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Discussion Paper

Fracking: an option for Germany?
Opportunities, risks and uncertainties of fracking in unconventional reservoirs

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Discussion Paper

Should national shale gas extraction supplement the natural gas supply in Germany? This question was discussed anew in the course of the gas shortage in 2022. This publication of Impulse analyses arguments for and against the use of fracking in unconventional reservoirs. The following points can be summarised:

- **Low environmental risks:** The environmental risks induced by fracking **are low**. This concerns the risk of earthquakes, possible groundwater pollution and addi-tional methane emissions. However, residual risks cannot be ruled out.
- **Contribution to climate protection cannot be assessed conclusively:** Compared to importing fracked gas from the US, national extraction would result in **less CO_2 emissions** (elimination of liquefaction and transport). However, the extent **to which the additional amounts of fossil natural gas** would influence climate targets in the long term cannot be assessed conclusively.
- **Can only be used in the medium term:** If the fracking ban were to be lifted, gas extraction would probably not be possible for at least **three to four years**, due to the required technical and legal steps.
- **Greater security of supply:** National shale gas extraction would **increase** the supply security in Germany in the medium term. However, against the backdrop of an increasing supply of natural gas on the global market, this would also be possible through the **diversification of supplier countries**.

Contents

Fracking in Germany: an option?

Should fracking contribute to the energy supply in Germany? This question seemed to be answered with "no" after intensive debates and the decision of the Bundestag in 2016 to ban fracking. Against the backdrop of Russia's war of aggression against Ukraine, however, it took on a new meaning. Russia has almost completely stopped supplying natural gas to the European Union in the wake of the war. As a result, the availability of natural gas has fallen, and prices have risen sharply, at least temporarily. Against this background and in view of the climate policy goals, natural gas consumption must be reduced anyway, and natural gas must be replaced by renewable energy sources.

However, as long as natural gas is needed as a bridging technology, politicians are called upon to diversify the procurement options for natural gas. In addition to the increased import of liquefied natural gas (LNG), could or should the domestic extraction of natural gas from unconventional reservoirs through fracking (hydraulic induced fracturing) contribute to this diversification? This could supplement the extraction of natural gas in Germany from conventional reservoirs, which currently provides around five percent of the natural gas used in Germany. [1]

This paper discusses various issues relevant to a decision on whether fracking in unconventional reservoirs should be considered in Germany. In doing so, it considers technical, ecological, economic, social and overall systemic aspects. The statements made here are largely based on findings from a workshop conducted by the Academies' Project "Energy Systems of the Future" (ESYS) [2], on expert interviews and on an analysis of current literature.

1 The domestic extraction of natural gas amounted to 44 TWh natural gas in 2022 [2]. Even with this low production volume, the conventional reservoirs in Germany will be exhausted in a few years. In 2022, around 847 TWh of natural gas were consumed in Germany (2021: 1,029 TWh).

2 The workshop was held on November 2, 2022. The workshop participants were: Stephanie Dachsberger (acatech office), Dr. Berit Erlach (ESYS coordination office| acatech office), Prof. Dr.-Ing. Manfred Fischedick (ESYS Directorate | Wuppertal Institute), Dr. Dieter Franke (Federal Institute for Geosciences and Natural Resources), Prof. Dr. Hans-Georg Frede (University of Giessen), Jörn Gierds (ESYS coordination office | acatech office), Dr. Ulrich Glotzbach (acatech office), Matthias Hartung (Wintershall Dea), Dr. Gernot K. Kalkoffen (Exxon Mobil | acatech), Dr. Johanna Kemper (Wintershall Dea), Bernd Kirschbaum (Federal Environment Agency), Prof. Dr. Hans-Joachim Kümpel (acatech), Prof. Dr. Johann Christian Pielow (Ruhr University Bochum), Prof. Dr. Karen Pittel (ESYS Directorate | Ifo Institute), Daniel Raimi (Resources for the Future and University of Michigan), Prof. Dr. Michael Reinhardt (Trier University), Prof. Dr. Ortwin Renn (IASS Potsdam – Institute for Advanced Sustainability Studies), Prof. Dr. Dirk Uwe Sauer (ESYS Directorate | RWTH Aachen University), Frank Sailer (Foundation for Environmental Energy Law), David Schlund (EWI – Institute for Energy Economics at the University of Cologne), Prof Dr. dr hc Christoph M. Schmidt (RWI – Leibniz Institute for Economic Research | acatech), Dr. Cyril Stephanos (ESYS coordination office | acatech office), Prof. Dr.-Ing. Jan Wörner (acatech). This paper does not reflect the assessment of individual workshop participants but was written by the named authors for the paper after the workshop and based on the workshop results.

What is fracking, and where is it used?

Fracking involves injecting a fluid ("fracking fluid") into a subsurface under high pressure. This creates fissures, which are kept open by additives used in the fluid, allowing natural gas in the rock layer to escape. Fracking is used in both conventional and unconventional reservoirs. These differ in their geological properties:

- **Conventional reservoirs** refer to reservoirs in which hydrocarbons have accumulated in permeable reservoir rocks. Natural gas can be extracted from them without the use of fracking. However, fracking is sometimes also used in conventional reservoirs to mantain economic production rates. Fracking in conventional reservoirs has been used for this purpose around three hundred times in Germany since the 1960s and is still not prohibited today. Compared to unconventional reservoirs, its use is less controversial in view of other methods (e.g. regarding the type and quantity of chemicals used).
- The concept of **unconventional reservoirs** is fuzzy and not used consistently. Unconventional reservoirs usually have very low permeability, so it is necessary to break up the rock and create fractures ("fracs") in order to extract gas. Fracking is, therefore, a prerequisite for extracting natural gas from unconventional reservoirs. For this purpose, a deep borehole is drilled into the gas-bearing sediment layers and continued by horizontal drilling (see Figure 1). The fracking fluid is pumped into the subsoil through the borehole. Because the rock layers are often shale, natural gas extracted in this way is often referred to as "shale gas".

In the following, this publication focuses exclusively on fracking in unconventional reservoirs.

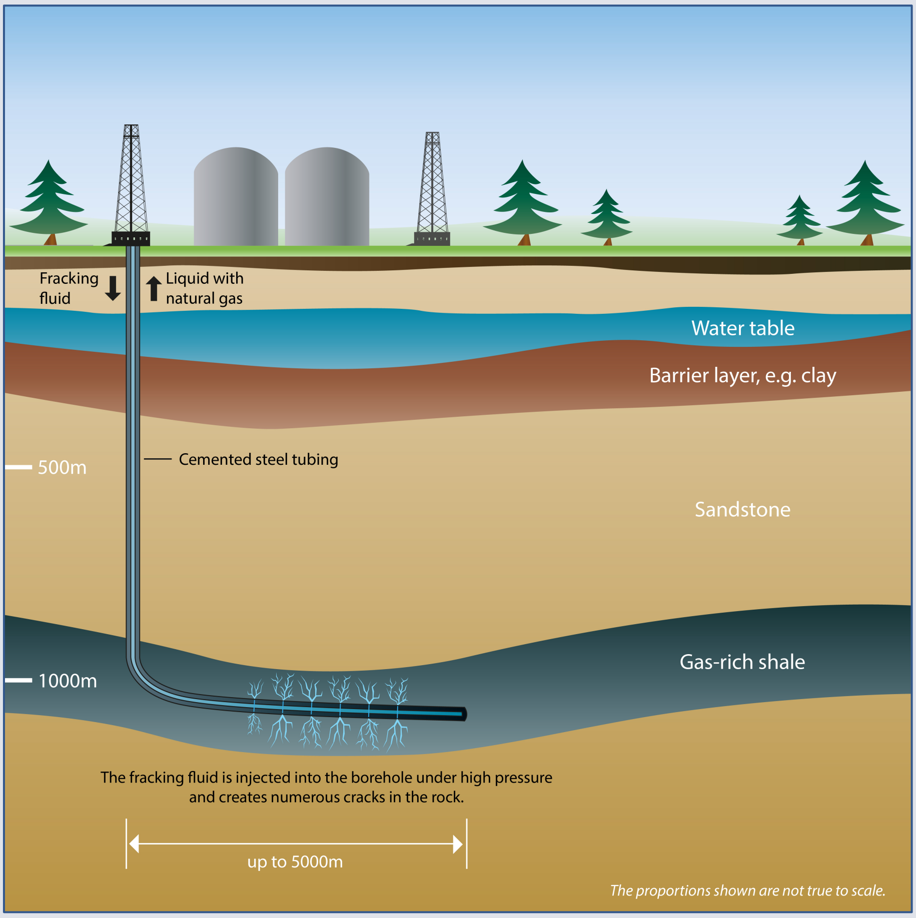

Figure 1: Schematic diagram of the fracking process (Source: bilderzwerg/stock.adobe.com, figure changed)

1. What is the natural gas potential in unconventional reservoirs in Germany?

In order to classify the possible importance of extracting natural gas from unconventional reservoirs in Germany, the magnitude of the existing natural gas potential must first be clarified. However, there is no clear answer to this question: The Federal Institute for Geosciences and Natural Resources (BGR) estimates that **320 to 2,030 billion cubic metres of technically recoverable shale gas are present in Germany** at a depth of between 1,000 and 5,000 meters ([1] p. 86).[3] These potentials are referred to as **resources** [1]. The largest reservoirs in Germany are located in Lower Saxony on the border with North Rhine-Westphalia (see Figure 2). Within the European Union, only France, Spain and Romania have larger shale gas resources than Germany.[4]

So far, there are no estimates as to what proportion of the natural gas resources could be economically produced given current technology and prices. In addition, there are other limiting framework conditions: For example, some resources are not eligible for extraction because they are located under cities or in nature reserves. The amount of natural gas that can actually be extracted is referred to as **reserves**. Dedicated investigations with exploration drilling would be necessary in order to analyse the reserves in Germany. These investigations have not yet been carried out for Germany [6][5], so only estimates are available thus far.

Experts estimate that around 5 to 10 billion cubic metres of natural gas could be extracted from unconventional reservoirs in Germany every year. This corresponds to around 6 to 12 percent of natural gas consumption in Germany, based on the year 2022.[6] Production of this magnitude would require around 400 to 800 wells. These would be located on around 30 to 60 so-called cluster sites.[7]

3 If potentials between a depth of 500 m and 1,000 m are also taken into account, the amount of technically extractable shale gas in Germany increases to between 380 and 2,240 billion. m^3 ([1] p. 86). However, with extraction at a depth interval of 500 to 1,000 m, the risk of adversely affecting the groundwater increases. It is therefore recommended to keep a distance of 1,000 m to aquifers when drilling fracking wells (cf. e.g. [3]). In the past, however, there have also been fracking wells in the USA at depths of less than 1,000 and 500 m [4]. Extraction from depths of more than 5,000 m would be technically possible but is costly and generally uneconomical [5].

4 About 6% of the global shale gas resources are located in Europe. The majority of resources are located in North America (24%), Australasia (22%) and Latin America (20%) ([1] p. 90).

5 According to the Federal Environment Ministry, neither the responsible federal states nor companies have shown any initiatives for test drilling in the past [6]. The Lower Saxony state government is currently ruling out test drilling [7].

6 1 billion m^3 of natural gas corresponds to around 10 TWh of natural gas. Germany consumed around 847 TWh of gas in 2022 [2].

7 This range reflects the figures discussed at the ESYS workshop.

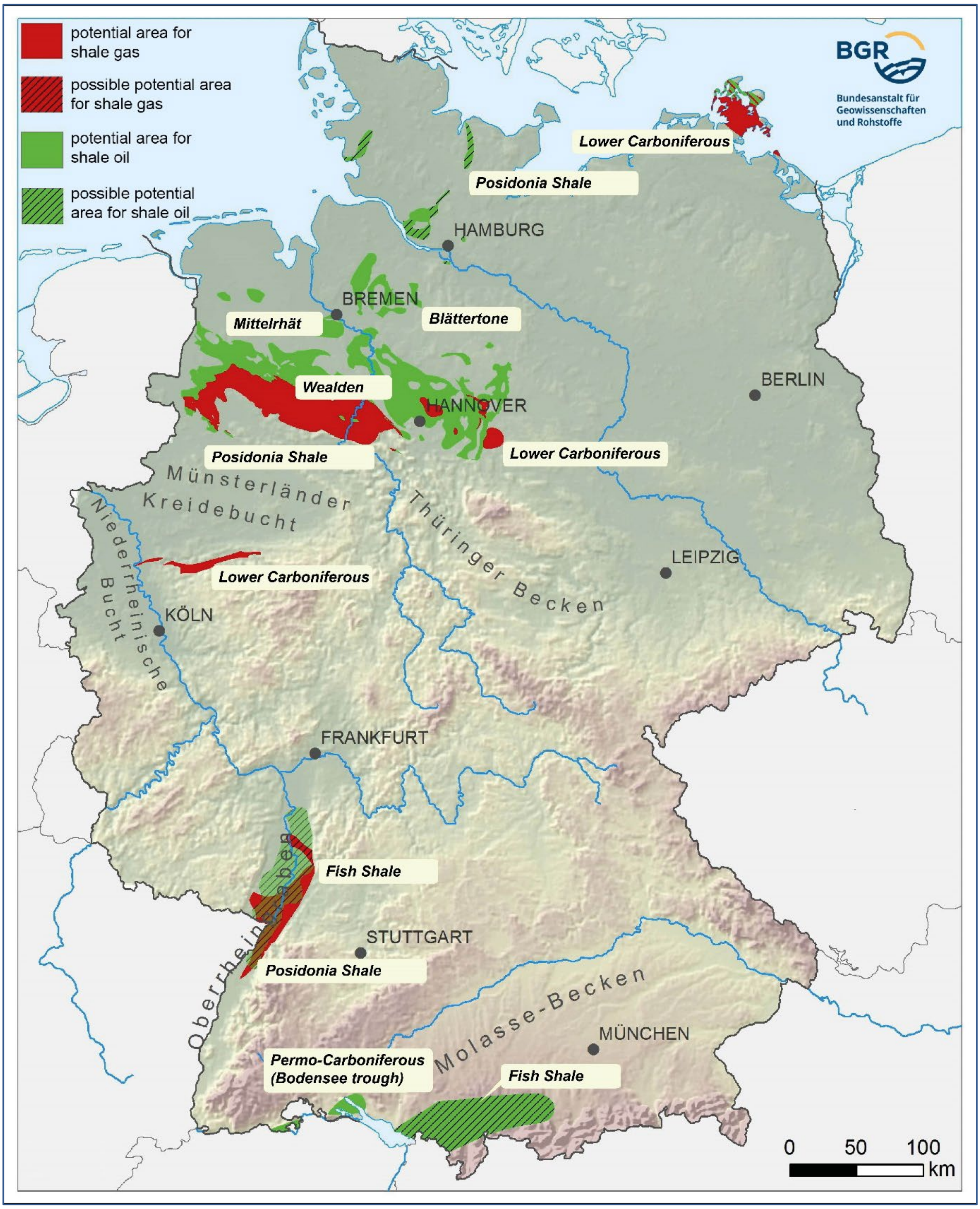

Figure 2: Overview of potential areas in Germany (Source: Digital Terrain Model: © GeoBasis-DE/BKG2015, data modified([1] p. 29))

2. Can experiences with possible environmental risks of fracking from abroad be transferred to Germany?

Germany and Europe have virtually no experience with fracking of unconventional reservoirs. However, for the assessment of environmental risks associated with fracking, we can draw on **extensive experience from abroad**[8]: Alone in the **USA**[9], around two million wells were drilled by 2020. Significant environmental damage was sometimes incurred, particularly in the early days of the fracking boom. Many US states have subsequently introduced environmental standards for the process and have increased these over time, thereby reducing environmental risks.

Much of the environmental damage that occurred in the USA in the early years of the fracking boom could be avoided in **Germany**, according to the Expert Commission on Fracking ([8]). In Germany, strict environmental requirements apply in many areas, which apply to the fracking of unconventional reservoirs and would go beyond the international standard. In Germany, for example, there is a Strategic Environmental Assessment (SEA)[10] and requirements for Environmental Impact Assessment (EIA) for fracking projects that do not apply in the USA, Canada and Australia ([10] p. 9 f.). Nevertheless, even when applying high environmental regulations, **residual risks** to the environment are not entirely unavoidable. This is especially true in Germany, given the dense settlement structure.

3. How significant is the risk of causing earthquakes through fracking?

In **Germany**, the risk of causing an earthquake from fracking is estimated to be **very low** ([8] p. 24 f.; [1] p. 173). To further reduce risks, the Expert Commission on Fracking recommends, among other things, a traffic light system based on detailed monitoring. This provides for seismological monitoring of areas where fracking is being carried out and, if seismicity is measured, for fracking measures to be reduced or stopped. However, it is impossible to avoid earthquake risks altogether, even when applying high standards. In recent years, earthquakes with significant damaging effects have occurred in individual cases in various areas of the world, which have been linked to fracking.[11] However, compared to the high number of fracking wells drilled **worldwide**, damaging earthquakes have only occurred in rare cases ([9] p. 152).

8 Fracking can only trigger earthquakes if stresses are already present in the subsoil. The fluids injected into the ground can reduce friction between the layers. Foreign geosystems with shale gas reservoirs (e.g. in the USA, Australia and Canada) are comparable to those in Germany. In Germany, however, higher tectonic stress can be assumed in certain areas, e.g. for the potential shale gas reservoirs in the Rhenish Massif ([8] p. 5). The main difference in large areas is a higher settlement intensity in shale gas reservoirs in Germany and Europe.

9 The United States is the world's largest producer of shale gas. In 2022, around 800 billion m^3 of shale gas were extracted there. This corresponds to approx. 80% of US natural gas production [8]. Shale gas is also extracted to a lesser extent in other countries (particularly China, Canada and Argentina).

10 The Strategic Environmental Assessment is a regulation for the planning and pre-intervention investigation of a project and serves, among other things, to define exclusion areas when selecting a site.

11 A fracking-induced earthquake in the Sichuan Basin, China, in February 2019 killed two people and injured 19 others. This earthquake was the first and, so far, only one induced by fracking that resulted in fatalities. Further earthquakes induced by fracking with considerable damaging effects have also been detected in Canada, Argentina and the USA ([8] p. 11 f.).

4. What are the risks of fracking for groundwater and surface water?

The Expert Commission on Fracking ([8] p. 22) estimates the risk of pollution of near-surface groundwater and surface waters through fracking of deep-lying (> 1,000 m) natural gas reservoirs to be **low**. So far, there is no evidence **worldwide** for the contamination of the near-surface groundwater by fracking fluids [12] or reservoir water [13] ([10] p. 12), although the authors note that such a risk cannot be ruled out for all geosystems. On the other hand, the most significant negative impact on groundwater and surface water comes from the **handling of water-polluting substances at the surface** of the extraction site ([10] p. 87).

In order to minimise the risks for groundwater and surface waters, the Expert Commission recommends comprehensive **baseline monitoring**, which records the condition of the area prior to fracking drilling and enables monitoring activities during and after fracking. In addition, before fracking wells are drilled, it must be clarified how to deal with the potentially accumulating so-called **flowback** [14], consisting of fracking fluids and reservoir water. This should be processed and reused as far as possible.

According to industry representatives at the ESYS workshop, between 30 and 70 percent of the liquids produced can be recycled and reused. In US practice, however, due to the high costs, only a very small proportion (less than one percent) of the liquids are treated and reused – the majority are injected into boreholes. Such deep injection is only permitted to a limited extent in Germany.[15] Disposing of large quantities of extracted water could thus become an important decision-making criterion for fracking unconventional reservoirs in Germany ([10] p. 81).

Epidemiological studies, available especially from the USA, show associations between fracking and **health effects**, primarily through flow back (e.g. [11]; [12]) and air pollutants [13].[16] However, the data available to date does not allow us to make reliable statements about the existence or non-existence of causal relationships ([14] p. 1007).[17] Against this background, it is important to evaluate health hazards in the vicinity of fracking extraction sites from a human toxicological point of view.

5. How much water is used in fracking?

The water requirement for fracking can be up to 19,000 cubic metres per well ([10] p. 71; [15]; [16]; [17]).[18] The exact consumption depends on the geosystem, the fracking method used and the number of fracs. The quantities of water required for fracking unconventional reservoirs usually account for only a very small proportion of regional water consumption. In the past, however, so-called water stress caused by fracking

12 The fracking fluids are the sum of all liquids introduced during fracking. Fracking fluids are composed of water and so-called fracking additives. Such additives include: hydrochloric acid, which cleans the pipes and helps fracture the rock, and corrosion protection that protects the plant, equipment and drill string. Wollin et al. [14] note the high number of chemicals used, some of which have unexplained toxicity. In Germany, however, according to the Fracking Act (Fracking-Gesetz), no water-polluting additives may be used in fracking in unconventional reservoirs.

13 Reservoir water is groundwater that occurs in deep aquifers and contains a high concentration of dissolved salts and sometimes also natural radioactive isotopes.

14 Flowback refers to the fluids that escape superficially at the well surface during and up to about a month after fracking. The water that flows out of the well over the long term is referred to as extracted water and increasingly consists of reservoir water.

15 The injection of fracking fluid is not permitted in Germany. Only the recirculation of reservoir water is permitted to a limited extent ([8] p. 22).

16 A recent study by Harvard University [13] found that people living in the immediate vicinity of, or downwind from, extraction sites have a statistically significant increased risk of death (+ 2.5%). The results suggest that air pollutants emitted by extraction sites and carried by the wind contribute to increased mortality.

17 In particular, this is due to the fact that data are not available due to a lack of baseline monitoring [14].

18 This figure aligns with estimates by the International Association of Oil and Gas Producers. It estimates that between 10,000 and 20,000 m^3 of water is required for a horizontal well in Europe [15]. Raimi [16], as well as Kondash and Vengosh [17] indicate the water consumption per unit of energy produced. According to this, the water consumption is between 6 and 23 litres per gigajoule or between about 20 and 80 litres per MWh. Water consumption occurs selectively during fracking, not over the entire extraction period.

occurred in individual (water-scarce) regions of the USA ([10] p. 71, [18]). Water stress occurs when twenty percent or more of the renewable water supply is used [19].

As climate change progresses, high water consumption is becoming more relevant: regionally, high water demand for fracking could exacerbate **water scarcity** in dry and drought conditions. As a rule, this would first affect ecosystems that depend on groundwater, such as wetlands, moors, marshes and forests. At the same time, the need for agricultural irrigation will increase in the future due to rising temperatures and more extended periods of drought, which will lead to growing competition for available groundwater. There is a need to research whether and to what extent fracking of unconventional reservoirs in **Germany** could exacerbate a potential water shortage.

6. How high are the methane emissions caused by fracking?

During the extraction and processing of natural gas, a proportion of the natural gas usually escapes into the atmosphere. Since natural gas (methane) is a potent greenhouse gas, the proportion of this methane emission is particularly relevant. [19] Methane emissions from fracking in unconventional reservoirs are **of the same order of magnitude as those from natural gas extraction in conventional reservoirs** ([20] p. 32 ff.). This is because the vast majority of methane emissions (approx. 99 percent) in the natural gas value chain are not generated during exploration [20] but during extraction, processing, storage and transport as well as distribution. These process steps are almost exclusively independent of the reservoirs [21], since, for example, the gas is processed in the same gas network in both extraction methods. More important for the level of methane emissions, on the other hand, is the age and maintenance status of the extraction plants ([21] p. 30).

International literature states widely differing values regarding methane emissions in the natural gas value chain. These range from 0.1 to 17 percent ([20] p. 11; [21]). Estimates of the expected methane emission rate from possible shale gas extraction in **Germany** also differ:

- A report commissioned by the Expert Commission on Fracking assumes that emission rates significantly lower than one percent can be expected for extraction from unconventional reservoirs provided the best available technology [22] is used ([20] p. 5).
- The Expert Commission does not agree with the report's assessment and assumes that the methane emission rate in Germany would be around two to four percent ([8] p. 23).

The various data on methane emission rates can be attributed, in particular, to **inadequate measurement techniques**. Against this backdrop, the Expert Commission on Fracking advocates improved methane monitoring, which includes a combination of site-based measurements (bottom-up approach) and measurements by remote sensing, such as satellites and drones (top-down approach).

19 In the first 100 years after release, methane contributes about 25 to 34 times more to the greenhouse effect than carbon dioxide. In the first 20 years after release methane is about 84 to 86 times as strong as carbon dioxide [22]. Against this background, methane leakage is particularly relevant to climate change. In addition to the energy industry, methane emissions occur in particular in agriculture and waste management.

20 The exploration process includes the so-called “hydrofracturing completion”, which comprises the actual fracking process with the development of the well, including all associated technical equipment required [20].

21 A clear allocation to gas extraction from unconventional reservoirs can only be made for the well workover. However, this accounts for only 0.8% of extraction emissions (a total share of 58%) [20].

22 The best available technology should be used both in exploration and development of the reservoir as well as in extraction, processing and distribution in connection with the custody of wells and the context of monitoring ([20] p. 60). The use of low-emission compressors and valves could have a particularly high impact, as these components are responsible for a large proportion of emissions during extraction (ibid. p. 35).

7. What impact would fracking have on climate protection in Germany?

In order to be able to assess the effects of fracking in Germany on climate protection**, various effects** must be taken into account: On the one hand, shale gas extracted in Germany would have a **lower CO_2 emission factor than imported LNG** since domestic extraction and distribution does not require energy for liquefaction, regasification and shipping of LNG.[23] In addition, the methane emissions from the extraction and distribution of natural gas in Germany could be lower than in other countries due to **comparatively high environmental standards**.

On the other hand, given the high global demand, it can be assumed that additional natural gas extracted in Germany would **not replace previously imported quantities on the global market** but would be offered in addition to these. The increased supply could lead to a slight drop in natural gas prices on the global market. However, given the relatively small quantities in relation to global supply (5 to 10 billion cubic metres of gas extracted in Germany corresponds to around 0.125 to 0.25 percent of global natural gas extraction in 2021), this effect is likely to be limited.

Should the regional price of natural gas in Germany and Europe fall due to fracking in Germany, this could lead to **coal being replaced more quickly** by natural gas. That could reduce greenhouse gas emissions, as burning natural gas produces less CO_2 than burning coal.

23 According to BGR, the total energy consumption for LNG (liquefaction, transport and regasification) is between 7.5% and 19% of the energy supplied ([21] p. 34 ff.).

8. Can fracking increase the security of supply in Germany?

After a significant increase in natural gas prices in 2022, the situation on the global market has eased again. However, bottlenecks in the natural gas supply could still occur in the coming winters [23]. In addition to the reduced supply of natural gas on the global market, increasing demand for LNG from China could also exacerbate the possible bottleneck situation in Europe in the coming months [24].[24] **In the medium and long term**, on the other hand, the risk of a gas shortage in the European Union and Germany is expected to decrease significantly. Climate protection measures in Germany and Europe, such as increasing efficiency and expanding renewable energies, will result in the demand for natural gas falling continuously in the coming years.

Estimates of the Copernicus project Ariadne ([25] p. 26) assume that gas demand in Germany could fall to around 600 terawatt hours by 2025 (down 29 percent compared to 2022) and to 400 to 500 terawatt hours by 2030 (down 41 to 53 percent compared to 2022).[25] After 2030, if the climate neutrality target is implemented by 2045, an additional rapid decline in natural gas demand is to be expected [26].[26] At the same time, calculations show that the supply of LNG on the global market could increase rapidly from 2026 [27].[27]

In principle, the following applies: as long as natural gas is used in Germany, domestic fracking would strengthen the **resilience** of Germany's natural gas supply, as higher national extraction would reduce dependence on imports from other countries. In order to assess the contribution of fracking to the security of supply, however, it is also essential to consider the time frame in which fracking from unconventional reservoirs could be implemented in Germany.

9. How soon would fracking be possible in Germany under current legislation?

Fracking of unconventional reservoirs is prohibited by law in Germany.[28] In order to extract domestic shale gas, the German Bundestag would have to lift this ban – and a broad social and political debate would be needed beforehand. Following the repeal of the fracking law, the general mining and water law regulations would apply. While mining law already has a differentiated regulatory framework for site construction, drilling, production operations and dismantling (e.g. through ABBergV, EinwirkungsBergV and the deep drilling ordinances of the federal states), in water law, the addition of fracking-specific regulations to the existing legal framework should be examined, for example in order to introduce water protection and precautionary standards with regard to water-polluting substances.[29] In addition, European law would have to be considered when designing the legal framework for fracking. However, according to statements by legal experts at the ESYS workshop, there are no fundamental concerns about fracking under EU law.

24 According to the International Energy Agency (IEA) ([24] p. 3), the European Union will have to import an additional 40 billion m³ of LNG by the end of 2023 compared to the previous year. However, the IEA expects that this year only 20 billion m³ of additional LNG will be offered on the global market. In addition, Chinese demand for LNG is expected to increase sharply compared to 2022, which could lead to additional competition for the scarce LNG supply.

25 Other studies point to a smaller decline by 2030 (e. g. dena ([28] p. 21): 711 TWh).

26 Meta-studies, e.g. Kopp et al. ([26]) show that a sharper fall in natural gas demand is expected from the point at which greenhouse gas emissions fall by more than 70% compared to 1990. According to the Climate Protection Act (Klimaschutzgesetz), this is expected to happen in Germany in the early 2030s. After all, according to the German Climate Protection Act, the aim is to reduce GHG emissions by 65% by 2030, by 88% by 2040 and by 100% by 2045 compared to 1990.

27 According to projections by the Institute for Energy Economics and Financial Analysis (IEEFA) ([27]), LNG will remain a scarce and expensive commodity, especially until 2025. Long-term supply contracts with delivery before 2026 are sold out. However, according to the research institute, the supply of LNG will increase rapidly from 2025.

28 Prohibition according to section 13 a of the Water Resources Act (Wasserhaushaltsgesetz). Exceptions are up to four test wells which have not yet been drilled.

29 According to the current legal situation, handling water-polluting substances is partly subject to the same requirements as agricultural operations.

According to industry representatives, it would take **5 to 9 years** before extraction can start in the current administrative procedure. Once the ban on fracking is lifted, natural gas-extracting companies would be able to initiate the administrative procedures necessary to put the drilling site into operation. Figure 3 illustrates these steps as an example, consisting of the permit process, preparation of the operating plans for the exploration, including the environmental impact assessment (EIA), production permit, planning approval process with subsequent renewed EIA as well as the simultaneous approval procedure under water law, the procurement of the plants and the technical construction of the production site. A prerequisite would be a rapid build-up of the required expertise in the companies. Appeal procedures could result in a further delay of several years.

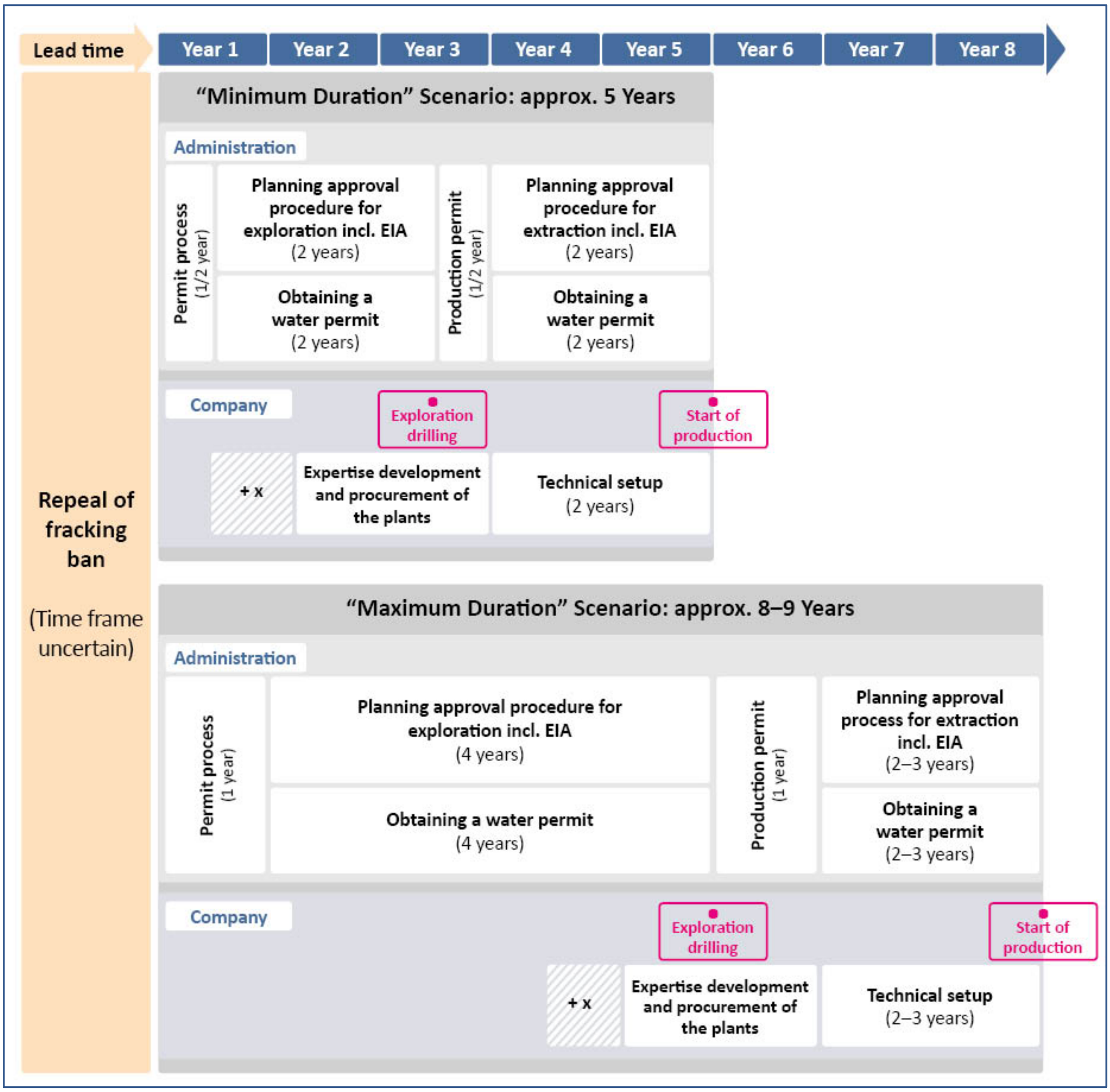

Figure 3: Provides an exemplary illustration of the administrative procedures for a fracking well with additional steps after estimating "minimum duration" and "maximum duration". The timelines reflect the results of the workshop conducted by ESYS. Source: own figure.

If an exploration well in an unconventional reservoir is successful, it can be used directly for extraction and extract the majority of the natural gas available there within 2 to 3 years.[30] Shale gas extraction can be scaled up or down at short notice.

10. Could the time it takes to commission fracking wells be significantly reduced?

According to estimates by industry representatives at the ESYS workshop, the period from permit procedures to the start of extraction in a well could be reduced to **3 to 4 years**.[31] Such a reduction of the administrative procedure could be based on the rapid construction of the LNG terminals within the framework of the LNG Acceleration Act (LNG-Beschleunigungsgesetz), which significantly reduces the planning and approval processes. For this purpose, for example, the requirements for the upstream environmental assessments would have to be redesigned. It would be conceivable, for example, not to carry out any environmental impact assessments, including public participation, for fracking projects, at least in the exploration phase, but only to carry out a preliminary EIA assessment, as is already stipulated for smaller-scale extraction projects.[32] At the same time, it would be conceivable to waive the requirement for a permit under water law for fracking projects.

However, to what extent changes to the EIA requirement would be possible under European law remains to be seen. In addition, experts at the ESYS workshop pointed out that shortening environmental assessments and restricting the possibilities for objection could reduce the acceptance of fracking, which is already being critically discussed. Industry representatives who participated in the ESYS workshop consider the potential to parallelise planning and approval steps to be low. For example, the construction of production facilities is only applied for after successful exploration. However, combining the environmental assessments for the exploration and extraction phase would be conceivable.

11. Are there viable business models for fracking in Germany?

It remains to be seen to what extent shale gas from Germany could be extracted at **competitive prices** (in the future).[33] The United States has a mature fracking industry, given the extensive fracking activity in recent years. This is lacking in Germany, which is why economies of scale are not to be expected, at least for the time being. The Energy Economics Institute of the University of Cologne (EWI) estimates that the extraction costs for fracking in Germany could be in a range between 26 and 43 euros per megawatt hour[34] ([30] p. 22).[35] Estimates of the future price of natural gas in Europe range between 25 and 66 euros per megawatt hour in 2026 and between 18 and 59 euros per megawatt hour in 2030 ([31] p. 3). Gas from

30 In order to continue using a well, it can be partially re-fracked or diverted (diverting involves drilling in a different direction within the shale formation to develop additional gas in neighbouring areas). New wells are usually required within the cluster sites to ensure consistently high gas extraction over several years.

31 The assessment is consistent with statements by Charlotte Krawczyk, Chair of the Expert Commission on Fracking, who estimates the period at three years plus groundwater monitoring [8, 29].

32 Cf. section 1 No. 2.b of the Environmental Impact Assessment Test Ordinance [Mining UVP-V Bergbau]. An EIA preliminary assessment is planned if the expected daily extraction volume does not exceed 500,000 m³ of natural gas. A full environmental impact assessment, including public participation, would only be required if the preliminary assessment showed that the project could have significant adverse environmental effects. According to the law, an EIA preliminary check must be carried out within six weeks. As a rule, the period is around 3 to 6 months, according to estimates from the business community.

33 The production costs of shale gas depend, in particular, on the productivity of the well and the well depth. It can also be assumed that the costs will increase with the degree of safety and environmental standards. However, experience from the United States shows that even in Colorado, where strict environmental regulations apply, there is a great deal of shale oil and shale gas extraction. This indicates that the additional costs caused by environmental regulations are not prohibitively high.

34 European Monetary Union [EWI] data are based on Riedel et al. ([32]) and have been adjusted for inflation in consultation with the EMI for the current year.

35 Additional price components such as transport or profit margin are not included in this figure and would lead to higher prices. Riedel et al. ([32] p. 297) also point out that their cost estimates for shale gas extraction in Europe do not take into account costs for environmental regulations.

fracking of unconventional reservoirs in Germany would probably only be competitive compared to imported LNG if the actual extraction costs were at the lower end of the estimated range.

In addition, it remains to be seen whether the establishment of a domestic fracking industry would be worthwhile from a business perspective, given the **limited remaining period** for natural gas extraction in Germany. According to the Expert Commission on Fracking ([8] p. 9), extraction from an unconventional reservoir is usually operated for 20 to 30 years due to the high development costs.[36] However, depending on the achievable margins, the investments could also be profitable earlier, according to industry representatives at the ESYS workshop.[37]

36 This would require regular new drilling and fracking to maintain extraction in the reservoir.
37 This depends in particular on the development costs. In the case of shale gas extraction in Lower Saxony, for example, the costs for connecting to the gas infrastructure could be low due to the proximity of Lower Saxony's shale gas reservoirs to existing gas pipelines, according to business representatives at the ESYS workshop.

Summary and conclusions

Can or should fracking in Germany contribute to the German energy mix? An evaluation of the facts shows that there are arguments for and against developing unconventional reservoirs in Germany, which in turn depend on various factors. A conclusive answer is not always possible.

Environmental risks induced by fracking, often cited as an argument against fracking, are **very low,** according to experts - although they cannot be ruled out. This concerns both the risk of earthquakes and the pollution of groundwater and surface waters. However, minimising risks requires strict environmental protection requirements and using the best available technology.

On the other hand, various arguments that could advocate entering into national shale gas extraction cannot be clearly assessed:

- **Climate protection**: There is no definitive answer as to how fracking in unconventional reservoirs would affect climate protection: The **lower emissions** due to higher environmental standards in Germany and the elimination of transport routes (including liquefaction and sea routes) for natural gas would have a positive impact compared to LNG imports. However, since natural gas extracted in Germany would also come onto the global market, the **total amount of fossil natural gas would increase**. This could initially have positive effects (particularly the substitution of coal), but in the medium and long term, it could also have adverse effects (additional consumption of fossil fuels).

- **Security of supply**: The analysis in this paper shows that national shale gas extraction will very likely **make no contribution to the security of supply in the coming years**, given the necessary lead times.

  In the **long term**, additional national extraction could increase the security of supply in Germany and the European Union to a certain extent, as dependence on gas imports would decrease. However, it can be assumed that the global natural gas supply will increase in the coming years, and greater diversification of gas imports will become possible due to reduced infrastructure restrictions (e.g. through the expansion of LNG terminals). At the same time, the demand for natural gas in Germany and Europe is expected to decline significantly by 2030. Against this background, a diversification of natural gas procurement and, thus, an increase in supply security would also be possible via the world market.

- **Cost-effectiveness**: It is also difficult to assess whether it would be possible to extract shale gas nationally at competitive prices on the global market. This would probably only be the case if the extraction costs were at the lower end of the estimates and only small costs for additional environmental regulations were added. At the same time, domestically produced natural gas would be under increasing price pressure on the global market, with demand possibly falling in the medium and long term. It, therefore, remains uncertain to what extent companies would consider entering the market without state protection against the backdrop of these and the other uncertainties associated with fracking. Whether natural gas prices could be reduced by domestic shale gas extraction also remains to be seen.

Possible implementation horizon decisive

Fracking in Germany could contribute to security of supply. However, it is unclear **how quickly** the technology could be implemented. For companies to invest in the technology, they must expect a sufficiently long period of use. However, it is uncertain to what extent a quick entry can be achieved:

- According to experts, a period of at least 3 to 4 years could be expected, provided that the existing administrative procedure is accelerated and previously planned measures, such as environmental impact assessments, are shortened.
- In addition, there is a unknown period of time needed to lift the fracking ban and related **social and political discussions**.

Based on the necessary lead time and the requirements of the climate targets in Germany and the European Union, a **limited time window** for the extraction of shale gas in Germany can be expected. This could have a negative impact on investment by private companies. However, in order to provide this window of opportunity procedures would need to be shortened, objection deadlines would need to be limited, and a social and political agreement would need to be reached very quickly.

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