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FACTS AND FIGURES NATURAL GAS

METHANE EMISSIONS

FROM NATURAL GAS INFRASTRUCTURE

Facts, figures and initiatives by the gas industry

METHANE EMISSIONS: FACTS AND FIGURES

The public debate on climate protection is increasingly focusing on methane emissions from the production and transmission of natural gas. Yet it is frequently unclear how much methane is actually released into the atmosphere and how this impacts the climate. This may lead to the wrong conclusions.

The true impact of methane on global warming can only be assessed on the basis of robust scientific data. Hence, this booklet offers some facts and figures that have been compiled from recent studies and publications.

Methane (CH_4) is the main component of natural gas, and as such plays a pivotal role in energy supply in Germany and Europe. Its high hydrogen (H) / carbon (C) ratio means that its combustion process produces significantly less carbon dioxide (CO_2) than other conventional fuels like e. g. fuel oil. Natural gas is, therefore, key to the energy turnaround and the effort to tackle climate change.

If methane escapes into the atmosphere, however, its greenhouse gas effect is many times that of the same amount of e. g. carbon dioxide. The public debate on climate protection is therefore increasingly focusing on diffuse methane emissions along the natural gas supply chain. Consequently, it is essential to base any discussion of the issue on scientifically robust data. This booklet provides an overview of the key facts and figures.

Key facts at a glance

- **Methane emissions** account for 11 % of all anthropogenically produced – i. e. man-made – **greenhouse gas (GHG) emissions**. The figures for the European Union (EU) and Germany are 10 % and 6 %, respectively.[1]
- The global **contribution of methane emissions from the crude oil and gas industries** to the total GHG emission inventory is about 2.9 %; the figures for the European Union and Germany are 0.6 % and 0.5 %, respectively.
- Since 1990, **diffuse methane emissions from natural gas** have been declining by 40 % and by more than 50 % in Germany and in the EU, respectively, showing an ongoing downward trend.[1]
- Current **pre-chain emissions** related to gas distributed in Germany account for approximately 12.5 % of the total greenhouse gas emissions from natural gas, including combustion and diffuse emissions. Methane losses from the transmission, distribution and production of the gas used in Germany amount to approximately 0.6 %.[2]
- 84 % of all diffuse methane emissions from pre-chain emissions in Germany stem from the **transmission and distribution** of natural gas.[1]
- Even when taking into account emissions from pre-chain resources, natural gas is still more climate-friendly than other fossil energy carriers such as diesel or brown coal. In transport, so-called "well-to-wheel" analyses show **significantly lower total GHG emissions for natural gas vs. diesel**.[3]
- Methane has a higher greenhouse gas potential than CO_2. Over a 100-year time horizon (GWP 100, see disambiguation on p. 4) – the observation period recommended by the Intergovernmental Panel on Climate Change (IPCC), – **methane is about 25 times more effective than CO_2**.[**, 5]
- The German gas industry has been overhauling and modernising the gas infrastructure for decades, thus achieving a significant reduction of methane emissions. In the past decades, material like e. g. grey cast iron that can cause undesirable emissions has been substituted with modern materials, which has brought down the number of **gas pipeline-related** incidents – **i. e. leaks and damage – by 90 % since 1990**.[6]

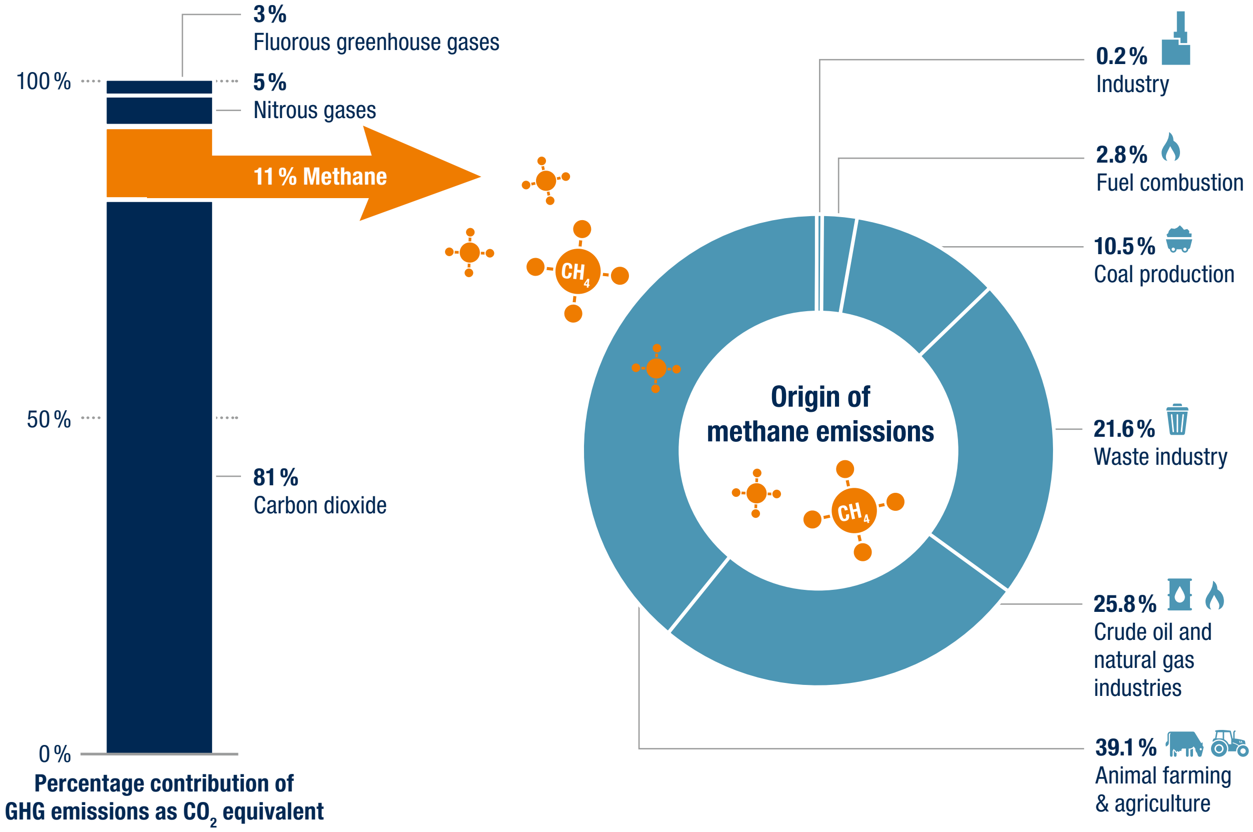
* The "well-to-wheel" analysis is commonly used by the mobility sector to determine the greenhouse gas emissions from the overall fuel chain, i.e. from fuel production to the use of fuel in the vehicle.

** The currently applicable UNFCCC guidelines envisage setting up greenhouse gas inventories with a GWP 100 = 25 for methane. The latest IPCC Assessment Report however mentions a factor of 34.[4]

World

- In 2017, methane accounted for 11 % of total global GHG emissions produced by humans (Fig. 1).[1]
- **Globally**, the **crude oil and gas industries account for about one quarter of all anthropogenic methane emissions**, which corresponds to 2.9 % of all GHG emissions generated by humans.
- The natural gas industry generates **methane emissions** both **during the early phase of pre-chain activities**, e.g. during gas production, and during the subsequent gas transmission and distribution processes.

FIGURE 1: Percentage contribution of methane to global anthropogenic greenhouse gas emissions (2017) and origin of methane emissions[1]



Not all emissions are equal – disambiguation

- **Greenhouse gas emissions (GHG emissions):** The emissions of all gases that have been shown to contribute to the greenhouse effect. These include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). All gases differ in their potential to cause global warming.

- **Methane emissions:** The direct release of methane into the atmosphere. Using the global warming potential (GWP) metric, the impact on the climate can be calculated in terms of carbon dioxide equivalent, i.e. the amount of carbon dioxide that would produce an equivalent global warming effect over the same period (e.g. 100 years = GWP 100). The IPCC report [4] uses two values for assessing the climate change impact: a GWP value of 100 for a 100-year time horizon with a factor of either 25 or 34; and a GWP value of 20 for a 20-year time horizon with a factor of 84 or 86. While methane has a shorter residence time in the atmosphere than carbon dioxide, it has a radically higher effect so that the global warming factor is inversely proportional to the observation period. The higher values result from the inclusion of feedback mechanisms. The IPCC recommends using the GWP 100 metric to estimate the long-term climate effect of methane emissions.

- **Diffuse methane emissions**: The amount of methane that is released directly into the atmosphere through e.g. minor leaks in machinery and pipelines or tubes. These emissions are not caused by fuel combustion and / or energetic use.

- **Pre-chain emissions:** The total amount of greenhouse gases produced during the production and treatment of natural gas as well as the emissions that occur during the transmission, storage and distribution of gas. For one thing, the energy required for these processes generates greenhouse gas emissions; secondly, methane can reach the atmosphere, e.g. through leaks, during pre-chain activities. The total amount of all pre-chain emissions from the natural gas industry varies, depending on transmission routes and production types.

Europe

- In Europe, the percentage contribution of methane to **GHG emissions** is below the global average. It accounted for 10 % in 2017.[1]
- Methane emissions from the **crude oil and natural gas industries account for 0.6 %** of **all European greenhouse gas emissions** (Fig. 2).[1]
- In 2017, about 50 % of all methane emissions were generated by pre-chain activities of the European natural gas industry, i.e. during the **production of natural gas** and its subsequent transmission; the **other half was produced during gas distribution** (Fig. 3).
- **Since 1990, methane emissions** along the **natural gas value chain** in the EU **have been cut by more than 50 %**, despite the fact that gas consumption has increased by 25 % over the same period of time and although gas grids have been extended considerably (Fig. 4).[1]

FIGURE 2: Percentage contribution of methane to anthropogenic greenhouse gas emissions in Europe (2017) and origin of methane emissions[1]

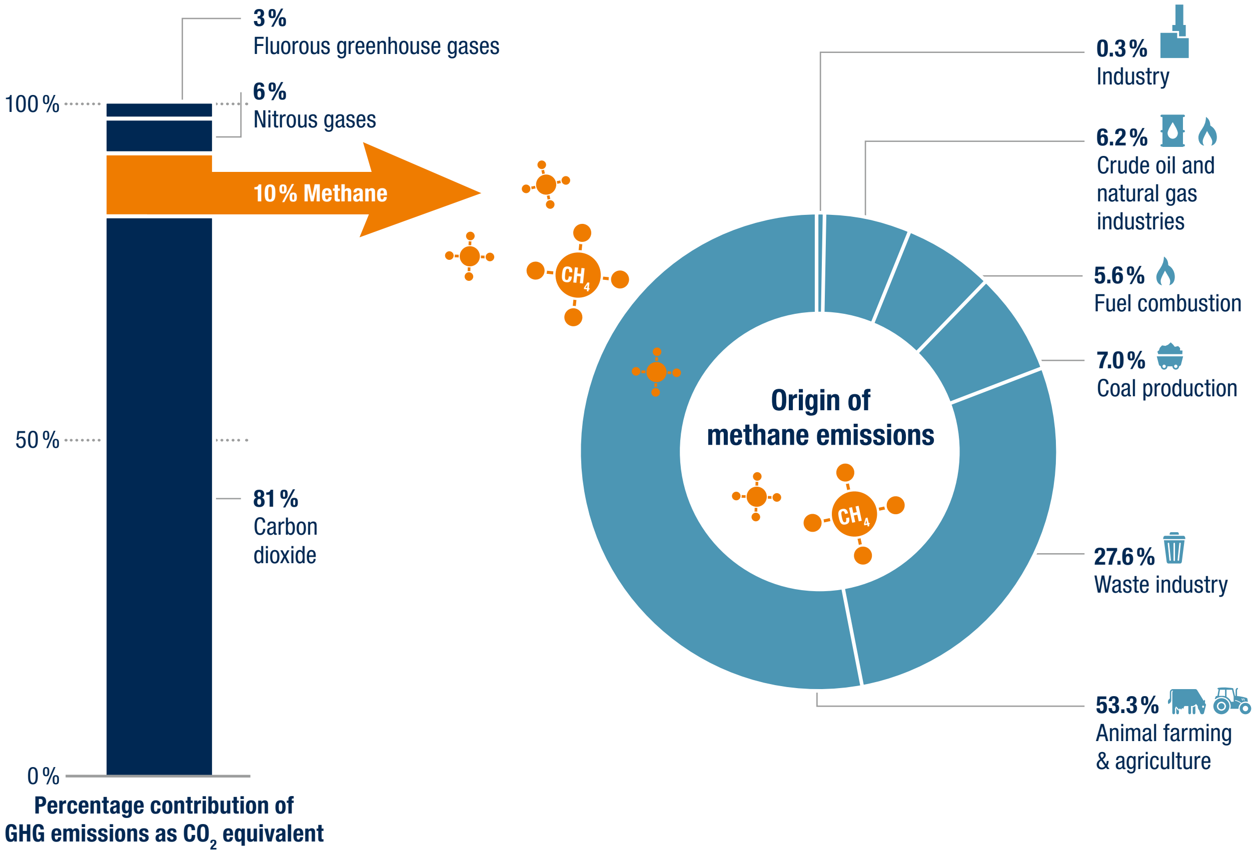


FIGURE 3: Percentage distribution of diffuse methane emissions from pre-chain activities of the natural gas industry in the European Union (EU28) in 2017[1]

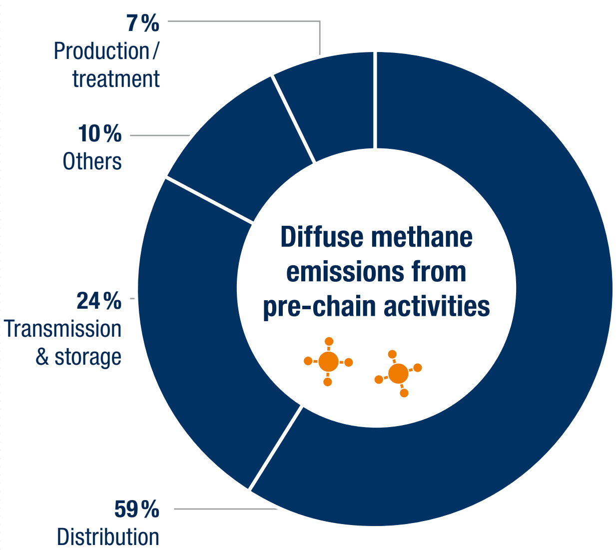
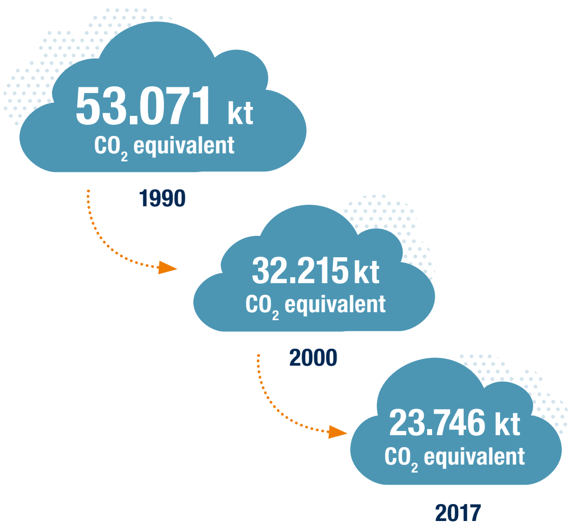


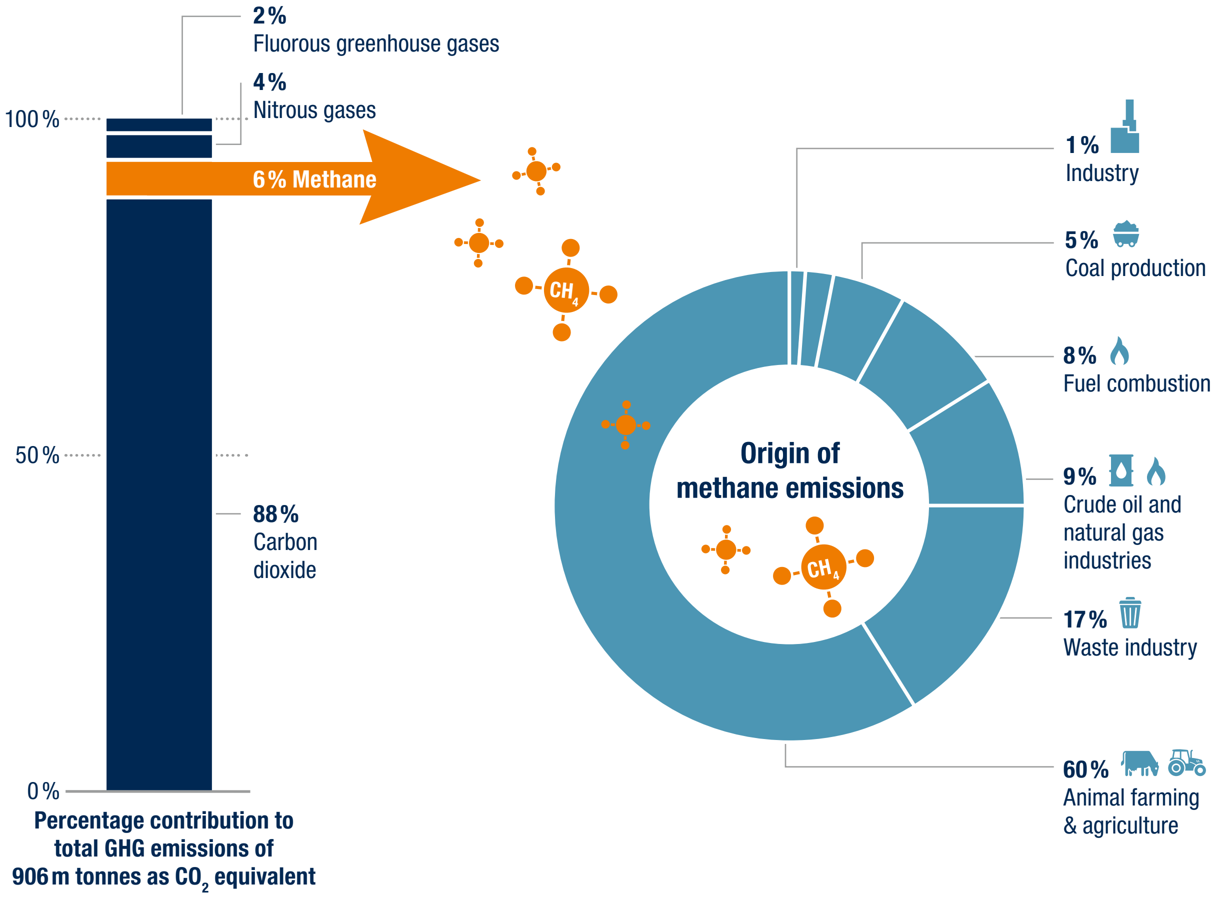
FIGURE 4: History of diffuse methane emissions from the natural gas industry in Europe in kilotonnes of CO_2 equivalent in 1990, 2000 and 2017[1]



Germany

- In 2017, **methane emissions** accounted for **6 %** of **total greenhouse gas emissions in Germany**, with the **crude oil and natural gas industries** contributing approximately **9 % of all diffuse methane emissions in Germany** (Fig. 5).[1]
- Based on these findings, **methane emissions from the crude oil and natural gas industries** account for only **0.5 %** of the **total GHG emissions in Germany**, which is **slightly below the EU average.**

FIGURE 5: Percentage contribution of methane emissions to anthropogenic greenhouse gas emissions in Germany (2017) and origin of methane emissions[1]



- **Pre-chain emissions** from the German natural gas mix account for approximately **12.5 % of total** natural gas **emissions**, including diffuse emissions and energetic use. Methane losses from the transmission and production of the gas used in Germany amount to approximately 0.6 %.[2]
- In **Germany, total natural gas emissions – including the climate impact of pre-chain emissions – amount to approximately 230 g CO_2 equivalent / kWh**, with about 18 g stemming from the energy required for transmission and production and about 11 g being accounted for by methane emissions from pre-chain emissions.[2]
- With respect to diffuse emissions from natural gas distributed across Germany, **84 % of all methane emissions are caused by gas transmission and distribution**, while gas production and treatment contribute 0.3 % (Fig. 6).[1]
- **Since 1990, methane emissions from the German natural gas industry** have **declined by 40 %** (Fig. 7).[1]

FIGURE 6: Percentage distribution of diffuse methane emissions from pre-chain activities of the natural gas industry in Germany in 2017[1]

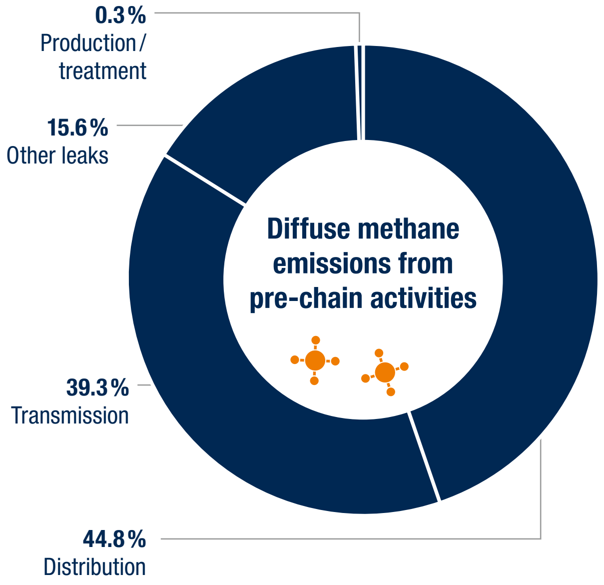
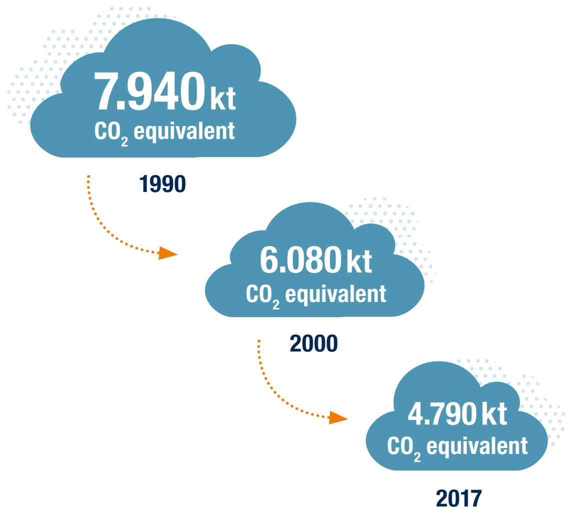


FIGURE 7: History of diffuse methane emissions from the natural gas industry in Germany, comparing figures from 1990, 2000 and 2017[1]



EMISSIONS COMPARISON

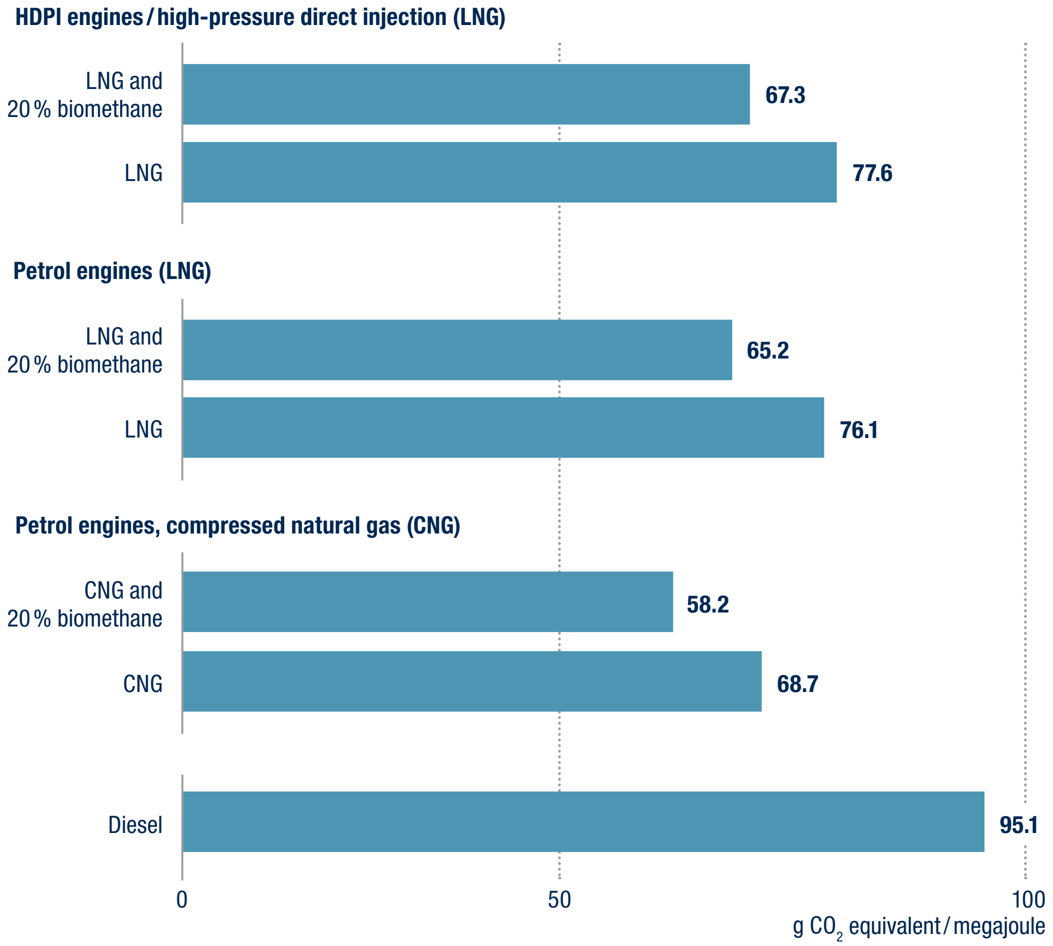
LNG vs. diesel

In view of the fact that liquefied natural gas (LNG) is becoming increasingly relevant alongside the pipeline-bound gas supply, the *Umweltbundesamt* (Federal Environmental Agency of Germany) decided to conduct a life cycle assessment of liquefied natural gas.[3] This meta-analysis of various studies shows that it does make sense to use LNG under certain conditions and for a range of applications.

Application options for LNG exist in particular in sectors like e. g. the mobility sector that still suffer from a lack of sophisticated state-of-the-art solutions. So-called "well to wheel" studies show that the use of natural gas produces significantly lower total GHG emissions than other fossil energy carriers such as diesel, for instance, even when including pre-chain emissions. CO_2 emissions from heavy-duty traffic could be reduced by up to 30 % if diesel were substituted with compressed natural gas (CNG),[7] while using LNG would reduce CO_2 emissions by one fifth (Fig. 8).

The total GHG emissions from pre-chain emissions that occur during the production and transmission of LNG vary depending on the supplier country. Key factors include the distance between the country of origin and the recipient country as well as technical conditions and the natural gas deposit and production types. Further progress in emission reduction is possible thanks to modernisation efforts and efficiency increases along the LNG value chain. Methane emissions from US-American crude oil and natural gas production are already declining.[8]

FIGURE 8: Well-to-wheel emissions* from heavy-duty traffic in g of CO_2 equivalent per megajoule[7]



* The "well-to-wheel" analysis is commonly used by the mobility sector to determine the greenhouse gas emissions from the overall fuel chain, i. e. from fuel production to the use of fuel in the vehicle.

Natural gas vs. coal

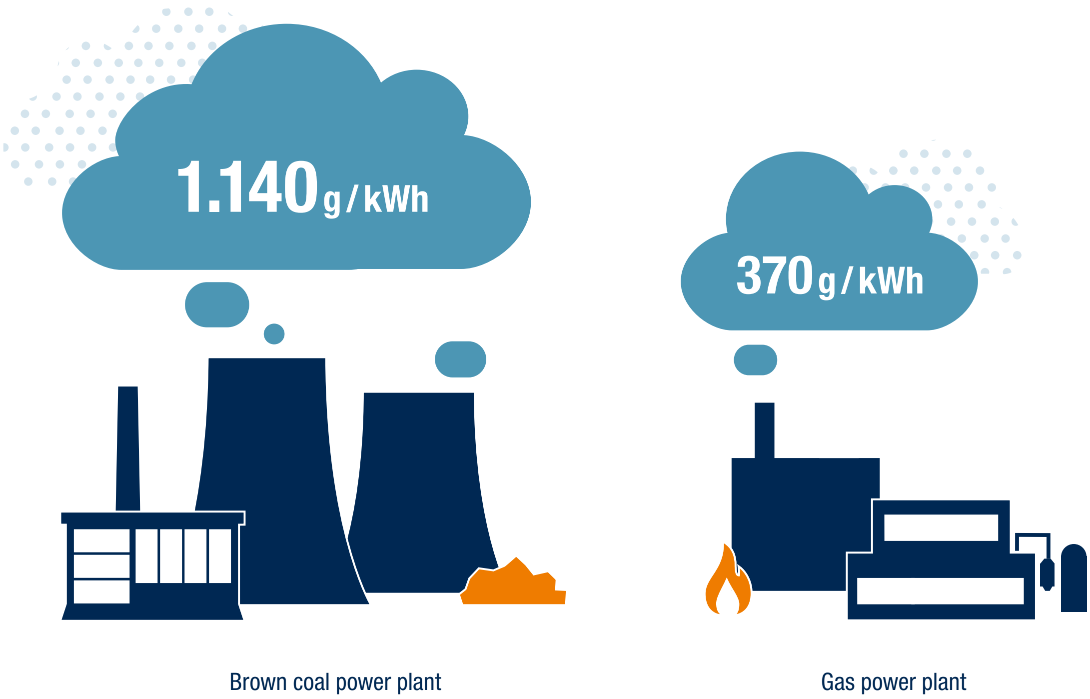
The lion's share of natural gas and coal produced these days is used to generate electricity and heat for the industry and for the operation of buildings. While CO_2 emissions from burning natural gas are lower than from burning coal, methane emissions as well as pre-chain emissions in general affect the overall GHG balance results for natural gas. It should be mentioned in this context that the production of other solid fuels, e. g. brown coal open cast mining, also releases methane.

Consequently, any GHG emissions assessment must take into account the total life cycle of a fuel, from its production to its use. A comparison of the net balances of the GHG emissions from different energy carriers, including emissions from the related pre-chain activities, nevertheless shows that using natural gas does have advantages over other fossil fuels.

Example: Power generation

- Based on estimates by the International Energy Agency (IEA) that considered both CO_2 and methane, about 98 % of the consumed gas has a lower life cycle emission intensity than coal, provided it is used for the generation of electricity or heat. This analysis proves that a switch from coal to gas would, on average, reduce the emissions from power generation and heat supply by 50 % and one third, respectively.[18]
- A comparison of GHG emissions shows that a gas power plant generates 370 g of CO_2 equivalent per produced kilowatt-hour (kWh), compared to 1,140 g produced by a brown coal power plant. This is due to the low CO_2 emissions of the gaseous fuel as such on the one hand, and to the higher efficiency of gas plants on the other (Fig. 9).

FIGURE 9: Comparison of CO_2 emissions from brown coal and gas power plants, in grams per kWh generated[9]



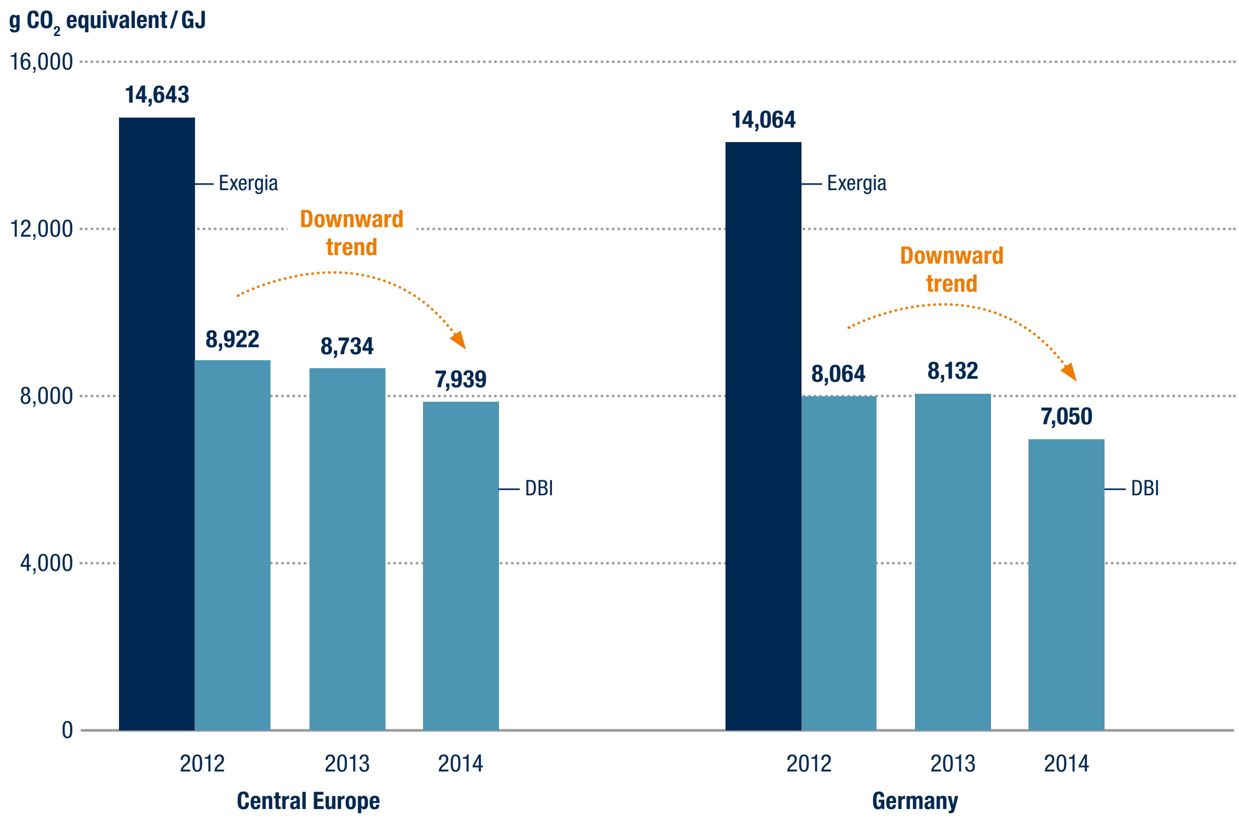
Effects of different databases and calculation models

A 2015 *Exergia* study that was commissioned by the European Commission concluded that the impact from pre-chain emissions related to natural gas – i. e. emissions generated during e. g. the production, transmission and distribution of natural gas – had hitherto been underestimated.[10]

The *DBI Gas- und Umwelttechnik* critically analysed these findings in 2016 and revised them on the basis of more recent data and updated calculation methods[2]: While the Exergia study indicated an average emission value of 14,643 g CO_2 equivalent per gigajoule (GJ) for Central Europe in 2012, the DBI found a lower value, viz. 8,922 g CO_2 equivalent / GJ (Fig. 10).

This difference is attributable to the fact that the DBI study used updated input data for gas transmissions up to the German border as well as for gas transmissions and gas distribution in Germany. These data eventually yielded a significantly lower emission value. The *Umweltbundesamt* (Federal Environmental Agency of Germany) audited the DBI review of the Exergia analysis and confirmed that it was correct.[11]

FIGURE 10: Comparison of emission values found by Exergia and by the DBI [2, 10]



Using the latest available data is also essential for a specific assessment of methane emissions from crude oil and natural gas production in the USA, for they show a downward trend.[8] This fact must be taken into account when looking at emissions from US-American pre-chain activities that have been calculated on the basis of older studies.

INITIATIVES BY THE GAS INDUSTRY

International initiatives

The increasing relevance of methane emissions from the natural gas infrastructure in media and political discussions has led to a series of initiatives. The *International Gas Union* (IGU) and the *Madrid Forum* are particularly important at the international and European levels, respectively. Moreover, efforts to reduce methane emissions have been going on for decades for environmental, economic and technical safety reasons, and have spawned many initiatives in this field.

Central initiatives [14]

The gas industry already employs many *best available techniques* (BAT) on a voluntary basis in its efforts to reduce methane emissions. These techniques are used for building and commissioning as well as for operating and maintaining the infrastructure.[12] Additionally, some of the biggest individual companies of the industry have voluntarily defined an average greenhouse gas emission reduction target of 2.3 % per annum. The industry uses special methane emission reduction programmes like *leak detection and repair* (LDAR) to this end. Such detection and management concepts help monitor plants and plant activities that search for and, ultimately, prevent potential gas leaks.

Other global initiatives include, among others, the *Methane Guiding Principles* industry initiative, the *Climate and Clean Air Coalition* (CCAC) – *Oil and Gas Methane Partnership* (GMP), the *EPA Natural Gas STAR Program*, the *World Bank's Global Gas Flaring Reduction* (GGFR), die intergovernmental and inter-industry *Global Methane Initiative* (GMI) and the *Oil & Gas Climate Initiative* (OGCI) industry association.

Europe aims to render the acquisition of emission data, data records and calculation methods transparent and to work towards harmonised and comparable standards. The gas industry will update the "carbon footprint" assessment and enhance the corresponding database. The data acquisition process in particular needs to be optimised.[12]

Central measures by the International Gas Union [14]

- The IGU points out that methane emissions play an increasingly important role in the global dialogue with environmental associations and the media, in particular. Therefore, the IGU calls upon
- the global gas industry to harmonise measurement methods and to systematically identify and cost-effectively eliminate emission sources, to communicate progress in a transparent manner, capture data records in a standardised way and make them available in a transparent fashion;
- governments to fund innovations designed to raise the technological and labour standards of the gas industry;
- all players to tackle large emission sources swiftly by employing cost-effective measures, bearing in mind the need to continuously improve the gas infrastructure.
- The IGU would like to set up a *Global Academic Expert Peer Review Panel* with the objective being to achieve transparency and create awareness of these problems.
- Companies, too, are called upon to educate their staff in line with their capacities, e. g. by training employees to become methane emissions experts and sharing the latest data on internet platforms.

Central requirements by the European platform for dialogue: The Madrid Forum [12]

- At the European level, the European Commission has set up the European Gas Regulatory Forum (Madrid Forum), a forum for dialogue that addresses numerous subjects related to the conflicting priorities of the gas industry and policymakers.
- European natural gas associations like *Gas Infrastructure Europe* (GIE) and *Marcogaz* have prepared some guidance for the Madrid Forum that includes, among other things, the harmonisation of definitions, comparison standards and methods for measuring methane emissions as well as the elaboration of joint reporting systems. Policymakers are called upon to create innovation funds designed to support the gas industry in the development of new technologies.

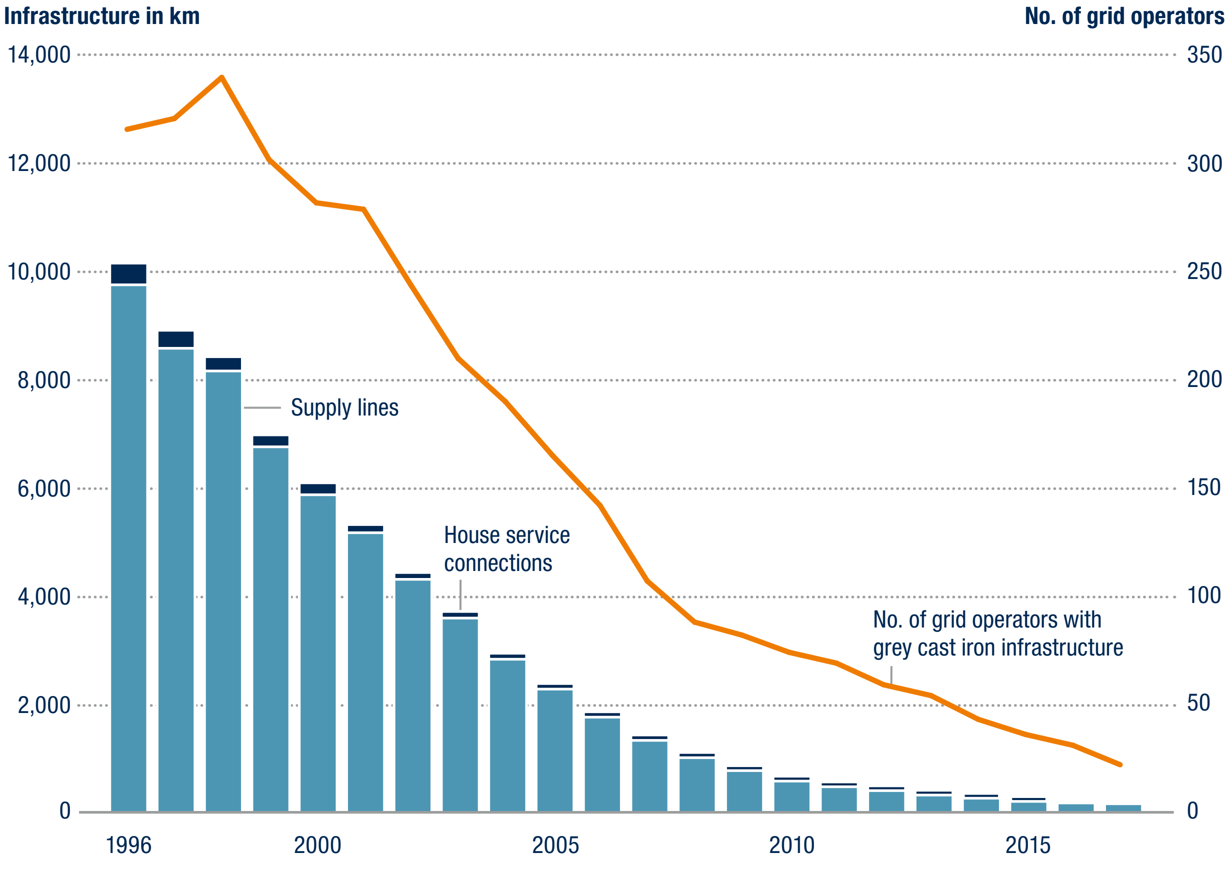
German initiatives

The German gas industry is continuously striving to reduce Germany's already low methane emissions further. Various measures have been and still are being implemented across all industries and by individual associations alike.

Inter-industry initiatives by the German gas sector

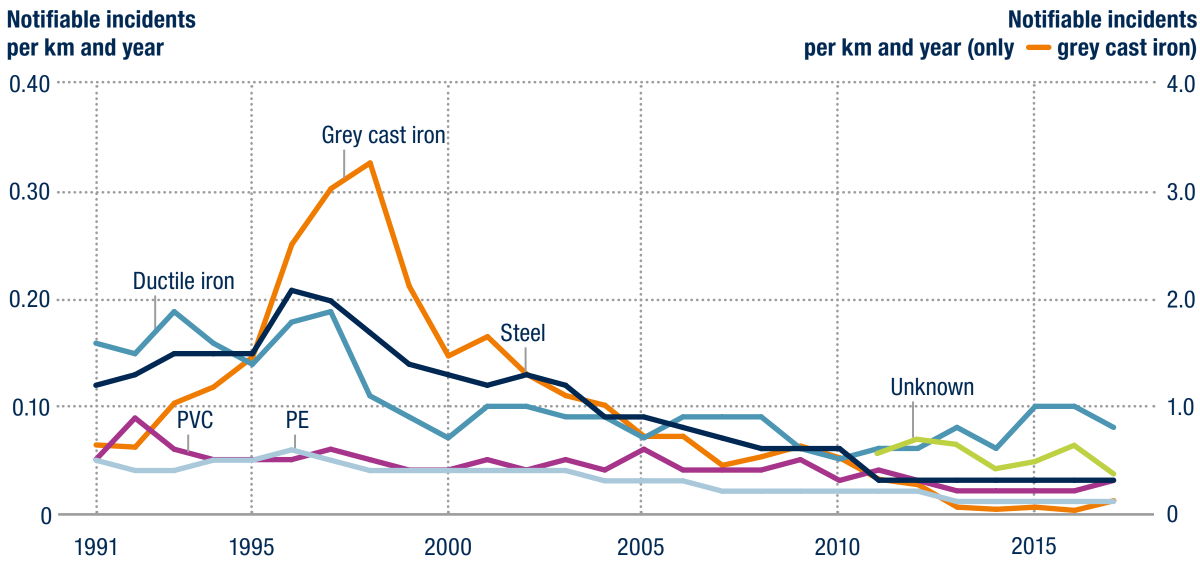
- As a consequence of the Kyoto Protocol and in the framework of the "Climate Protection Declaration of the German Gas Industry", the **German gas industry committed itself in 2001 to drastically reducing its methane emissions**.[13] German gas producers have since been working towards the implementation of potential measures designed to reduce emissions along the entire value chain. Their efforts have been successful: Since 1990, methane emissions have been reduced by about 40 %.[1]
- With its project "Guideline for technical measures for the reduction of methane emissions from the gas distribution network (ME-Red DSO)" the DVGW has prepared and published a guideline with technical measures to reduce methane emissions from the natural gas grid.[19]
- Some measures have already been implemented in the field and are successfully contributing towards reducing emissions, e. g. the use of **mobile compressors and mobile flares** instead of venting lines or the **abandonment of pneumatic valves**. The German gas industry will launch a **transparency campaign** to inform all citizens about the high safety and climate standards that apply to the German gas infrastructure.
- Since **1990, incidents of gas-line related leaks and damage have declined by 90 %**. This is partially due to large-scale modernisation projects. The replacement of old pipelines in particular led to a lower number of incidents and, consequently, fewer methane emissions.[6, 15] This proven strategy of using new technologies and pipe materials to achieve significant emission reductions will be continued.
- In recent years, almost all grey cast iron pipelines in Germany have been replaced, so that today only modern materials are used. This measure has contributed to a significant **reduction in damage and methane emissions** (Fig. 11).

FIGURE 11: Grey cast iron infrastructure 1996 – 2017[17]



- **An extensive measurement programme** is currently being carried out, with the objective being to further reduce and appropriately manage methane emissions from the German gas infrastructure. The programme specifically intends to improve the distribution network database and identify steps for further emission reductions.
- The DVGW principles on the acquisition of gas damage and accident statistics have been bindingly defined in Standard G 410 "Registration of Asset Inventory and Incident Data of Gas Infra-structures", which stipulates that gas utilities are obliged to report gas leaks to both the federal ministry and the local Land regulator as well as to the DVGW as the gas industry's rule-setting body. The **DVGW publishes an annual damage statistics report**. (Fig. 12).[6]
- Since many unwanted incidents in the gas grid are due to mechanical damage caused by third-party activities such as, for instance, excavation work, the DVGW and its partners have launched the *BALSibau* initiative.[16] This initiative provides relevant guidance and training for civil engineers and their staff. Gas pipeline-related incidents and accidents have been **significantly reduced** since the project was launched, with the corresponding effect on **methane emission sources**.
- Moreover, the DVGW offers regular information and training seminars on how to prevent damage to pipeline grids. **There is evidence of a decreasing number of incidents** in regions where such training courses were held.

FIGURE 12: History of notifiable incidents between 1991 and 2017 on all gas pipelines, broken down by material [15]



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This booklet provides an overview of the currently available facts and figures and reflects the current scientific state-of-the-art. For further information on methodology approaches and basic assumptions, please refer to the sources cited.

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