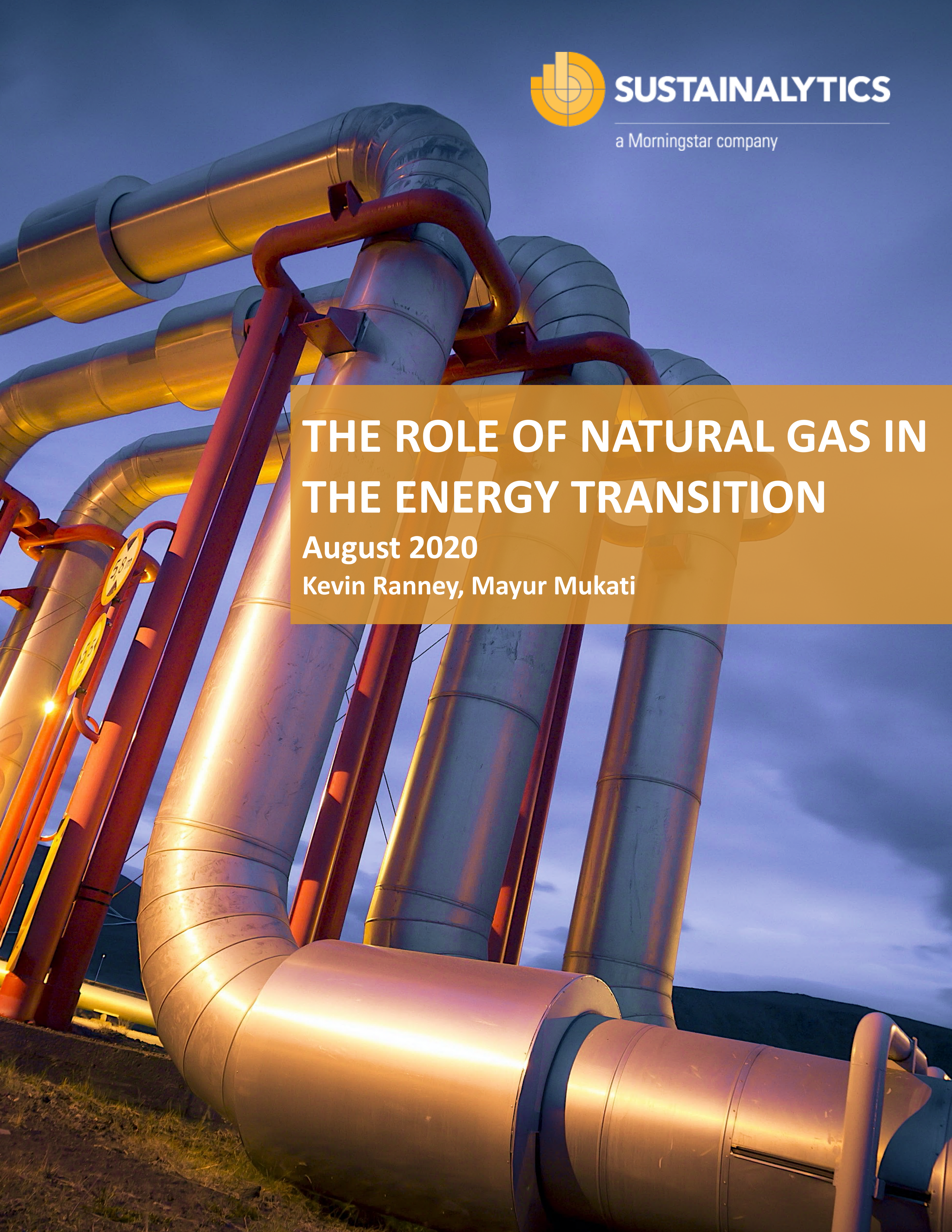

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THE ROLE OF NATURAL GAS IN THE ENERGY TRANSITION

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The role of Natural Gas in the Energy Transition

Transition finance aims to facilitate the long-term decarbonization of "hard-to-abate" economic activities whose transition will be critical to the achievement of international climate goals.

This document outlines Sustainalytics' view on the potential areas of investment in the supply and use of **Natural Gas** that can support decarbonization of multiple sectors**.**

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Introduction

As the fastest growing fossil fuel, natural gas accounted for nearly 23% of global primary energy demand and a quarter of energy generation in 2018.[1] With lower direct emissions from combustion, natural gas is perceived as the cleanest-burning fossil fuel, offering operational flexibility in power generation and enhancing the security of electricity supply as back-up to variable renewables. Additionally, natural gas can play an important role in meeting peak winter heating in buildings as well as providing high-temperature heat for industrial processes. Moving away from more polluting fuels to natural gas, especially through the use of existing infrastructure, has the potential to offer short-term climate benefits under certain conditions. However, as with other fossil fuels, there is a clear need to transition away from unabated combustion of natural gas over the coming decades if international climate goals are to be achieved.

This document outlines several key characteristics of natural gas, its role in the energy transition, and potential areas for transition finance involving natural gas infrastructure and its end uses. Its scope is limited to gas infrastructure for transmission and distribution via pipelines, and to downstream uses, including power and heat generation, and residential/commercial and industrial applications.[2]

Background

The natural gas supply chain can broadly be divided into five stages: (i) exploration and production, (ii) gathering and boosting, (iii) processing, (iv) transmission[3] and storage, and (v) distribution. Downstream (end) uses of natural gas include power and heat generation, and residential/commercial and industrial applications. Indirect emissions from the gas supply chain include carbon dioxide released during the extraction, processing, and transportation of gas, as well as upstream and downstream methane emissions (leakage).[4,5]

Sustainalytics has identified three key characteristics of natural gas, and its infrastructure, that shape its potential role in the transition to a low-carbon energy system:

1 International Energy Agency, Fuels & technologies, Gas: https://www.iea.org/fuels-and-technologies/gas.

2 Sustainalytics intends to publish separate position statements on industries/sectors, such as steel, cement, aluminum, aviation, and shipping.

3 This includes both piped transmission, and Liquefied Natural Gas (LNG) related stages, particularly Liquefaction, Floating Storage / Shipping, and Regasification to be stored or transported via pipelines.

4 International Energy Agency, Methane Tracker 2020: https://www.iea.org/reports/methane-tracker-2020/methane-from-oil-gas.

5 Several estimates from studies conducted in the US and China show that "approximately 20–50% of the natural gas life-cycle emissions are upstream emissions from well-to city-gate, including extraction, processing, and transmission for pipeline gas and additional processes of liquefaction, shipping, storage, and regasification for LNG." Nature Communications, Carbon footprint of global natural gas supplies to China: https://www.nature.com/articles/s41467-020-14606-4.

1. Firstly, natural gas has lower direct carbon emissions from combustion than higher polluting (fossil) fuels such as coal and oil.[6] According to the International Energy Agency (IEA), coal-to-gas switching reduced carbon dioxide emissions by about 500 million tonnes between 2010 and 2018.[7] The IEA's estimates of climate benefits from coal-to-gas switching (under certain conditions) for power generation and heating for industry and buildings show that: (i) accounting for both carbon dioxide and methane emissions, nearly 98% of gas used for power or heat has a lower lifecycle emissions intensity than coal; the analysis shows that, on average, coal-to-gas switching reduces emissions by 50% when electricity is generated, and by 33% when heat is provided; and (ii) evidence of climate benefits from coal-to-gas switching is clearest when using existing infrastructure that can provide the same energy services but with lower emissions.

   It must be noted that, despite the carbon dioxide emissions reduction potential (and air quality benefits) for specific regions and timeframes, switching to *unabated gas* will not result in the level of emissions reductions required to achieve international climate goals. Among other challenges, indirect emissions throughout the gas supply chain must be addressed. In recent years, studies have shown that the leakage of methane – which has a Global Warming Potential (GWP) 28 times greater than that of carbon dioxide[8] – across the gas supply chain in the US was significantly higher (by almost 60%) than the previous estimate of around 1.4% per cubic feet of natural gas drawn from underground reservoirs. Such leakage measurements include fugitive emissions from equipment leaks and failures, process venting, evaporation losses, and venting/flaring.[9,10] These findings demonstrate the need to address the root causes of high emissions from equipment malfunctions and other abnormal operating conditions (generally referred to as "super emitters")[11] through effective mitigation strategies that include both best available technologies and best practices.[12]

[6] Natural gas combustion emits roughly 50% less carbon dioxide in a new, efficient natural gas combined-cycle (NGCC) power plant compared to typical new coal plants, including integrated gasification combined-cycle (IGCC) and pulverized coal (PC) systems. Cost and Performance Baseline for Fossil Energy Plants Volume1: Bituminous Coal and Natural Gas to Electricity: https://www.netl.doe.gov/projects/files/CostAndPerformanceBaselineForFossilEnergyPlantsVol1BitumCoalAndNGtoElectBBRRev4-1_092419.pdf.

[7] International Energy Agency, The Role of Gas in Today's Energy Transitions: https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions.

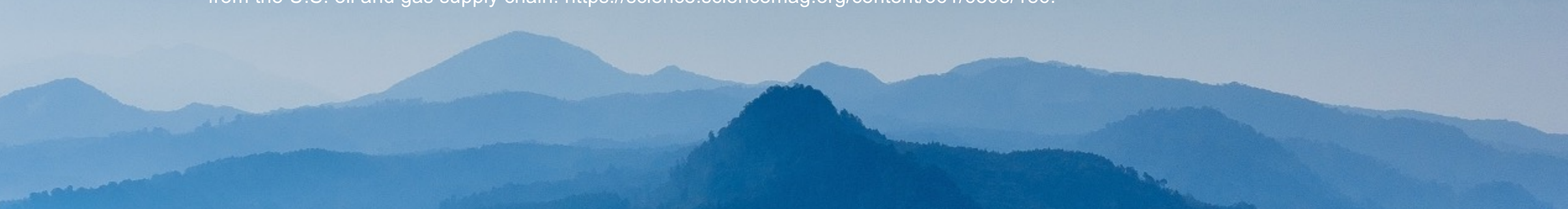
[8] GWP value for 100-year time horizon according to the IPCC Fifth Assessment Report, 2014 (AR5).

[9] The estimates of methane emissions across the gas supply chain have been subject to ongoing assessments, especially due to a high level of uncertainty regarding the underlying assumptions, quality of data and methodology applied. Various geological formations, technologies, plant age, gas composition, and local/regional regulations, to name a few, add complexities in such estimates. ACS Sustainable Chemistry & Engineering, The Natural Gas Supply Chain: The Importance of Methane and Carbon Dioxide Emissions:https://pubs.acs.org/doi/10.1021/acssuschemeng.6b00144.

[10] EDF, Major studies reveal 60% more methane emissions: https://www.edf.org/climate/methane-studies.

[11] Measurements were classified as either top-down that "quantify ambient methane enhancements using aircraft, satellites, or tower networks and infer aggregate emissions from all contributing sources across large geographies", or bottom-up as "performed on equipment or facilities that are expected to represent the vast majority of emissions" from the supply chain. Science, Assessment of methane emissions from the U.S. oil and gas supply chain: https://science.sciencemag.org/content/361/6398/186.

[12] Such mitigation strategies included onsite leak surveys through optical gas imaging, passive sensors, in situ remote sensing approaches using tower networks, aircrafts, or satellites, and failure-prone systems. Science, Assessment of methane emissions from the U.S. oil and gas supply chain: https://science.sciencemag.org/content/361/6398/186.



2. Secondly, natural gas can serve as a back-up fuel to seasonally variable renewable energy for uninterrupted power and/or heat supply. According to the IEA, gas currently provides energy security and seasonal balancing that are not easily replicated by renewable energy. The storability and operational flexibility of gas-fired power plants allow for seasonal and short-term demand fluctuations, given their ability to restart and ramp up quickly for power production. These attributes of gas will be particularly relevant until utility-scale energy storage is adequately deployed at scale. Similarly, significant demand for peak winter heating in buildings and high-temperature heat for industrial processes – which cannot yet be met by electricity – means that gas will continue to play an important role in such applications in the interim.[13]

3. Lastly, natural gas infrastructure can be repurposed to deliver low- or zero-carbon gases such as biomethane[14] and hydrogen[15] in the long-term. Since infrastructure for the transport of decarbonized gases like hydrogen has not yet been developed, the repurposing of existing gas grids to deliver such gases in many countries could be relatively economical. The blending of blue or green hydrogen[16] would help to lower the carbon emissions of the gas supply and to scale up production routes for such low- or zero-carbon energy vectors.[17]

[13] The energy delivery capacity of gas infrastructure in Europe is nearly 1000 bcm – twice as much as an electricity grid on an energy-equivalent basis. IEA, The Role of Gas in Today's Energy Transitions: https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions.

[14] Biomethane is observed to be more commercially viable for integration in the current state as it is largely indistinguishable from natural gas having an untapped potential to be produced from sustainable feedstocks, such as biodegradable waste and wastewater, with wide geographic spread. IEA, Outlook for biogas and biomethane: Prospects for organic growth: https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth.

[15] Hydrogen has a significant potential to gradually assume the role of an energy vector beyond its storage capacity and is generally considered as a fuel/feedstock replacement for natural gas for heating, transport and industrial applications. Presently, multiple barriers are posited for full-scale decarbonization of gas networks through hydrogen, such as leakage and explosion risks arising from hydrogen embrittlement of metal. Hydrogen embrittlement (or hydrogen-assisted cracking) may occur due to the penetration of hydrogen through metal defects and imperfections leading to fractures. Journal of Mechanical Science and Technology, Influence of gaseous components and pressures on hydrogen embrittlement of natural gas pipeline: https://link.springer.com/article/10.1007/s12206-017-0711-2.

[16] Blue hydrogen refers to the production of hydrogen from steam methane reforming coupled with carbon capture systems. Green hydrogen refers to the production of hydrogen through a water electrolysis process using low-carbon electricity.

[17] Currently, natural gas supply specifications and/or equipment tolerance within the gas grid govern hydrogen blending. In many countries, very low levels of hydrogen blending are permitted (up to 2% by volume). IEA, Special Focus on Gas Infrastructure: https://www.iea.org/articles/special-focus-on-gas-infrastructure.

The Role of Natural Gas in Transition Pathways

Based on an extensive literature review,[18] Sustainalytics believes that natural gas has an important role to play in the energy transition, and therefore is an appropriate target for transition finance. Key areas include emissions abatement from existing infrastructure, particularly in the context of transmission and distribution pipelines; power and heat generation; and residential, commercial, and industrial applications.

System boundary	Potential investment
Existing transmission and distribution (T&D) pipelines	• Retrofit to reduce methane leakage and make pipelines ready for integration of (or increasing the blend of) hydrogen or other low-carbon gases. • Installation of energy-efficient systems within the grid connecting gas-fired power plant (with CCS) and substation or network upgrades to existing grid to reduce losses.
Existing and new gas-fired power (or cogeneration of power and heat)	• Integration of CCS and/or substitution with low-carbon fuels for substantial emissions reduction over unabated combustion of natural gas.
Residential / Commercial end use	• Maintenance and repair of gas fittings and gas-fired equipment to substitute coal-fired boilers and enhance energy efficiency or reduce gas leakage • Development and operation of district heating networks connected to gas-fired CHP unit with CCS (and/or that derives its power and heat from low-carbon fuels).
Industrial end use	• Switch from coal-fired processes and supply of high-grade heat.

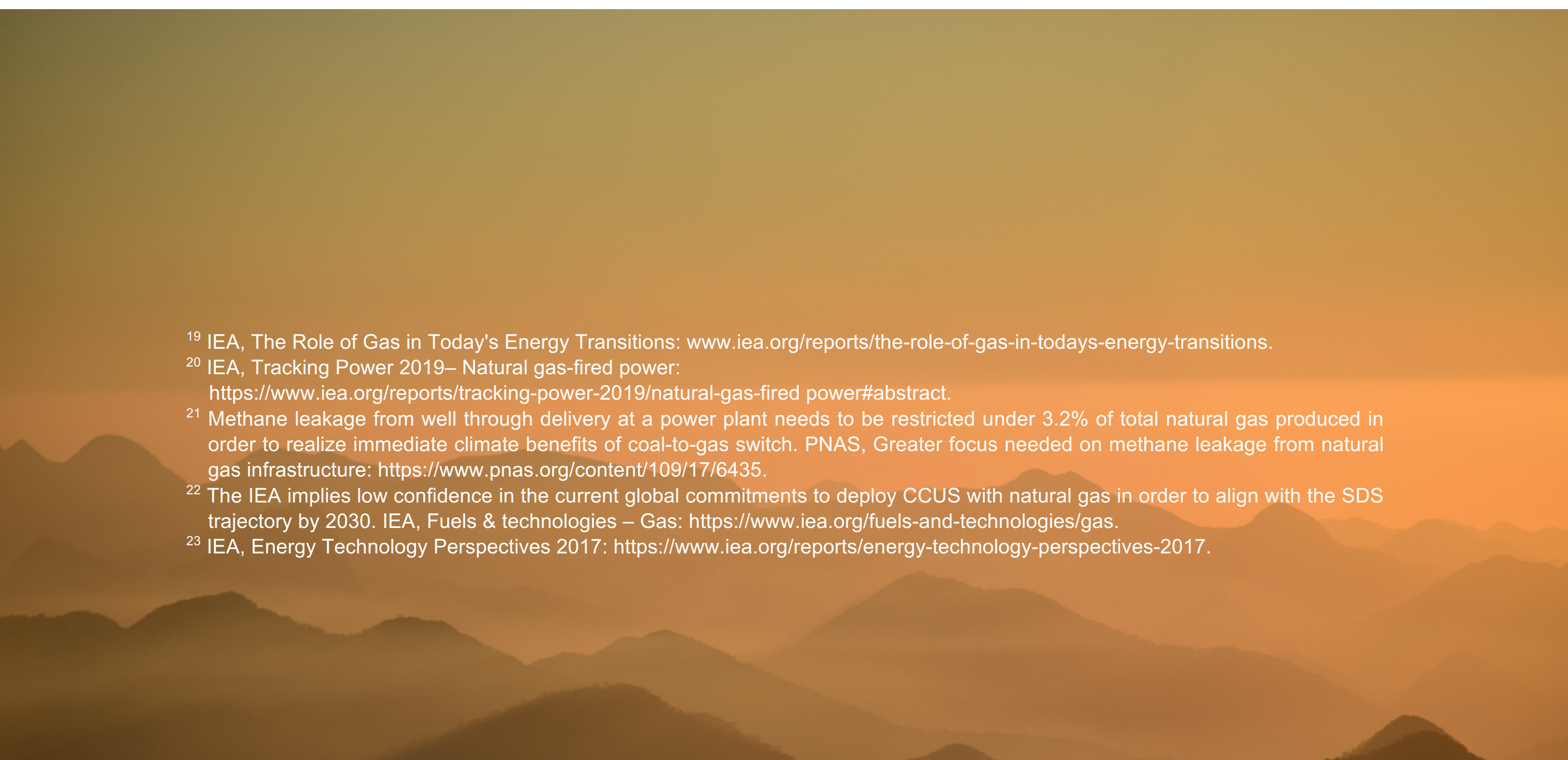
Table: System boundaries with potential investment opportunities in the gas supply chain

[18] Sustainalytics' conclusions are grounded most importantly in the International Energy Agency (IEA)'s Sustainable Development Scenario (SDS 2019) and Energy Technology Perspectives (ETP 2017), which provide a credible and authoritative benchmark in the sense that it charts a path fully consistent with the Paris Agreement by holding the rise in global average temperature to well below 2 degree Celsius compared to pre-industrial levels.

With respect to **gas transmission and distribution via pipelines**, Sustainalytics believes that investment in natural gas infrastructure can play a significant role in decarbonizing industrial, residential, and commercial end uses. Considering the potential to decarbonize gas networks themselves, Sustainalytics highlights the importance of retrofitting existing gas pipelines with the aim of minimizing indirect emissions, especially methane leakage, while retrofitting such pipelines to enable the integration of (or increasing the blend of) low-carbon gases such as blue/green hydrogen and sustainably sourced biomethane.

With respect to **power generation**, coal-to-gas switching has the potential, when using existing gas infrastructure, to reduce power sector emissions and total energy-related carbon dioxide emissions.[19] Given that unabated natural gas is unlikely to be aligned with the achievement of ambitious climate targets in the long term,[20] the climate benefits of switching to gas-fired power generation under all timeframes are dependent on two key factors: (i) direct emissions abatement such as through the deployment of carbon capture systems, and (ii) limited (well-to-burner-tip) methane leakage.[21] In the Sustainable Development Scenario (SDS) trajectories, the large-scale deployment of carbon capture, utilization, and storage (CCUS) projects at gas-fired power plants is expected to rise to 35 GW by 2030.[22]

The carbon intensity of new-built power projects is a "driver metric" that will influence the downward trajectory of the global average power grid intensity and its alignment (or lack thereof) with the 2-degree scenario outlined in the IEA's modelled pathways.[23] For alignment, the average carbon intensity of new power capacity should be around 100 gCO_2/kWh in 2025, thus requiring steep reduction compared to unabated gas combustion, which is estimated to be in the range of 410-650 gCO_2/kWh on a lifecycle basis.



[19] IEA, The Role of Gas in Today's Energy Transitions: www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions.
[20] IEA, Tracking Power 2019– Natural gas-fired power: https://www.iea.org/reports/tracking-power-2019/natural-gas-fired power#abstract.
[21] Methane leakage from well through delivery at a power plant needs to be restricted under 3.2% of total natural gas produced in order to realize immediate climate benefits of coal-to-gas switch. PNAS, Greater focus needed on methane leakage from natural gas infrastructure: https://www.pnas.org/content/109/17/6435.
[22] The IEA implies low confidence in the current global commitments to deploy CCUS with natural gas in order to align with the SDS trajectory by 2030. IEA, Fuels & technologies – Gas: https://www.iea.org/fuels-and-technologies/gas.
[23] IEA, Energy Technology Perspectives 2017: https://www.iea.org/reports/energy-technology-perspectives-2017.

Additionally, the decline in the average carbon intensity of electricity generation must accelerate to 3.4% per year to meet the SDS's average grid intensity of approximately 240 gCO2/kWh by 2030,[24] about half of the global average of 463 gCO_2/kWh in 2019. Therefore, in line with SDS's emissions trajectory, the existing gas power projects should also be retrofitted with post-combustion carbon capture systems and/or substituted with low-carbon gases, such as bio-synthetic natural gas (Bio-SNG). Several estimates suggest that an abated natural gas power plant (with CCS) can reach lifecycle emissions of between 90 and 370 gCO_2/kWh[25], with a median of 170 gCO_2/kWh.[26]

Therefore, with reasonable assurance of limited indirect emissions from the gas supply chain, abated gas-fired power generation can support seasonally variable renewables and on-demand electricity generation for uninterrupted operation of electrical grids, as well as contribute to climate mitigation and the reduction of air pollution in the near term. In the medium to long term, growth in renewable energy generation with utility-scale energy storage solutions is expected to dominate as lower-carbon alternatives.[27]

[24] IEA, Tracking Power 2020: https://www.iea.org/reports/tracking-power-2020.

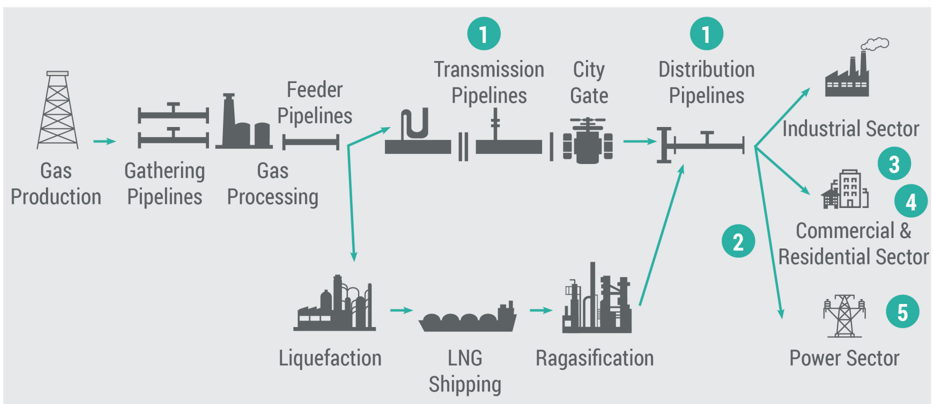
[25] As per the IPCC, for gas power, the literature specifies such range of emissions with natural gas leakage between 0.8-5.5% and an assumption of 90% captured CO2 from the flue gas. IPCC, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change - Energy Systems: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter7.pdf.

[26] IEA, [26] IPCC, Annex III: Technology-specific Cost and Performance Parameters. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf.

[27] Both coal-to-gas switching and growth in renewable power generation are expected to be encouraged further with the regulation of plant emissions and implementation of carbon taxes.

In the context of **residential/commercial and industrial end uses**, particularly in regions where air quality is a significant concern, switching away from small-scale coal-fired boilers offers immediate benefits, especially as these boilers are rarely equipped with the advanced pollution control technologies needed to limit air pollutants. Therefore, gas-fired systems for heating hold the potential to reduce emissions in the short term. Similarly, natural gas can act as a heating fuel for **industrial applications**. Most industrial processes are driven by high temperatures, large heat flux, and a reliable energy source which is dispatchable and available for robust and continuous operations. Given that the electrification of all industrial applications faces significant challenges in the short term, natural gas can act as one of the alternate solutions for generating high-grade heat with immediate climate benefits.

Natural Gas Supply Chain



1. **Retrofit of gas T&D pipeline network to reduce methane leakage and integrate (increase) blends of hydrogen and low-carbon gases**
2. **Installation of energy-efficicient systems within the grid connecting gas-fired power plant (with CCS) and substation or network, upgrades to existing grid to reduce losses**
3. **Maintenance and repair of gas fittings and gas-fired equipment to substitute coal-fired boilers and enhance energy efficiency or reduce gas leakage**
4. **Development and operation of district heating networks connected to gas-fired CHP unit (with CCS)**
5. **Production of electricity or co-generation of electricity and heating from gas (with CCS)**

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