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Expansion of natural gas infrastructure: a bridge technology or a liability for the energy transition?

(version 1.0, English)

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Abstract:

Natural gas can no longer be considered a bridge technology to a fossil-free future. The assumption that natural gas is more favorable than coal as an energy source with regards to its climate impact must be revised. The planned expansion of natural gas infrastructure in Germany is not justifiable in terms of climate policy, not compatible with Germany's goals to meet the Paris climate accord, and even entails numerous financial risks. Moreover, it will delay the planned energy transition.

This text was written by members of Scientists for Future and was extensively reviewed by colleagues for scientific quality (especially with respect to the validy of the arguments).

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1. Future demand for natural gas will decrease

Natural gas is still a central component of Germany’s energy supply in 2020. A quarter of Germany's primary energy consumption is covered by natural gas (AG Energiebilanzen e.V. 2020). Almost all of the natural gas used in Germany is imported. More than half of the imported natural gas originates from Russia, followed by Norway and the Netherlands (Statista GmbH 2020). Due to high demand and few resources, Germany is the largest importer of natural gas in Europe (Heilmann, De Pous, and Fischer 2019).

Future gas consumption in Germany has been examined in various studies and scenarios. These generally include biogenic and synthetic gases (e.g., hydrogen) in addition to natural gas. However, the majority of the currently available studies and meta-analyses do not yet take into account the stricter climate targets adopted by the EU in 2020, which will require a more significant decrease in the use of fossil fuels for electricity and heat (Wachsmuth et al. 2019; Hainsch et al. 2020; Oei, Pao-Yu et al. 2019).

2. The climate impact of natural gas

Natural gas consists largely of methane (CH_4), a gas that has a very high climate impact. According to the latest figures by the Intergovernmental Panel on Climate Change (IPCC), the global warming potential (GWP) of methane is up to 87 times greater than that of CO_2 in the first 20 years and up to 36 times greater in the first 100 years (Myhre et al. 2013 Table 8.7, p. 714). Because of the high global warming potential of methane, especially in the first 20 years after its emission, the use of natural gas as a (temporary) substitute for coal may lead to an additional short-term temperature increase. As a result, tipping points in the climate system leading to abrupt and irreversible climate change could be reached even faster, i.e., as early as in the next 10 to 20 years (Schellnhuber, Rahmstorf, and Winkelmann 2016).

In addition to the direct impact of methane on the climate, the total amount of greenhouse gas (GHG) emissions generated from the use of natural gas has long been underestimated. GHG emissions in the natural gas sector are generated in particular during combustion (creating CO_2 emissions) and during extraction, transport, and storage (causing direct CH_4 emissions). Frequently, methane emissions resulting from leakage are not included, or not fully included, in the calculation of the climate impact of natural gas. The same is true for methane emissions from deliberate venting or flaring, particularly during natural gas production (Cremonese and Gusev 2016). However, these emissions of natural gas itself, through leakage and venting, can range from about 2 % to 6 % of the total amount of natural gas produced (e.g. Hausfather 2015, Zhang et al. 2016, Alvarez et al. 2018). Some measurements even show leakage rates of up to 17 % for certain regions (Caulton et al. 2014). Taking these quantities into account, current assumptions underestimate the climate impact of natural gas. In terms of specific carbon dioxide emissions from the energy sources used, the UBA calculates at least 97,920 kilograms of carbon dioxide per Terajoule (kg CO_2/TJ) for lignite, 93,369 kg CO_2/TJ for black coal, and currently 55,827 kg CO_2/TJ for natural gas CCGT plants (UBA 2020). However, this figure only applies to direct CO_2 emissions from natural gas. While appearing comparatively positive, it doesn't take into account the total emissions from the value chain over the entire usage cycle of natural gas. Under certain conditions, natural gas can thus have a poor climate footprint which can be comparable to coal (Alvarez et al. 2012; Howarth 2014; Hausfather 2015; Gilbert and Sovacool 2017).

The overall impact of natural gas as a greenhouse gas depends not only on the quantity of methane emissions, but also on the choice of time period for calculating its climate impact (e.g., 20, 100, or 500 years): Methane has a stronger warming effect over short time periods compared to CO_2 due to its more potent greenhouse effect within decades. The comparison also depends on the efficiency of the power plants (Zhang 2016) and the origin of the gas. For example, methane emissions from natural gas delivered via long pipelines from Russia are roughly 10 times higher than those of imports from Norway and the Netherlands, due to the long distances of transport. In the case of liquified natural gas (LNG) imports, for example from Qatar or the USA, additional emissions are caused by the energy-intensive liquefaction process due to the need for cooling it to -160 °C. Total emissions related to LNG are thus on the order of magnitude of those from pipeline imports from Russia (BGR, 2020).

3. There is no supply shortage in the German and European natural gas market.

A meta-study by the German Federal Environment Agency (UBA) took a comparative look at various scenarios for future gas use. Development pathways compatible with the German government's climate protection targets for 2030 were taken into account, while differentiating between different ambition levels for 2050 (either minus 80 % or 95 % compared to the base year 1990) (Wachsmuth et al. 2019). All scenarios assume a decrease in total gas consumption (natural gas and synthetic gases): Gas consumption is projected to decrease by 49 to 63 % and by 14 to 83 %, respectively, for an 80 % and 95 % decrease in emissions by 2050, in each case with respect to 2015 as a reference year. With these assumptions, however, it should be noted that the decline in natural gas use is significantly greater in each of these cases. Depending on the scenario, varying degrees of hydrogen and synthetic methane usage partially offset the decline in natural gas use (Wachsmuth et al. 2019). With the expected target increase in order for Europe and Germany to be climate neutral by 2050, the reduction of natural gas will need to be even greater (Auer et al. 2020).

Based on the assumed decrease in gas consumption, the UBA study does not see a need for an expansion of the gas distribution network. The UBA rather predicts that the utilization of long distance transmission networks for gas will decrease. At the distribution network level, a significant portion is even expected to be decommissioned in the domain of the lowest gas pressure levels, as residential and commercial areas switch to other renewable energy sources (Wachsmuth et al. 2019).

EU-wide modelling, that considers Germany as a transit country to supply gas to neighboring European countries, also sees no need for an expansion of the gas distribution networks (Holz and Kemfert 2021). Furthermore, current projections by the European Commission assume a 29% decline in natural gas by 2030 (compared to 2015). Collectively, this demonstrates that the gas infrastructure already in place is fully sufficient for a secure gas supply. Planned investments in new gas infrastructure, thus, represent a risky overinvestment (Heilmann, De Pous, and Fischer 2019).

4. Risks: Loss of value and a delay of the renewable energy expansion

Considering all of the above, it does not make sense, neither ecologically nor economically, to invest billions of euros into the expansion of gas infrastructure. Germany has the second-largest gas investment plans in Europe (Inman 2020). These investments add up to approximately 18.3 billion euros for power plants, gas distribution systems and liquefied natural gas terminals, have a high risk of turning into stranded assets and would have to be paid in large part from taxpayers' money as well as by consumers (Heilmann, De Pous, and Fischer 2019; Löffler et al. 2019). In the event of premature closures, there is a risk of state-investor dispute settlements based on the European Energy Charter, which could result in further budgetary liabilities.

As outlined above, one of the reasons for misguided infrastructure development is that natural gas demand is often overestimated during the planning phase. For example, transmission system operators (TSOs) base their gas network development plan (NEP) on two particular scenarios which assume either a very moderate decline or even an increase in gas demand (Heilmann, De Pous, and Fischer 2019). Since the expansion measures proposed in the NEP can be passed on to natural gas customers by TSOs, there is a risk that consumers will have to pay these unnecessary costs.

The situation is similar for planned investments in liquefied natural gas infrastructure. Existing infrastructure across the EU has only been utilized at an average of 25 % of their capacity over the past decade (Holz and Kemfert 2021). With a projected decline in gas demand, further investment is neither necessary nor economical. Yet, three terminals are currently planned in Germany, partly financed by taxpayers' money (Fitzgerald, Braunger, and Brauers 2019; Hirschhausen, Praeger, and Kemfert, Claudia 2020).

Because gas infrastructure has a technical lifetime of approximately 20 to 50 years, expansion increases the likelihood that operators will continue to operate this infrastructure beyond 2050, due to economic and political pressure for the continued use of these assets. This in turn leads to rising GHG emissions and global temperature increases, and prevents the ability to meet climate change targets (Eyre and Baruah 2015; P. Hammond and O' Grady 2017; Serkin and Vandenbergh 2018; Verhagen, der Voet, and Sprecher 2020).

Additional investment in natural gas also poses a risk in terms of climate policy, as the funds tied up in this area are not available for renewable energy expansion or energy efficiency measures (Stephenson, Doukas, and Shaw 2012; Cotton, Rattle, and Van Alstine 2014; Davis and Shearer 2014; Hausfather 2015; Lenox and Kaplan 2016; Healey and Jaccard 2016; Zhang et al. 2016; P. Hammond and O' Grady 2017). When investments in natural gas inhibit investments in renewables, they thereby delay the transition to renewables and flatten the learning curve of the transition. As a result, the costs of the global energy transition increase.

As calculations show, the continued use of natural gas either does not reduce overall costs, or increases the cumulative costs of a transition compatible with climate targets (Paula Díaz, Oscar van Vliet, and Anthony Patt 2017; Nava Guerrero et al. 2019).

5. The role and importance of hydrogen

In a system powered entirely by renewable energy sources, renewable hydrogen will play a crucial role. Renewable (or ‘green’) hydrogen is produced by water electrolysis using electricity from photovoltaics and wind power. As a flexible energy carrier, hydrogen can function as a long-term storage medium for electricity from renewable sources, as raw material for the chemical industry, and in the decarbonization of specific industrial processes (Matthes 2020). The argument that future use of hydrogen requires the expansion of natural gas infrastructure must be questioned for energy-related reasons and with respect to climate policy, as described above.

Although the German government projects the use of hydrogen in all sectors in its "National Hydrogen Strategy" (NWS) and hopes to establish a hydrogen economy, serious questions remain regarding the feasibility of the enormous quantities that will need to be produced. By 2030, the NWS assumes a demand of 90 to 110 TWh. By contrast, current domestic production stands at 14 TWh, which is only about 15 % of that targeted volume (BMWi 2020). The majority would therefore need to be covered by imports. Hydrogen derived from renewable sources is considered sustainable within the NWS, but the NWS does not explicitly exclude the use of non-renewable hydrogen from fossil sources (ibid.). However, due to upstream emissions associated with natural gas production, high costs of CO_2 capture and limited CO_2 storage capacities, the production of non-renewable hydrogen cannot be considered CO_2 neutral (Hebling et al. 2019). Even the use of imported hydrogen from electrolysis is not climate-friendly per se. Furthermore, from a climate ethics perspective, the import of renewable hydrogen from developing and emerging countries must be critically evaluated. If the electricity used for hydrogen production is not originating from renewable surplus, there is a risk that national emissions reductions will be hampered by the use of fossil energy sources instead.

An energy system solely based on renewable energy sources will likely not be able to operate entirely without hydrogen. Therefore, the focus should be on European hydrogen production from renewable energy sources. Blending of green hydrogen with natural gas would not add value due to the high inherent value of hydrogen with respect to economic, applicability and technology criteria; thus, there is no need to maintain natural gas capacity for blending purposes. (Matthes es al. 2020; Wachsmuth et al. 2019) .

6. Expansion of natural gas infrastructure would have negative climate impacts and is unnecessary from an energy supply perspective

In summary, the construction of new natural gas infrastructure is not needed. It slows down the expansion of renewables as well as measures to improve energy efficiency and sufficiency. It creates lock-in effects beyond 2050, the EU's confirmed target for complete decarbonization. It poses a considerable risk for stranded investments.

Based on recent scientific insights, it is necessary to politically define the gradual phase-out of natural gas now. There will be no supply gap in the German or European natural gas market, and climate protection scenarios demonstrate that natural gas consumption needs to decline. Therefore, already at present and from an energy policy or energy industry perspective, there is no need for the new construction of any natural gas infrastructure.

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