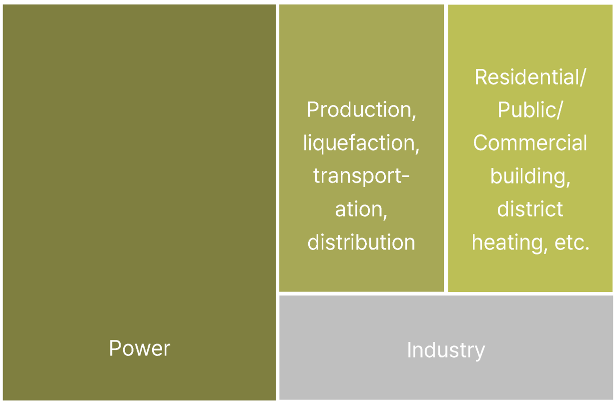
While city gas providers may contribute significantly to South Korea's fugitive emissions, they stand to gain substantial economic benefits through the capture and utilization of these elusive methane emissions. This economic value can range from tens to hundreds of billions KRW, contingent on the prevailing retail gas prices at the point of consumption.[10] Despite the fact that nearly half of the total methane emissions (approximately 17,700 CH_4 tons) are emitted from decades-old city gas pipelines, it is worth noting that city gas providers are currently not required to measure and report their greenhouse gas emissions, including methane, to the Ministry of Environment. Furthermore, with methane emissions from electricity generation comprising approximately 45% of total fugitive emissions from natural gas, there is a considerable hidden economic cost, in addition to adverse climate impact, that requires attention.[11]

[9] In the case of South Korea, government-run city gas providers are responsible for distributing gas to households, commercial and public buildings.

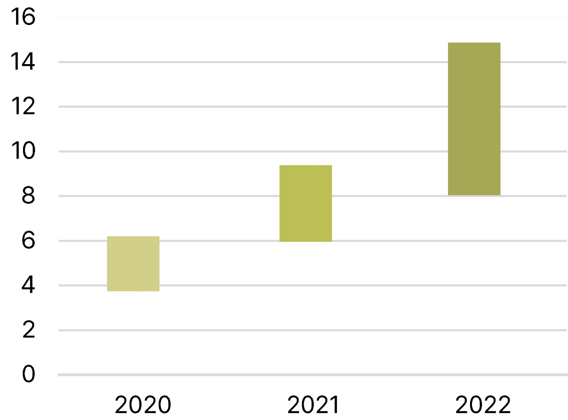
[10] In our calculation, city gas providers' share of methane emissions comes not only from distribution but also the industrial, residential, commercial, and public sectors [5].

[11] In our study, electricity generation does not include natural gas input for district heating and losses during the transformation process.

[Figure 3] Breakdown of Fugitive Methane in Natural Gas Sector in South Korea, 2020



[Figure 4] Estimated Value of Fugitive Methane from South Korea's City Gas Sector (10 billion KRW)*



* The estimated value of methane emissions from the city gas sector in 2020 is based on the annual average retail prices for residential, heating, cooling, and industrial uses for that year

Sources: 2022 National GHG Inventory Report [5], 2021 Energy Statistics Yearbook [3], City Gas Rate Table [7]

° Methane Mitigation Measures for the Gas Industry

The gas industry can significantly reduce methane emissions through the modernization of outdated infrastructure, application of comprehensive Leak Detection and Repair (LDAR) programs, and participation in global methane reduction initiatives.

Firstly, regular maintenance and equipment repair are crucial. Gas suppliers should proactively inspect and replace aging pneumatic devices, such as pumps and compressor seals, that are prone to methane leaks, or implement technical measures to avoid unnecessary fugitive emissions. Considerations might include replacing gas-driven pneumatic devices with electric counterparts or substituting leaking compressor seals or rods [14]. Suppliers can also prevent or recycle unnecessary gas blowdowns from vessels or compressors used in gas field operations or supply chains. In the event of unexpected gas leakage, they should halt or reboot the procedure, allowing the recovery of the leaked gas. This captured gas can then be transported to the sales line, facilitating on-site recycling and potential resale [14]. By installing plunger lifts, suppliers can also enhance productivity, directing gas from wells to offsite sales pipelines, rather than venting it into the atmosphere [14].

Secondly, the adoption of LDAR, a systematic program to inspect and repair devices and equipment contributing to methane fugitive leaks, is recommended. The LDAR system identifies leaking equipment – valves, connectors, flanges, open lines, pumps, and compressors – by unique identifiers and location data, allowing quick detection of leaks and efficient emission management. Here, infrared cameras commonly serve as useful tools for methane detection.

The IEA reports that frequent LDAR execution correlates with a decline in methane emissions [14]. Moreover, LDAR programs have been found to prevent hazardous incidents, improve working conditions, and deliver substantial economic and environmental benefits [6]. Consequently, globally new technologies for measurement devices, fugitive emissions reporting/forecasting systems, along with satellite detection, are being developed. From the late 2010s, global oil and gas firms have voluntarily adopted methane reduction guidelines, and in 2014, the United Nations launched the Oil and Gas Methane Partnership (OGMP) [20].

However, as of May 2023, no South Korean company has subscribed to an initiative like the OGMP; and from government, technical guidelines for the oil and gas sector remain absent. Although petrochemical companies have been implementing LDAR programs to manage air pollutants, methane is not included in the list of air pollutants regulated by the *Clean Air Conservation Act*. As such, methane LDAR implementation in South Korean gas companies remains notably low. To effectively remedy this situation, South Korean energy suppliers should draw insights from international efforts and strategies to realize their emission reduction goals more efficiently. This shift could potentially catalyze the growth of related business opportunities in South Korea, including sensor technology, Internet of Things (IoT), and data management crucial for successful methane LDAR.

[Table 2] Methane Reduction Initiatives from International Organizations

Initiatives	Organizations/ Corporations	Descriptions
Oil and Gas Methane Partnership 2.0 (OGMP)	UN Environmental Program (UNEP)	▪ The program aims to reduce methane emissions in oil and gas production and the LNG industry, among others. ▪ Upon joining, companies must set their own methane reduction targets for the following six years and report their methane emissions to UNEP every year. ▪ There are no fees associated with joining the program; membership is sustained even if the set reduction targets are not met. ▪ As of May 2023, the program has attracted approximately 100 energy companies, including multinational oil companies, LNG developers and transporters, and city gas providers.

Methane Guiding Principle (MGP)	MGP	▪ The program began with 8 companies in 2017, but it has been growing steadily with around 27 new companies in 2023. ▪ MGP doesn't have a reporting framework. Noteworthy participants include Beijing Gas, ENN Natural Gas, and Japan's Towngas. ▪ The program shares best practices for different facilities and processes across the natural gas supply chain. ▪ Efforts are being made to improve the accuracy of methane data reporting and to support the development of methane policies.
Oil and Gas Climate Initiative (OGCI)	Association of 12 Gas Corporations (Aramco, BP, Shell, Total, CNPC, etc.)	▪ The initiative was originally spearheaded by the CEOs of 12 oil and gas companies. ▪ The program encourages research into mitigation technologies, like those at Stanford University, methane monitoring satellites, and supports the development of methane reduction policies.
Aiming for Zero (AZ)	OGCI	▪ The program primarily targets oil and gas companies. Similar to the OGMP, companies must join, report their methane emissions, and work towards meeting their methane emissions targets. ▪ There are no enrollment fees for AZ, and companies can voluntarily exit the program at any time.

Sources: Compiled from the UNEP OGMP 2.0, OGCI, Methane Guiding Principle, and Aiming for Zero websites [8, 17, 18, 20]

° Recommendations

- **South Korean gas companies should consistently track their methane emissions at home and abroad and actively participate in global initiatives aimed at reducing methane levels.**

Captured methane can be a valuable commodity. Thus, controlling methane leakage becomes a matter of asset protection to businesses importing gas into South Korea. Ensuring regular equipment checks and timely repairs of leak-prone machinery like pneumatics and tanks can be instrumental in mitigating methane leakage. In this context, it is vital for the South Korean government authorities to devise credible systems for quantifying and reducing methane emissions.

Moreover, South Korean energy suppliers should also engage in international methane reduction programs, such as the OGMP 2.0. Cooperation with global oil and gas corporations can provide opportunities to improve methane reduction strategies, fostering a conducive environment for these initiatives. By doing so, South Korean corporations can exchange insights and effective practices with global partners engaged in similar methane reduction endeavors, equipping themselves better to counter the growing pressures to mitigate methane emissions from both domestic and international gas assets.

- **In the policy landscape, it is crucial that the South Korean government establish guidelines designed to reduce methane emissions, given their significant climate impact and economic value.**

The current lack of effective systems for measuring and monitoring methane emissions calls for the South Korean government to develop reliable standards for measuring, reporting, and verifying (MRV) methane emissions. These standards will help improve the gas industry's effectiveness in reducing methane emissions and create a transparent methane inventory system.

In South Korea, the gas industry is bifurcated into wholesale and retail businesses. As the wholesale energy supplier is a public entity, it falls under government supervision. Hence, its effective handling of methane emissions should be integrated into national corporation performance evaluation indicators.

On the other hand, the retailers, namely the South Korean city gas providers, despite the significant methane emissions from old pipelines, are currently not obligated to report their greenhouse gas emissions. This hinders the ability to accurately estimate and verify their actual emissions. Broadly, the government should consider policies that recognize the efforts of the South Korean gas industry in reducing methane as a step towards improving energy efficiency and greenhouse gas reduction, in addition to fostering the development of methane reduction technologies.

On the international stage, the South Korean government has the opportunity to partner with gas-exporting countries capable of efficiently managing methane emissions throughout the production to consumption stages. Drawing from EU's legislative efforts to develop a system that sources gas with lower methane emissions, South Korea can also develop regulatory frameworks that encourage collaboration with gas producers. This would enhance joint methane reduction initiatives across the entire value chain.

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Solutions for Our Climate (SFOC) is an independent policy research and advocacy group that aims to make emissions trajectories across Asia compatible with the Paris Agreement 1.5°C warming target.
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