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Discussion Paper

The Impacts of the War in Ukraine on Energy Prices and Security of Supply in Europe

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Discussion Paper

The suspension of Russian energy imports would pose extremely serious challenges for Germany and the EU.

- If Russian gas imports were suspended with immediate effect, **Europe would be unable to meet around 25% of peak winter demand for gas (based on 2021 figures).** This shortfall is due to **infrastructure issues** – even if enough gas could be sourced from the global market, **there are not enough LNG terminals and pipelines** to bring ashore and distribute the gas in Europe. Short-term reductions in gas demand are thus essential. The supply shortfall can be closed if gas consumption is reduced by 20% across Europe and the gas infrastructure is expanded.

- **Energy prices** in Europe could remain high even in the medium to long term. Consequently, measures must be introduced to **support low-income households** and **safeguard industrial competitiveness**.

- To maintain security of supply in Europe, it will be necessary to adopt a **pan-European strategy for expanding and operating the gas infrastructure** and a joint European gas procurement policy.

- Actions to **improve energy efficiency** and **accelerate the growth of renewables** should be prioritised. Both of these measures reduce reliance on fossil fuels and help to keep energy prices in check.

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1 Introduction

Russia's war on Ukraine and the resulting geopolitical upheaval are shaking the foundations of our energy supply. Germany and the rest of the European Union (EU) are heavily reliant on Russian energy imports. The shortages that are likely to occur if Europe imposes an embargo or Russia suspends its exports could jeopardise the stability of our energy and raw material supply. Meanwhile, the current situation is fuelling a further hike in energy prices, which had already risen sharply at the end of 2021. This will cause serious difficulties for households and industry in Germany and Europe, not only in the short run but also in the medium to long term.

This discussion paper explores the likely implications of a partial or total suspension of Russian energy imports for energy prices in Europe and Europe's gas supply and infrastructure. The focus is mainly on the medium term (up to 2030). The analysis is based on two reports commissioned by the Academies' Project "Energy Systems of the Future" (ESYS)[1]:

- The report "*Szenarien für die Preisentwicklung von Energieträgern*" (Scenarios for Commodity Price Trends) [1] was produced by the Institute of Energy Economics at the University of Cologne (EWI). It investigates different coal, oil, gas and electricity price trend scenarios for 2026 and 2030, using global gas and European electricity market models. The scenarios differ in terms of their assumptions about electricity and gas demand, growth in renewable energy and the medium-term availability of Russian energy imports.

- The report "*Europäische Gasversorgungssicherheit aus technischer und wirtschaftlicher Perspektive vor dem Hintergrund unterbrochener Versorgung aus Russland*" (Technical and Economic Outlook for the Security of Europe's Gas Supply if Russian Imports are Suspended) [2] was produced by the Fraunhofer IEG, Fraunhofer SCAI and TU Berlin. It uses fluid mechanical simulations to analyse infrastructure capacity for transporting gas. The report calculates the extent to which gas demand in Europe can be met with existing infrastructure and how security of supply can be strengthened by expanding and modifying this infrastructure. While its main focus is on the period to 2026, it also provides an outlook for 2030.

An interdisciplinary ESYS working group comprising members from science, industry and civil society analysed the findings of the reports and identified the potential implications for German and European energy policy. A core team of the Academies' Project ESYS used the working group's findings to draft this discussion paper, which was then discussed in a multi-stage process involving the working group and the EWI and Fraunhofer IEG/Fraunhofer SCAI/TU Berlin teams who wrote the reports. The way the discussion paper was produced means that its conclusions reflect the core team's views as informed by their discussions with the working group, but do not necessarily reflect the opinions of every individual working group member.

1 The appendix to this discussion paper contains additional information about the reports and in particular the methodologies employed. References in this paper to EWI and Fraunhofer IEG et al. relate to these reports unless otherwise stated.

2 Key findings of the reports

2.1 How would the suspension of Russian energy imports affect gas, coal, oil and electricity prices?

Fossil fuel prices in the EU had in some cases already risen sharply several months before Russia launched its war on Ukraine. The EWI report found that the Ukraine war and its geopolitical implications have led to a continuation of this trend and will probably result in **comparatively high gas, coal and oil prices** in the EU, not only in the short run but also in the medium to long term.

The EWI simulations indicate that if Russian **gas imports** were to cease completely ("without Russian imports (oRU)"), gas prices would increase by significantly more than in a scenario where some gas is still imported from Russia ("low Russian imports (nRU)") (see Figure 1):

- **In the absence of Russian gas imports**, and if gas demand in the EU remains at the same level ("mEL"), gas prices in 2026 and 2030 would exceed the average level in 2021, which was already comparatively high in historical terms. However, if ambitious reductions in gas demand are achieved over the next few years ("hEL") and there is significant investment in LNG infrastructure around the world, then even without any Russian gas imports, gas prices in the EU could stabilise at somewhere between the 2021 and 2018 levels by 2026 and even come down to the 2018 level by 2030.
- **If Russian gas imports only decline by 50%** ("nRU"), the simulations project that gas prices will fall to around the 2018 level in both 2026 and 2030.

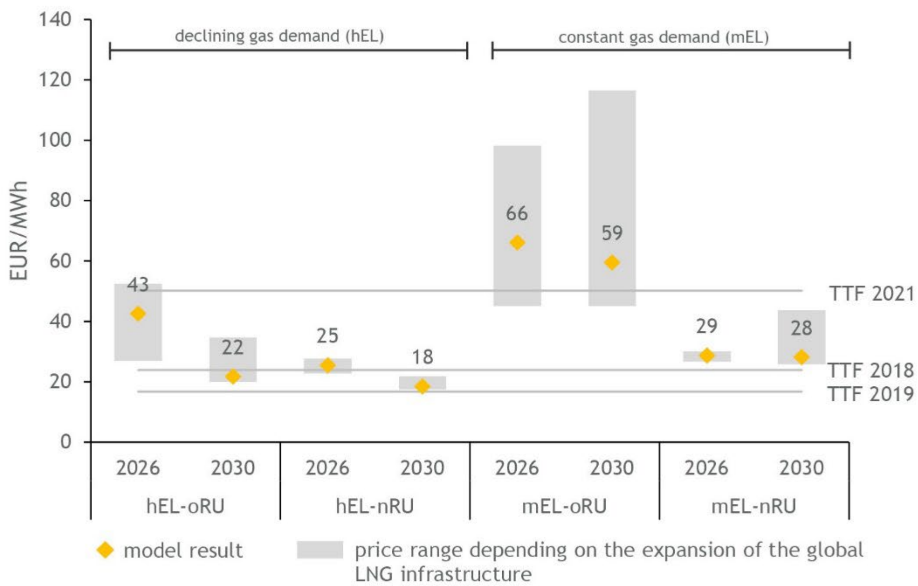

Figure 1: Projected gas price trends in Europe (mEL: moderate electrification, stable gas demand; hEL: high electrification, falling gas demand; oRU: no Russian imports; nRU: limited Russian imports) (Source: EWI 2022 [1]).

The EWI study suggests that **oil and coal** prices could come back down from their current high over the next few years (see Figure 2). If Russian fuel imports do not stop completely, the price of oil and coal could return to somewhere near the historical levels of 2016-2021 (approx. €50/megawatt hour (MWh) and €10/MWh respectively). If Russian energy imports to the EU cease completely, the projected prices for both coal and oil are approximately €10/MWh higher than the prices in the limited Russian imports scenario.

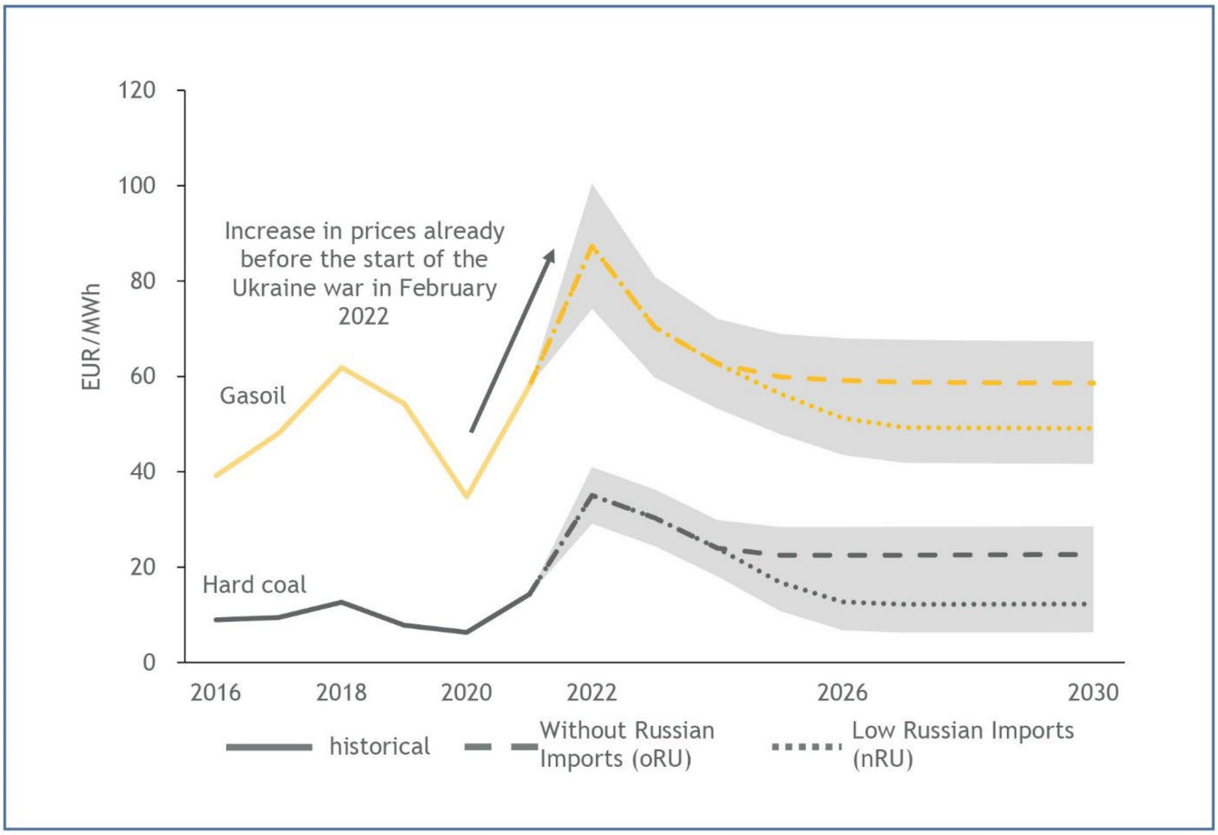

Figure 2: Projected gasoil[2] and coal prices in Europe (Source: EWI 2022 [1]).

Factors including high fuel prices could cause the current **trend of high electricity prices to continue in years to come**. The simulations give a wide range of possible price trajectories (see Figure 3). The projected price range is between approx. €80/MWh and approx. €130/MWh for 2026 and approx. €50/MWh and approx. €140/MWh for 2030. This is significantly higher than the price level prior to the second half of 2021. The availability of Russian imports once again has a significant influence on prices – the scenario where Russian gas and coal imports cease completely projects higher electricity prices, especially between now and 2026.

2 Gasoil is obtained from crude oil. It is traded on the stock exchange and used to produce diesel and heating oil.

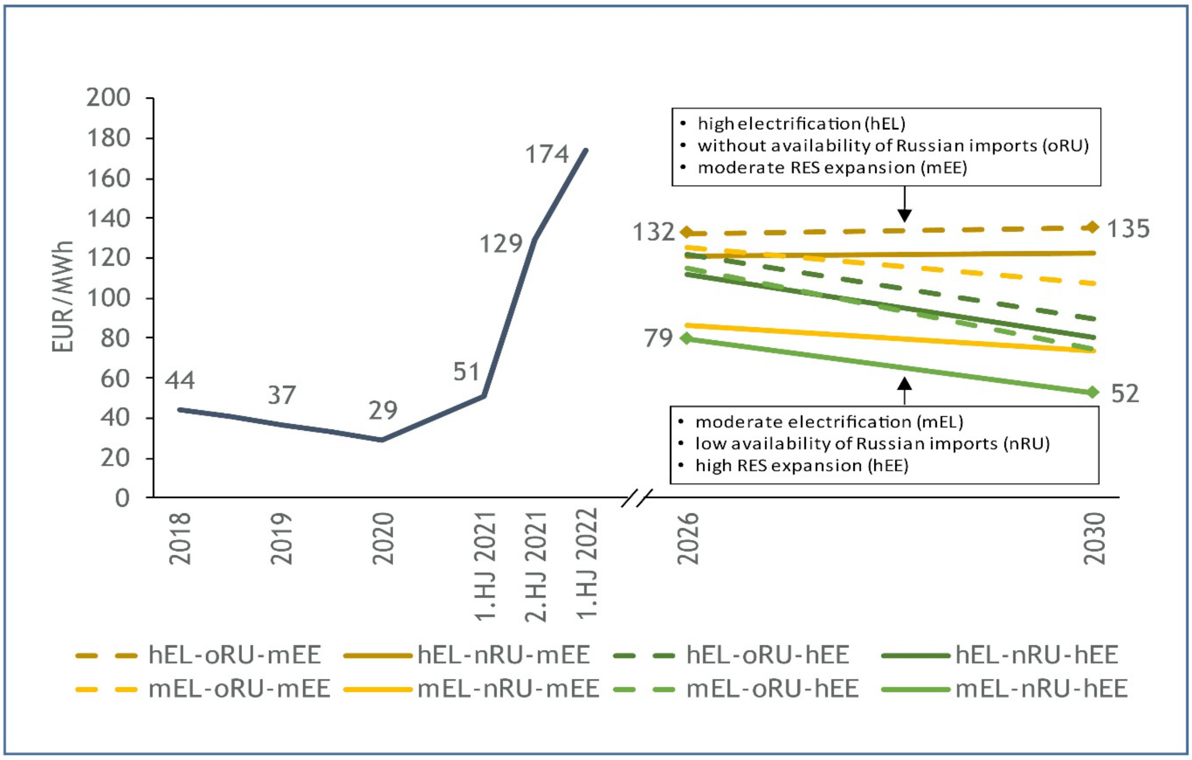

Figure 3: Projected wholesale electricity price trends in Germany (mEL: moderate electrification, stable gas demand; hEL: high electrification, falling gas demand; oRU: no Russian imports; nRU: limited Russian imports; hEE: high renewable energy growth; mEE: moderate renewable energy growth) (Source: EWI 2022 [1])

In addition to the availability of Russian energy imports, there are various **other factors** that have a significant influence on energy prices:

- The **rate of renewable energy growth** is a key driver of **electricity prices**. If renewables are expanded in line with the German government's 2022 "Easter package" ("hEE"), wholesale electricity prices in 2026 could be between €7/MWh and €11/MWh lower than if there is only moderate renewable energy growth ("mEE"). The effect becomes even more pronounced in 2030, since the simulations assume that most of the additional renewable capacity will be built between 2026 and 2030 – the EWI simulations project that the difference between the two scenarios will be between €21/MWh and €46/MWh in 2030. However, this growth will require **significant investment** that is not fully reflected in the electricity price, since it will be partly funded by the state.

- The **carbon price** is another important driver of electricity prices. The carbon price for electricity generation is determined by demand for emission certificates in the European Union Emissions Trading System (EU ETS). The EWI's sensitivity analysis for 2030 shows that the carbon price has a key influence on wholesale electricity price trends. Depending on the scenario, a 20% reduction in the model's EU ETS carbon price causes wholesale electricity prices to fall by as much as 14%. In some scenarios, a decline in the carbon price also has a significant impact on the electricity generation mix and thus on electricity sector emissions.

- In addition to the availability of Russian imports in the EU, another key driver of **gas prices** in the model is the **global level of investment in LNG plants**. Without additional investments over and above projects that have already been officially approved, long-term gas prices could be significantly higher than the 2021 average if Russian gas imports cease completely (see the price range in Figure 1).

- The price is also influenced by **demand for natural gas**. A decline in consumption would lead to a significant drop in prices. The different gas demand levels chosen for the scenarios with no Russian gas imports result in gas price differences of up to €34/MWh in 2026 and up to €49/MWh in 2030.[3]

Rising and persistently high prices will have **significant implications for households and industry**. Low-income households will be hardest hit, since the percentage of their budgets spent on energy is likely to rise more than for other groups. Higher-income households spend a comparatively lower share of their income on energy and are able to reduce their energy consumption by investing in more efficient technology or in their own renewable energy generation systems. As a result, there is a danger that the financing of energy system costs will focus on a declining number of consumers, and that lower-income households will end up having to shoulder a greater share of the burden.

The competitiveness of **European industry** will also suffer if prices remain high in the long term. A growing **gas price gap** between net exporters and net importers could put Europe at a relative disadvantage. The US could benefit from comparatively low gas prices between now and 2030, whereas Europe and Asia would have to compensate for relatively high gas prices (see Figure 4). The US already enjoys a cost advantage over other parts of the world thanks to its growing domestic fracking industry. Australia is another nation that has gained a global competitive advantage by increasing domestic gas production in recent years.

3 Around ¼ of the decline in demand for natural gas in the EWI simulations is accounted for by increased biomethane production in the EU. In the high electrification and falling gas demand scenario ("hEL"), the EWI assumes that Europe will produce 416 TWh (approx. 37 billion cubic metres) of biomethane based on the figures in the TYNDP Distributed Energy scenario. This is in line with the target in the European Commision's RepowerEU plan to produce 35 billion cubic metres of biomethane in the EU by 2030. If this increase in production over the next few years does not occur, e.g. due to environmental concerns (see also Chapter 2.2), there would be a corresponding reduction in the amount of natural gas substituted by biomethane. By way of comparison, in the stable gas demand scenario ("mEL"), the EWI assumes that biomethane will account for just 152 TWh (approx. 14 billion cubic metres) in 2030, based on the figures in the TYNDP National Trends scenario.

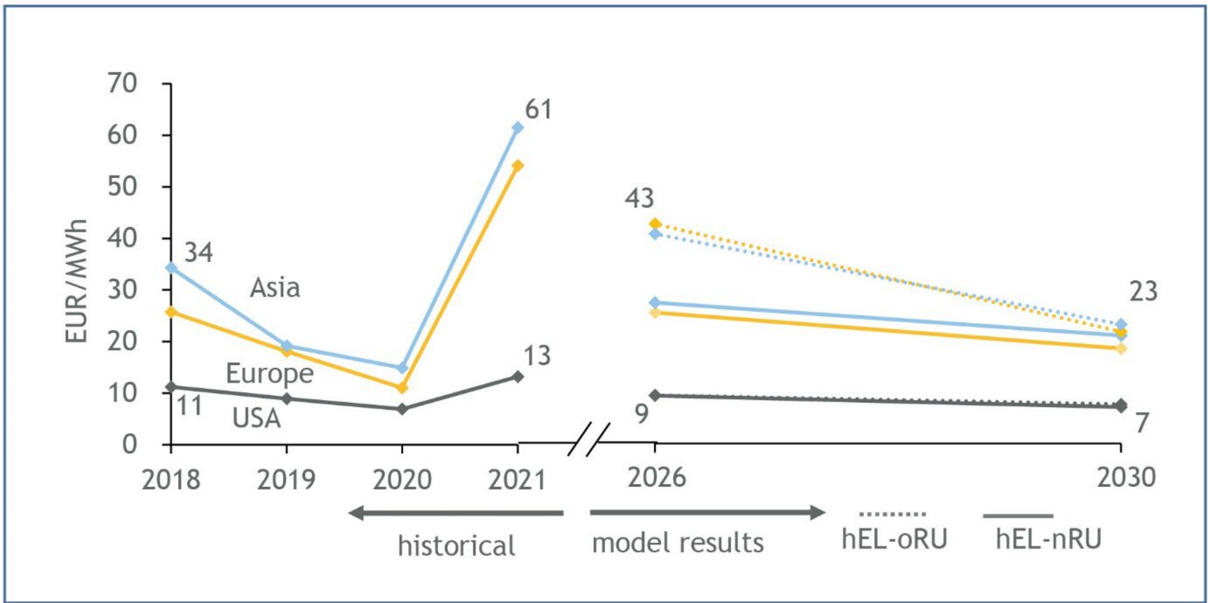

Figure 4: Projected gas price trends in Asia, Europe and the US (hEL: high electrification, falling gas demand; oRU: no Russian imports; nRU: limited Russian imports) (Source: EWI 2022 [1]).

In conclusion, if Russian energy imports were to cease completely, energy prices in Europe would remain above 2021 levels in the medium term (between now and 2026). However, the EWI report suggests that an ambitious reduction in demand for natural gas coupled with high levels of investment in LNG infrastructure around the world could bring gas prices back down to 2018 levels by 2030, even if gas is no longer imported from Russia. Electricity prices could also fall again in the medium to long term, but this will call for an ambitious expansion of renewable energy.

Maintaining an affordable energy supply and ensuring industrial competitiveness will be a huge challenge for decision-makers. However, reducing persistently high fossil fuel prices through state subsidies or interventions in the European wholesale market pricing mechanism is not the answer. As well as imposing an huge burden on the public finances, this would counteract efforts to reduce demand for fossil fuels. In order to prevent a lasting relocation of value creation to parts of the world with lower energy prices, it will be necessary to take action to support industrial competitiveness. These measures should place particular emphasis on strengthening non-energy-related local factors. A coordinated European gas procurement strategy could also help to prevent intra-European competition for limited supplies of gas in the global market.

2.2 Can alternative natural gas sources replace Russian gas imports?

In 2021, the EU imported approximately 155 billion cubic metres (approx. 1,720 terawatt hours (TWh))[4] of natural gas from Russia. The **EU's gas import structure** will need to change significantly in the next few years to compensate for the partial or complete suspension of Russian imports. This applies both to the countries from which it imports its gas and to the relevant infrastructure. While around **75%** of the EU's gas imports were still transported **by pipeline** in 2021, in some of the EWI scenarios this figure falls to less than 50% for the EU[5] by 2030. Transporting gas by pipeline is usually cheaper than transporting LNG (liquefied

4 The standard gas industry abbreviation "bcm" is widely used to refer to a billion cubic metres. One billion cubic metres is equivalent to around 11.1 TWh (in energy value terms).
5 These EWI simulations include the UK alongside the 27 EU member states.

natural gas) by ship due to the additional cost of liquefaction and regasification. Higher transport costs will thus have a knock-on effect on gas prices. However, this trend can be counteracted, especially by significantly reducing gas consumption.

- According to the EWI report, most Russian gas imports could be replaced by **LNG from the US**. The EWI concludes that the US has the greatest potential of any country in the world to increase its production and liquefaction capacity over the next few years. The report found that there could be a two to sevenfold increase in the amount of US gas imported by the EU, rising from the current level of approx. 18 billion cubic metres (approx. 200 TWh) to between approx. 35 and 130 billion cubic metres (approx. 390 TWh - 1,440 TWh). By 2030, US gas could account for as much as 35% of EU gas imports. However, this would be at odds with efforts to diversify the EU's gas imports, since the whole of Europe would be highly reliant on US LNG exports.[6] The percentage of gas imported from the US could be even higher if biomethane production in the EU falls short of the European Commission's target (see below). In this scenario, the gas gap would have to be made up by US exports.

- Gas imports from **Norway** remain important. According to the EWI report, the amount of Norwegian gas imported by the EU could rise from its current level of 119 billion cubic metres (approx. 1,320 TWh, or around 30% of total EU gas imports) to as much as 127 billion cubic metres (approx. 1,410 TWh, or around 37% of total EU gas imports) by 2026. However, the projected decline in Norwegian gas production means that exports would then be expected to fall back to no more than 114 billion cubic metres (approx. 1,270 TWh) by 2030. Be that as it may, the EU will continue to rely heavily on Norwegian gas imports in years to come.[7]

- It is considered unlikely that gas imports from **Qatar** will increase significantly. In 2021, Qatar exported 22 billion cubic metres (approx. 240 TWh) of LNG to the EU. Any further increase in gas production would only be possible post-2026, once the North Field Expansion project is operational. However, according to the EWI report, long-term supply relationships with Asian countries mean that there is unlikely to be a significant increase in gas exports from Qatar to the EU before 2030 (the projection for 2030 is between 21 and 33 billion cubic metres or approx. 230-370 TWh). Any increase in trade with Qatar would also need to take the country's sociopolitical situation into account.

- Imports from **North Africa** are expected to decline. According to the EWI report, gas imports from North Africa will fall from their current level of 52 billion cubic metres (approx. 580 TWh) to between 31 and 34 billion cubic metres (approx. 340-380 TWh) in 2026 and between 27 and 30 billion cubic metres (approx. 300-330 TWh) in 2030. The EWI report attributes this to a decline in production in North Africa's main exporter, Algeria, and rising demand for gas within the region.

- Imports could be partly substituted by increasing **gas production in the EU**. In 2020, Germany produced 5.7 billion cubic metres (approx. 60 TWh) of natural gas, which is enough to meet around 5% of its domestic demand [5]. It is beyond the scope of this discussion paper to definitively

6 From a climate policy perspective, it is vital to carefully investigate and discuss the additional environmental costs and risks associated with increasing imports and consumption of US LNG. This is because the vast majority of imports from the US are likely to involve fracked gas. Ladage, Blumenberg, Franke (2020) [3] assume that US LNG derived predominantly from shale gas will have roughly the same emissions footprint as pipeline gas from Russia. However, other studies (e.g. UBA (2019) [4] argue that US LNG is worse for the climate than Russian pipeline gas, while recognising that there is no consensus in the literature about the specific emissions of conventional and unconventional gas extraction.

7 An increasse in Norwegian gas production would have direct environmental policy implications, since it would involve further exploration of the Arctic Barents Sea that could potentially clash with conservation efforts in the Arctic.

establish the volume of gas imports that could be substituted by an **increase in Germany's domestic gas production**. In the short term, any increase would be extremely limited, since the extraction of Germany's shale gas reserves faces public opposition and would also require changes to the law. Moreover, it would take several years before it was technically possible to significantly increase production. There is also a danger of creating path dependencies that hamper the attainment of Germany's climate targets.

- **Biomethane** produced in the EU can also be used as a substitute for natural gas. The European Commission's RePowerEU plan includes a target to step up biomethane production in the EU from its current level of around 3 billion cubic metres (approx. 33 TWh) to 35 billion cubic metres (approx. 390 TWh). This would be enough to substitute roughly 9% of the EU's natural gas consumption in 2021 (approx. 412 billion cubic metres [6]).[8] However an increase of this order in biomethane production can only be achieved with intensively farmed energy crops such as maize [7]. Growing these crops as a monoculture and the associated fertiliser use would have serious environmental impacts including biodiversity loss, damage to soil and water quality and significant greenhouse gas emissions. The use of extensive tracts of land to grow energy crops is also problematic in the context of a food crisis exacerbated by the war in Ukraine. One conceivable approach would be to reduce the amount of biogas and biomethane used to produce electricity in favour of the production and use of biomethane in industry and for heating. However, this would deprive the electricity sector of a flexible, renewable fuel.

Figure 5 shows the countries that natural gas could be imported from in 2026 and 2030 based on the simulations in the EWI report.

8 The EWI scenario in which demand for gas falls ("hEL") is based on the TYNDP Distributed Energy scenario, which assumes that biomethane will account for 416 TWh (approx. 37 billion cubic metres) in Europe in 2030. This figure is of a similar order to the corresponding figure in the EWI scenario.

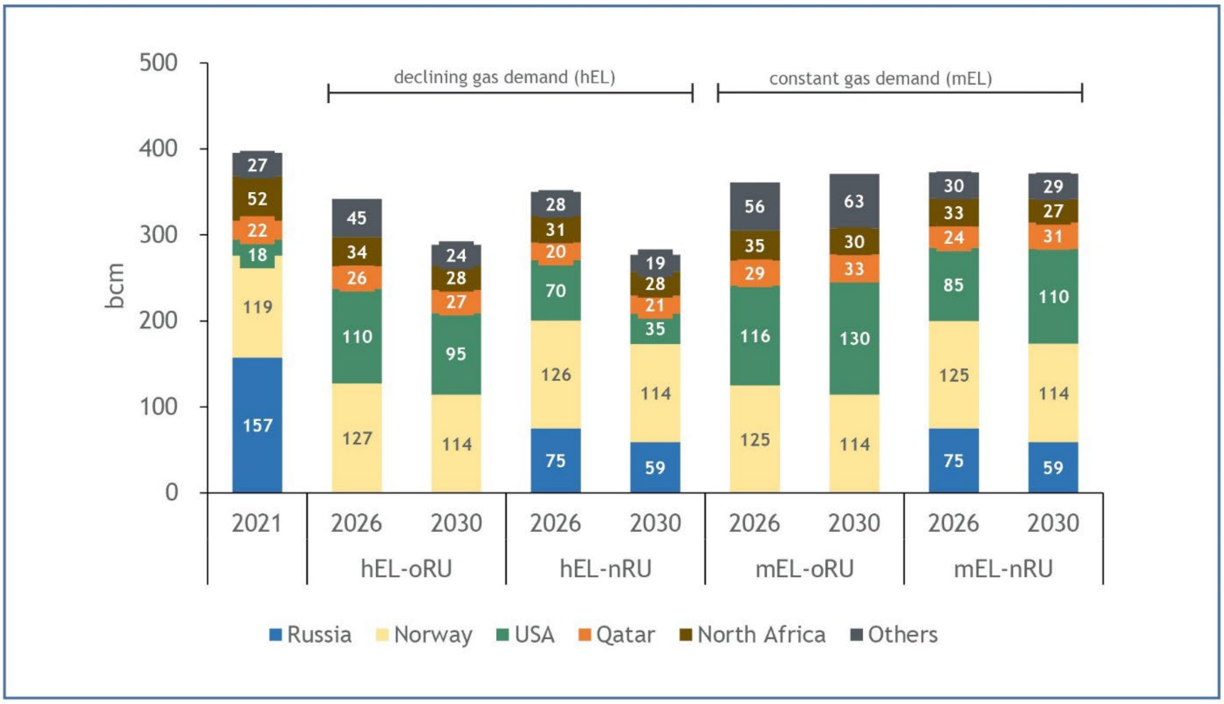

Figure 5: Projected gas import structure trends for EU27 + UK (mEL: moderate electrification, stable gas demand; hEL: high electrification, falling gas demand; oRU: no Russian imports; nRU: limited Russian imports) (Source: EWI 2022 [1]).

2.3 To what extent would the current gas infrastructure limit supply in the absence of Russian gas imports?

According to the fluid mechanical simulations for the whole of Europe carried out by Fraunhofer IEG et al., if Russian gas imports are suspended with no change in Europe's current gas infrastructure, there would be a **performance gap of around 25% in Europe and around 30% in Germany during peak load periods based on the consumption figures for 2021**. A performance gap[9] means that demand cannot be fully met at a given point in time. Peak load periods are defined as the average demand during a typical two-week winter cold spell (as per the definition in the TYNDP Distributed Energy scenarios) [8].[10] It is important to bear the following factors in mind:

- The performance gap still exists, even if natural gas storage facilities are full.
- Even higher short-term performance gaps are possible, since the peak load could be still higher on certain days (around 20% higher in the TYNDP scenarios).

9 The concept of a "performance gap" ("Leistungslücke") is a simplification based on the assumption of stable demand. In reality, demand responds to prices – the higher the price, the lower the demand for gas and the smaller the gap. In this paper, the term "performance gap" refers to a situation where it would not be possible to meet the demand for gas that would be expected in the absence of the current energy (price) crisis. Demand for gas is in any case expected to fall between now and 2030 due to the transition to a net-zero energy system.

10 These scenarios are used as the basis for the EU-27's electricity and gas network planning. Figure 13 of the TYNDP Scenario Report [8] published by the European Network of Transmission System Operators for Electricity and Gas for the Ten-Year Network Development Plan shows the annual average daily gas demand and and the daily gas demand during a two-week cold spell. Fraunhofer IEG et al. uses the gas demand in the TYNDP Distributed Energy Scenario as the basis for its own simulations. This scenario describes a pathway for achieving a 55% reduction in the EU's greenhouse gas emissions by 2030 and reaching net-zero by 2050. The scenario relies on a highly decentralised approach using locally available renewables, and on a high level of public support for the transition, which will involve changes in people's lifestyles.

- A performance gap can also be expected on several other days in the year when demand is higher than average. In these instances, however, the shortfall will be lower than the 25%-30% figure for peak load periods.
- Since the simulations are based on an average winter, the performance gap would be significantly greater in a cold winter.

The projected performance gap can be **attributed to infrastructure issues**. In other words, even if the European market was able to source more gas, the current landing and transport infrastructure would be unable to distribute enough of it. There are simply not enough import pipelines or LNG terminals to transport larger quantities of gas. The simulations already take the emptying of gas storage facilities into account. The extent of the gap varies from one European country to another due to differences in their infrastructure.[11]

There are two measures that can be taken to close the performance gap. The first is to **expand and modify the gas infrastructure** so that it is able to transport more gas. The second is to lessen the strain on the infrastructure by reducing demand for gas. If, between now and 2025, the **infrastructure is expanded** in line with the assumptions of the Fraunhofer IEG et al. report, which includes the LNG terminals already planned for Germany, **the performance gap during peak load periods in Europe could be closed if demand for gas fell by 20% compared to 2021.** While it would still not be possible to meet the current level of demand, this could well be unnecessary. The TYNDP Distributed Energy scenarios produced by the European Network of Transmission System Operators[12] before the war in Ukraine indicate that a 20% reduction in gas demand by 2025 is achievable. However, it will require the implementation of ambitious climate measures such as significant growth in renewables, the widespread use of efficient, electrified application technologies (e.g. heat pumps) and a major electricity grid expansion. If these measures are implemented, the infrastructure would be capable of fully serving the (lower) demand for gas.

Under the right circumstances, the performance gap could be closed even sooner, i.e. before 2025. This would require a faster reduction in gas demand than in the TYNDP Distributed Energy scenario. Potentially, this could be achieved through additional efforts to reduce consumption or through a short-term switch to using e.g. coal instead of gas for electricity generation. The infrastructure would also need to be expanded faster than in the IEG simulations.

Difficulties in meeting gas demand are not confined to peak load periods. Unless demand for gas falls, the IEG projects that there will also be an annual **infrastructure-driven supply shortfall**. While this is not expected to be as high as the performance gap, it will be of a similar order. In other words, it will not be possible to bring ashore and distribute enough gas to meet current demand levels over the course of an entire year, rather than just during peak load periods.[13] This is confirmed in a short paper published by the EWI in May 2022: if Russian imports are suspended before the expansion of Europe’s LNG terminals is

11 In their Special Report of June 2022, the leading economic research institutes responsible for the Joint Economic Forecast come to a seemingly more optimistic conclusion – the median of their simulation runs shows no gas gap for Germany, even if Russian gas imports are suspended with immediate effect. However, the report assumes that a range of savings will be implemented, for example a reduction in the amount of gas used for electricity generation, a reduction in gas demand for space heating (achieved e.g. by heating to lower temperatures) and a reduction in industrial demand. In this paper, these savings are treated as part of the “supply shortfall”. Furthermore, the Special Report only covers the period to the end of 2023 and says nothing about how the supply situation will develop thereafter. In addition, the fluid mechanical simulations used in the IEG report allow a more detailed analysis of infrastructure bottlenecks.

12 The gas demand figures modelled in the TNYPD Germany scenarios [8] and reported for the EU member states are used as model parameters in the Fraunhofer IEG et al. simulations.

13 It is important to take the role of gas storage facilities into account. At times of high demand, these facilities feed as much gas as is technically possible into the network, but they must then be filled up again at times of low demand.

completed, the supply shortfall due to insufficient LNG landing capacity alone would be around 18% of annual demand or 27% of winter demand [9].[14]

With or without Russian gas imports, Germany plays a central role in Europe's gas supply.

- Because of its **geographical location**, Germany is an important transit country for natural gas transport in Europe. In a scenario where no gas is imported from Russia, Europe's gas imports would initially be transported to Germany, primarily from Norway but also from countries such as Turkey, Spain and Italy where natural gas can be imported via LNG terminals. It would then be distributed from Germany throughout the continent, especially to Eastern Europe.

- Germany also has the largest **storage capacity** of any country in Europe. This is key to guaranteeing supply during the winter months. At times of high demand, the storage facilities feed as much gas as is technically possible into the network, but they must then be filled up again at times when demand is low. Fraunhofer IEG et al. estimate that there are no infrastructure issues to prevent the gas storage facilities from being filled up during the summer – as long as there is a sufficient supply of gas, the storage facilities can be filled.

2.4 How can infrastructure measures help to secure the gas supply?

Infrastructure measures that can be implemented as soon as possible are needed to minimise the impacts of a suspension of Russian gas imports on the gas supply. The following measures and factors are critical in this context.

LNG terminals

If LNG is to account for a larger share of Europe's gas supply, it will be necessary to expand and upgrade the continent's **LNG terminals**. Table 1 shows the planned expansions of Europe's LNG regasification capacity that were used as the basis for the Fraunhofer IEG et al. simulations.[15]

Expanding the LNG infrastructure will also enable geographical diversification of the gas supply. However, it takes time to build fixed terminals, and it is unlikely that any new ones will be operational in Germany before 2026.[16] On the other hand, Floating Storage and Regasification Units (FSRUs) could be operational by as soon as 2023. Germany is currently planning FSRUs in Wilhelmshaven and Brunsbüttel with an annual capacity of approx. 13 billion cubic metres (approx. 140 TWh) [10].

14 These figures are based on Russia completely suspending exports as of 01.05.2022 and are thus no longer up to date. The short paper does not draw any conclusions about infrastructure-driven supply bottlenecks caused by factors other than a shortage of LNG terminals.

15 Based on GLE/GIE and ENTSO-G, updated by Fraunhofer IEG et. al [2].

16 Elsewhere in Europe, there are several projects to build or upgrade LNG terminals, as well as plans to acquire new FSRUs. Some of these could enter service before 2026. These include FSRUs in Greece, Ireland, Poland and Estonia, expansions of existing terminals in Belgium, the Netherlands, France, Italy and Spain, and a completely new terminal in Latvia.

Project	Country	Operational by	Capacity [billion cubic metres]	Capacity (regasification) [GWh/h]
LNG terminal in Vassiliko (Gas2EU)	Cyprus	2023	2.44	3.1
FSRU in Alexandroupolis	Greece	2023	8.3	10.5
FSRU in Shannon (and connecting pipeline)	Ireland	2024	2.1	2.7
LNG terminal in Tallinn	Estonia	2025	4	5.1
FSRU in Wilhelmshaven	Germany	2023	9	11.4
FSRU in Brunsbüttel	Germany	2023	5	6.3
FSRU in Paldiski and Inkoo[17]	Estonia/ Finland	2023	4.6	5.8
LNG terminal in Fos Cavaou (expansion)	France	2023	3.6	4.6
LNG terminal in Montoir (expansion)	France	2023	3.3	4.2
LNG terminal in Skulte	Latvia	2023	1.5	1.9
LNG terminal in Swinoujscie (expansion)	Poland	2023	2.5	3.2
LNG terminal in Swinoujscie (expansion)	Poland	2024	0.8	1
LNG terminal in Rotterdam (expansion Phase 3)	Netherlands	2024	2	2.5
LNG terminal in Mugardos (expansion)	Spain	2024	3.6	4.6
FSRU in Klaipeda	Lithuania	2024	3.7	4.7
LNG terminal in Fos Cavaou (expansion)	France	2025	10.8	13.7
LNG terminal in Montoir (expansion)	France	2025	8.5	10.8
LNG terminal in Paldiski	Estonia	2025	2.5	3.2
FSRU in Shannon	Ireland	2025	2.8	3.6
LNG terminal in Stade	Germany	2026	3	3.8
LNG terminal in Brunsbüttel	Germany	2026	8	10.1
FSRU on the Baltic coast	Poland	2026	4.5	5.7
LNG terminal in Gioia Tauro (new)	Italy	2026	12	15.2
LNG terminal in Porto Empedocle (new)	Italy	2026	8	10.1

Table 1: Planned increase in LNG regasification capacity in Europe.

17 The FSRU may be operated in Paldiski (Estonia) or Inkoo (Finland).

The Fraunhofer IEG et al. simulations also show that these **German FSRUs will already be operating at very high capacity by 2023**. LNG terminals in Germany help to ease the pressure on the European supply and are also extremely important for the European supply due to Germany's geographical position as a distributor. External factors not included in the model, such as inadequate pan-European energy policy cooperation or less access than expected to Norwegian gas could further increase the importance of LNG terminals in Germany. **The construction of the LNG terminals can thus play a major part** in guaranteeing security of supply in Germany and the rest of Europe.

The **gas network in northwest Germany is already operating at very high capacity** due to the high level of imports from Norway. North Sea LNG terminals are competing for network capacity with Norwegian pipeline gas and contributing to a high network load. The network load in northeast Germany is much lower and would fall still further if Russian imports were suspended, since it is here that Russian gas is fed into the network. Consequently, from an infrastructure perspective, **new LNG terminals should ideally be located in northeast Germany**. Particular priority should be given to exploring the options for building LNG terminals in locations where Russian gas was formerly fed into the network, since these sites already have connections to the necessary distribution infrastructure. The construction of an LNG terminal at the Baltic port of Lubmin would be especially useful from a gas distribution perspective. However, other factors such as the potentially higher transport costs associated with a longer sea route must also be taken into account. It is also necessary to consider the possibility of Russian gas arriving there again at some point in the future, if the geopolitical situation changes.

In order to ensure that Europe's gas demand is met, the EWI scenarios include a 60-80% increase in the continent's regasification capacity by 2030, with most of this additional capacity being built by 2026. Many of the relevant projects are already at the planning stage. In addition to the planned LNG terminals, the scenarios indicate that the construction of a further new terminal in Italy would be particularly beneficial for Europe's gas supply. The scenarios do not provide for the construction of any additional terminals in Germany over and above the four that are already planned. This suggests that any additional capacity here would add very little value for Europe's gas supply.

Reverse flow

In addition to the expansion and upgrading of the LNG import infrastructure, infrastructure measures are also needed in relation to the pipeline supply.[18]

The modification of compressor stations should be prioritised in order to enable reverse flow, since transporting natural gas from Norway and LNG from southern Europe or the Netherlands to European consumers will require more gas to be piped from West to East and South to North. However, the existing infrastructure is mostly designed to transport gas from East to West. In order to enable this **reverse flow**, compressor stations must be modified so that the input and output pipelines are connected to the compressors in a manner that allows them to also transport the gas in the opposite direction. Once the modifications have been completed, the gas can flow in both directions.

One major advantage is that the **compressor station modifications** can be completed relatively quickly (within six to twelve months). This is because the licensing procedures are simpler, since the modifications are carried out on the gas network operators' existing premises. Reverse flow can help to resolve current

18 The planned network infrastructure expansion measures in the Fraunhofer IEG et al. simulations include over 260 individual projects. More than 180 of these are projects to upgrade or build new pipelines (including interconnectors) and/or compressor stations [2].

bottlenecks in the European transmission infrastructure, especially between Italy and Austria and between Germany and its western neighbours. Reverse flow is already possible at full capacity between Spain and France. However, some domestic compressor stations in these countries may need to be modified, since the direction of flow can also change within a country. Although it has hitherto received little attention in the current debate, the connection between Italy and Austria has a key role, not least in enabling the onward transmission of gas to Slovakia and Ukraine. Reverse flow between Belgium and the Netherlands would also help to fill storage facilities during the summer months.

Gas network capacity utilisation

Overall, **infrastructure capacity utilisation** in the Fraunhofer IEG et al. scenarios **is higher than it is today**. For instance, the interconnectors between Spain and France and some LNG terminals in these two countries operate at high capacity in the simulations. Pipeline import capacity from Norway is also almost fully utilised. This leads to very high regional network loads. There is very little leeway when infrastructure capacity utilisation is this high, and the risk to security of supply is correspondingly greater. The Fraunhofer IEG et al. report does not provide a detailed analysis of how much additional infrastructure would need to be built to enable more flexibility and strengthen the resilience[19] of the energy supply. Nevertheless, the infrastructure with high capacity utilisation in the Fraunhofer IEG et al. scenarios provides an indication of the places where the construction of new infrastructure should be studied in order to reduce the threat to security of supply if Russian gas imports are suspended indefinitely.

Global expansion of liquefaction terminals

In order to meet the rising demand for LNG in Europe, liquefaction capacity will need to increase in the LNG-exporting countries. There is a significant increase in all the EWI scenarios – the current liquefaction capacity of around 600 billion cubic metres a year grows by 50-70% by 2030. While the biggest rise occurs in the US, other regions with a significant increase are Qatar, Canada and – especially post-2026 – Africa.

Long-term infrastructure requirements

The climate targets adopted by EU and Germany entail a phase-out of natural gas within the next two decades. It is thus important to gradually ready the gas infrastructure for a net-zero energy system. This will first and foremost involve **repurposing existing pipelines for hydrogen** in order to address the increased use of hydrogen as a fuel and the resulting transport requirements. However, the extent to which this will be possible is limited by the high capacity utilisation of the natural gas infrastructure.

The changes to Europe's gas infrastructure needed to increase security of supply will also have implications for the planned expansion of the continent's hydrogen infrastructure. The shift in natural gas flows will mean that some infrastructure that was originally going to be repurposed for transporting hydrogen will still be needed for natural gas in the next few years. However, since the total volume of transported gas will be lower, routes or sections in other locations may be freed up for transporting hydrogen. The **planning of Europe's future hydrogen grid will therefore need to be realigned** based on a revised regional breakdown that reflects the current circumstances.[20] For instance, the new situation could affect regional decisions for electrolyser locations or major hydrogen consumers. Delays to the expansion of the hydrogen

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19 Resilience describes a system's ability to withstand adverse events with potentiallly disastrous consequences (e.g. armed conflicts or natural disasters) with a minimum of damage, recover from them rapidly and learn the relevant lessons. Resilience can be strengthened through diversification, maintaining redundancies and decoupling (i.e. removing the connection between formerly connected entities) [11].

20 For more information, see the Fraunhofer IEG's TransHyde project [12].

infrastructure could seriously jeopardise the hydrogen ramp-up that is so vital to the energy transition, not least because hydrogen is a climate-friendly substitute for natural gas.

From a climate policy perspective, it is important to ensure that the construction of additional natural gas infrastructure does not hamper efforts to tackle climate change by creating further **lock-in** to fossil fuels. If Germany's and the EU's climate targets are to be met, it may not be possible to use some of the new infrastructure to transport natural gas for the entirety of its lifetime. At some point, this infrastructure will need to be modified to transport hydrogen if it is to continue being used in the longer term.

In essence, the planned LNG terminals in Germany are situated in suitable locations. However, Germany's LNG Acceleration Act does not currently require the LNG terminals due to be built in Germany over the next few years to be designed so that they can also be used to transport hydrogen or hydrogen derivatives at some point in the future. The relevant legislation should be amended in order to reduce the risk of lock-in.

2.5 How can demand for gas be reduced to (partially) compensate for the suspension of Russian imports?

The Fraunhofer IEG et al. report makes it plain that, **without a reduction in demand, infrastructure measures alone will not be enough to achieve a stable supply at peak load times over the next few years if Russian imports are suspended**. This remains true even if the gas infrastructure is ambitiously expanded and modified. It is thus even more urgent to ensure faster implementation of the reductions in gas demand already established in the plans to cut greenhouse gas emissions.

If Russian imports are suspended, it will be necessary to significantly reduce gas demand throughout Europe in order to prevent a supply shortfall. The required reduction will be approximately 20-30% depending on the time (i.e. the infrastructure measures that have been implemented by a given timepoint) and country. The Bruegel think tank calculates that high gas prices between January and May 2022 caused gas demand in Europe to fall by 11% compared to the same period in 2021. Bruegel estimates that industrial demand fell by around 20% in the first quarter of 2022, while demand from households and other consumers declined by about 5% [13]. The pronounced drop in industrial demand can be partly attributed to increased imports of energy-intensive products. It will be necessary to investigate how damaging this could be for European industry and how it affects production-related emissions. In Germany, gas demand is currently 14% lower in 2022 than it was at the same point in 2021. However, this is partly due to mild weather conditions – the decline is just 6.4% when adjusted for temperature [14].

The reports that form the basis of this paper do not analyse how far gas demand will fall due to rising prices alone or the extent to which it can be reduced through other (e.g. regulatory) measures. Energy demand is determined exogenously in the models and does not respond endogenously to price changes.[21] Moreover, it is very difficult to predict with any certainty how higher prices will affect demand in the short to medium term (price elasticity) and the extent to which demand can actually be reduced in practice. Nevertheless, the following overview can help to prioritise the options:

- **Substitution of natural gas**: The main option is to use **coal to produce electricity** instead of natural gas. According to scenarios produced by the German Institute for Economic Research (DIW Berlin),

21 Price elasticity is an input parameter in the EWI gas market model. It was set to the lowest possible value in order to ensure that the exogenously determined demand from the TYNDP scenario was set consistently with the IEG model. This resulted in minimal deviations of no more than a few percentage points.

Germany could reduce its consumption of gas for electricity production by up to 43 TWh in 2023 if 41-73 TWh are produced with coal instead [15]. It is not possible to provide more precise figures because of the number of different factors at play. These include the level of growth in renewables, potential reductions in consumer demand, EU ETS carbon price trends and the overall trend of electricity demand in Europe.[22]

Another option for **substituting natural gas in electricity production** would be for Germany to keep its nuclear power plants open. However a U-turn on the decision to phase out nuclear power and coal-fired power generation would be likely to encounter strong public opposition. The decision to phase out nuclear power was taken after a bitter social struggle and helped to defuse the public controversy. This at least partly explains why the nuclear power plant operators have not signalled a strong interest in extending the plants' lifetimes, which are due to come to an end shortly. Quite apart from anything else, these companies' personnel and safety planning is geared towards an exit from nuclear. A temporary increase in the use of coal would also cause a certain amount of public debate. However, the scale of the measures needed to mitigate gas supply bottlenecks, the fact that they are easier to implement in practice and the fact that this alternative is less controversial than nuclear power combine to make coal a more attractive option.

Natural gas could also be replaced by oil in industrial facilities designed to use oil as well as gas. However, switching to oil would be at odds with climate policy goals due to its higher CO_2 emission factor. **Biomethane** can also be used as a substitute for natural gas in various applications. Provided that no new plants that could create a lock-in effect[23] are built, this substitution would be reversible. In other words, natural gas could be used again as soon as enough was available. However, these options come with the risk of unwanted environmental consequences such as the higher greenhouse gas emissions associated with increased use of coal and oil, and the environmental impacts of increased land use for energy crops to produce biomethane.

- **Reduction in energy service usage:** One option that can be quickly implemented is for households to cut back on their energy service usage by changing their behaviour and taking advantage of simple, easy-to-implement technological measures such as smart thermostats to help them use less gas. Campaigns could help to leverage some of the potential in this area.

  According to the German Environment Agency (UBA), **if every household in Germany turned the heating down by 2°C**, demand for natural gas would fall by around 21 TWh (1.89 billion cubic metres). A further 10 TWh (0.9 billion cubic metres) could be saved by **reducing the room temperature in hotels, guesthouses and other establishments** [17]. In total, this would be equivalent to approximately 3% of Germany's natural gas demand in 2021. The extent to which this potential reduction can actually be achieved depends on the regulatory enforcement of the relevant measures and the public's willingness to accept slightly less comfortable room temperatures.

22 As far as electricity production is concerned, there is a danger that a protracted shutdown of large numbers of French nuclear power plants could drive up demand for gas in the electricity market [16].

23 A lock-in effect could arise if there is a condition requiring new facilities (e.g. oil-fired instead of gas-fired plants) to be used until the end of their lifetime. However, this is reversible if it is accepted that they may be decommissioned some years before they reach the end of their lifetime.

- **Fall in demand due to high energy prices**: Short-term **price elasticity**[24] in the residential sector is considered to be relatively low.[25] In the medium term, however, rapidly rising energy prices are expected provide an incentive for people to switch to climate-friendly heating systems and improve home insulation.

  Price elasticity in **industry** is highly dependent on the individual production process. Natural gas used as a raw material will be extremely difficult to replace in the short to medium term. If energy prices in Europe climb too high compared to other parts of the world, it may no longer be profitable for energy-intensive industries (especially primary industries) to maintain production in Europe. In other words, there is a danger that plants could close and companies could relocate to regions with lower energy prices. Once they have done this, there will usually be little prospect of them returning. In most cases, there are unlikely to be any climate benefits, since production is only being relocated, potentially to countries with lower environmental standards. On the other hand, high gas prices could speed up the introduction of green alternatives made from hydrogen produced with renewable electricity.

- **Use of alternative application technologies and improved energy efficiency**: Natural gas demand can be significantly reduced in the medium term by electrifying its areas of application through the use of heat pumps and power-to-heat in industry, the use of hydrogen and synthetic fuels, and improvements in energy efficiency. All of these measures will be necessary anyway if the relevant climate targets are to be achieved. Natural gas demand must fall to zero by 2045/2050 if Germany and the EU are to achieve net zero by these dates. However, it will take time to make the switch and implement the relevant measures – and the available hydrogen supply over the next few years will be insufficient to replace significant quantities of natural gas.

  Nonetheless, the TYNDP Distributed Energy scenario – which provides the basis for the simulations in both the EWI and Fraunhofer IEG et al. reports – suggests that climate measures can enable a 22.5% reduction in total European gas demand by 2030 compared to 2018 levels. In this scenario, which was produced before the current supply crisis, the reduction in gas demand is achieved through extensive electrification of the heating and transport sectors, building insulation, more efficient end devices and changes in heating and mobility behaviour.

  Agora Energiewende illustrates how energy efficiency measures in the residential and industrial sectors, faster growth of renewables and increased use of heat pumps and hydrogen technology could combine to achieve a reduction in Germany's natural gas demand of around 20% by 2027 [19].

Overall, it can be assumed that only a **combination of the expected price-related demand effects and other energy policy instruments** will be enough to deliver the necessary reduction in demand.[26] Support can be provided through regulatory measures (e.g. higher energy efficiency standards) and funding for the promotion of energy-saving behaviour (e.g. information campaigns). According to Federal Minister for Economic Affairs and Climate Action, Robert Habeck, both of these approaches are already being discussed.

24 Price elasticity is a measure of how strongly demand responds to changes in price.
25 It is estimated that a 50% rise in gas prices would lead to roughly a 10% drop in demand. Part of this would be due to people heating their homes less because of higher gas prices [18].
26 Fischer C., 2022 [20] provides a compilation of proposed measures and assesses their energy saving and efficiency potential.

Nevertheless, a performance gap of 25-30% could occur if the planned infrastructure measures are not taken or if Russian gas imports are suspended before the infrastructure expansion is completed. Drastic measures will be required if this happens. The next one to two years will be a particularly critical time, since it will only be possible to implement limited infrastructure measures during this period and many of the demand reduction measures described above will also take longer. In the short term, the suspension of Russian gas imports could therefore result in the voluntary or mandatory shutdown of some industrial processes. Households could help to mitigate the situation by reducing their demand for energy services (especially heating).

There are major differences between the different options for reducing gas demand. Some can be achieved through relatively minor comfort sacrifices or through the acceleration or prioritisation of measures that are in any case needed to comply with the Federal Climate Change Act. However, some of the other options could result in loss of production and the relocation of industry to other parts of the world, with all the painful economic impacts that this entails. Consequently, when prioritising the options for reducing demand, it is important to avoid focusing solely on the short term and ensure that the long-term effects are also carefully weighed up.

2.6 Which supply-side measures can help to maintain security of supply?

Reliance on fossil fuel imports can be reduced by expanding renewable energy. The EWI simulations indicate that if renewables are expanded in line with the German government's 2022 Easter package, it should be possible to significantly reduce the output of conventional (soft/hard coal and natural gas) power plants by 2030. In this scenario, conventional plants are mainly used to cover peak loads and maintain supply during the winter, when less renewable electricity tends to be generated.

With this in mind, the conditions must be created to enable implementation of the growth targets for renewables in the EU's RePowerEU plan and in Germany's 2022 Easter package. The key challenges include providing adequate incentives for the necessary investment in renewable energy installations, dramatically speeding up the relevant planning and licensing procedures, driving power grid expansion in Germany and throughout Europe, and increasing production capacity for the raw materials, equipment and products needed to deliver the energy transition. In order to enable sector coupling, renewable energy must be cheaper and must not be unnecessarily encumbered by state-imposed price components. A first step in Germany would be to abolish the EEG surcharge. Reducing electricity tax to the European minimum would also help to make renewable electricity more competitive. At the same time, the planned reform of the Energy Taxation Directive should be driven forward at European level.[27]

In the new energy policy landscape, the rapid ramp-up of the hydrogen economy remains an indispensable element of the energy transition in Germany and Europe. Green hydrogen has the potential to replace fossil fuels in the long term.

However, the available hydrogen supply over the next few years will be insufficient to make a significant contribution to the energy transition and to security of supply in the short to medium term. Moreover, the new challenges in maintaining security of supply for natural gas could delay the development of the necessary hydrogen infrastructure (see 2.3). Blue hydrogen could serve as a stopgap solution until sufficient

27 Further measures for growing the renewable energy sector are described in the ESYS position paper "*Wie kann der Ausbau von Photovoltaik und Windenergie beschleunigt werden*?" (currently only available in German) [21].

quantities of green hydrogen are available, but if the assumptions made about natural gas supply and price trends are correct, the economic potential for the production of blue hydrogen will also be lower.

It will therefore be important to create incentives for the domestic production and importation of hydrogen. Global and European structures for importing hydrogen should be developed as soon as possible. Efforts should be made to diversify these import structures in order to prevent the emergence of new dependencies.

The conversion of coal-fired power plants threatened with closure into a contingency reserve will be increasingly necessary over the next few years in order to guarantee security of supply. It is thus likely that coal will continue to play a significant role in electricity generation for some years to come. In the EWI model, the suspension of Russian gas imports and high gas prices result in soft and hard coal pushing natural gas down the merit order and taking a larger relative share of the electricity generation market. This effect is exacerbated by high electricity demand and slow growth in renewables. Nevertheless, since renewables will still play an increasingly important role, none of the EWI scenarios for 2026 or 2030 project an absolute increase in coal-fired electricity generation compared to 2021.

There are currently too many imponderables to predict how long this increase in the use of coal will need to last. **However, there is no fundamental reason to assume that an early phase-out of coal cannot still be achieved by 2030.** That said, in addition to a rapid expansion of renewables and improvements in the energy efficiency of existing applications, this would call for the construction of new gas-fired power plants to cover peak loads, as provided for in the German government's coalition agreement. As things currently stand, however, it seems highly unlikely that these additional plants will be built without strong incentives from government, not least because they would also need to be H_2-ready.

According to the EWI simulations, if renewables are not expanded rapidly and growth in electricity demand is not curbed over the next few years, and if the percentage of coal-fired power generation rises as a result, it will be extremely difficult to meet the **2030 energy sector targets** in the climate action programme. There would also be a danger of Germany exceeding the national carbon budget established by a 2021 ruling of the Federal Constitutional Court. If the projected additional emissions occur in the next few years, they would need to be compensated for by an even faster reduction of emissions in subsequent years.

At European level, any target overruns should be absorbed by the EU ETS emission caps. However, this mechanism could come under increasing (political) pressure due to the potential increase in certificate prices, not least because other EU countries such as the Netherlands may also have to make greater use of coal-fired power plants.

3 Implications for German and European policy

3.1 The suspension of Russian gas imports poses a threat to security of supply in Europe

The suspension of Russian gas imports – either due to an EU embargo or because Russia cuts off its supply – would pose huge challenges for Germany and the rest of the EU. **If Russian imports were suspended in the next few months, Germany would be unable to meet around 30% and Europe around 25% of peak winter demand (based on 2021 figures).** Even if enough gas could be sourced from the global market in the form of LNG, there are not enough LNG terminals and pipelines to bring the gas ashore and distribute it in Europe. The picture is similar for annual demand – currently operational LNG terminals and pipelines are only able to meet about 80% of Europe's annual demand for natural gas based on 2021 levels.

As far as this winter is concerned, cutting gas consumption appears to be the only viable option. It is likely that industry will be forced to partially scale back production either due to higher prices or because it is required to do so by government. Households can help to mitigate the shortage by reducing their demand for energy services and in particular by turning down the heating.

The following measures should be prioritised:

- **Europe's gas infrastructure,** including both LNG terminals and pipelines, should be expanded and modified as soon as possible. Modifying compressor stations to enable reverse flow is a particularly effective measure that can be implemented relatively quickly. LNG terminals can help to diversify the gas supply. Expanding the gas infrastructure will make it possible to close the performance gap during peak load periods, provided that demand for gas in Europe also falls by 20%.

- The **substitution of natural gas** should also be accelerated, especially in the electricity sector. To achieve this, it is likely that coal will continue to play a significant role in electricity generation in the next few years. In the medium term, natural gas can gradually be replaced across all sectors through **the expansion of renewables** and sector coupling.

- Improvements in **energy efficiency** (especially building insulation and more efficient heating systems) are urgently necessary. The replacement of older, inefficient gas heating systems with electric heat pumps should be prioritised.

These measures will allow the physical supply shortfall to be closed **in the medium term**, from around 2025/26. Since this will not be possible without also reducing demand, it would be counterproductive to bring energy prices in Europe down through state subsidies, thereby incentivising consumption at a time when gas is in short supply. While it will be urgently necessary to provide support for low-income households, this should be done through social policy instruments. Another benefit of reducing demand is that it helps to keep energy prices in check.

3.2 High energy prices could cause difficulties for industry and households

If Russian energy imports are suspended, high energy prices could cause serious difficulties for the economy and society as a whole in Europe. The reports forecast that energy prices will remain above pre-2021 levels, at least in the medium term. This poses a huge challenge, especially for German industry, which has benefited from cheap gas imported from Russia by pipeline for several decades. **European countries could find themselves at a competitive disadvantage** compared to countries that have enough domestic gas reserves to meet their demand and are thus not dependent on the global market. Higher fuel prices could also lead to a continuation of the **trend towards higher electricity prices in Europe**. Energy prices could return to pre-2021 levels from around 2030, as long as the appropriate measures are taken. These include improved energy efficiency, the expansion of natural gas export and import capacity around the world and the expansion of renewables in Europe. However, this will call for high levels of investment.

Government could implement temporary measures to support **industrial competitiveness**. It will be necessary to discuss the level of this support and how long it should continue. Energy-intensive primary industries are particularly at risk. In order to maintain the competitiveness of energy-intensive industries in the medium to long term, it will be necessary to accelerate changes geared towards improving productivity in Germany and the EU as a whole and to strengthen non-energy-related local factors.

In the short term, it will be necessary to explore measures to prevent the closure of production facilities. These measures will be particularly important if there is a danger of cascade effects in downstream production stages and to prevent the permanent closure of facilities that perform a key function for German industry. If no action is taken, there is a risk that, once production facilities are closed, persistently high energy prices will prevent them from reopening and their production will be relocated to other countries. This could trigger further cascade effects, for example if the relocation of raw material production leads to the offshoring of entire value chains.

Households will also be hard hit by rising energy prices and the resulting hikes in the price of food and other products. The **affordability of energy** is thus set to become an even more important issue. In the next few years, the cost of a unit of energy is likely to be significantly higher than in recent decades. It will therefore be necessary to ensure that the **energy supply is socially equitable** and in particular to protect low-income households against rising energy prices. This will include financial support through social policy instruments and support with energy-saving measures.

3.3 Europe's nations must cooperate closely to guarantee security of supply

Close and finely-tuned cooperation between Europe's nations and coordination of gas distribution will be absolutely key to minimising the impacts if Russian gas imports are suspended. Germany is particularly reliant on imports from other European countries. This reliance will be even greater if Russian gas imports cease before the construction of Germany's planned new LNG terminals has been completed. At the same time, Germany has a central role in ensuring security of supply for the whole of Europe due to its position as a key transit country and because of its large gas storage capacity.

However, the likely gas shortage, especially between 2022 and 2025, could seriously test the solidarity of the EU's member states. It will be important for them to come to an agreement about whether the distribution of gas supplies should be left up to market forces or whether rationing should be employed to share the available gas among the member states. A coordinated European gas procurement strategy would help to prevent prices being driven up even further by intra-European competition for limited supplies of gas in the global market. Closer European cooperation on energy will also be extremely important over the longer term, for example with regard to the expansion of hydrogen grids and renewables.

3.4 Leveraging synergies between security of supply and climate action

Many measures aimed at tackling climate change also help to reduce reliance on fossil fuels. On the production side, it will be important to accelerate the **construction of new renewable energy installations** and of **electrolysers for the production of green hydrogen**. On the consumption side, it will be particularly vital to promote electricity- and hydrogen-based **sector coupling** and drive improvements in **energy efficiency**. Ambitious growth in renewables can help to keep wholesale electricity prices in check.

However, **significant investment will be required** to accelerate the energy transition – and **the greater the economic impact of rising energy prices, the harder it will be to deliver this investment**. Governments are likely to have less financial leeway and will need to make even tougher decisions about public spending priorities. Statutory regulations to prevent lock-in effects should be adopted in order to avoid bad investment decisions. For instance, new natural gas infrastructure should be easily convertible to hydrogen.

Increased use of coal for electricity generation would be at odds with efforts to meet Germany's climate targets. However, the EU ETS is designed to offset trends like this at European level, ensuring that incentives to reduce fossil fuel use are maintained. Higher emissions lead to higher prices in the EU ETS and to even higher costs for consumers and industry. This could result in public and political pressure to reduce carbon prices and suspend the relevant instruments. Policymakers must resist this pressure and find ways of providing social and economic policy support that do not jeopardise efforts to meet climate targets and reduce reliance on imports. This will be key to ensuring that the current supply crisis does not threaten the success of measures to tackle the climate crisis.

3.5 Strengthening the resilience of Europe's energy supply through diversification

Germany and the EU have become highly reliant on Russian energy, which accounts for a significant percentage of their energy imports. This dependency was accepted as the price that had to be paid for the competitive advantage offered by cheap energy imports, which European companies and consumers have benefited from for several years. It has become clear in the light of recent events that **the complete suspension of Russian energy imports would cause major economic problems for Germany and other European countries.**

In order to avoid the risks associated with strong, unilateral future dependencies and strengthen **the resilience of Europe's energy supply**, it will be vital to implement extensive energy-saving measures, expand renewable electricity generation capacity and diversify the countries from which Europe imports energy. There is a danger that the current situation could give rise to major new dependencies, especially if Russian natural gas is mainly replaced by LNG imports from the US. In the long term, there would be an economic and energy policy case for resuming a certain level of trade relations with Russia if the geopolitical and security policy situation permits. This would make it possible to diversify Europe's energy supply while still benefiting from relatively low prices. According to the EWI simulations, if Russian energy imports fell by just 50%, coal, oil, gas and electricity prices would be significantly lower in both 2026 and 2030 than if Russian imports were to cease completely.

However, the diversification that is key to achieving a **resilient European energy supply** should not be confined to fuels. It is also necessary to review critical dependencies in relationships with suppliers of the raw materials needed to build new renewable energy installations, electrolysers for producing green hydrogen and energy infrastructure. Policymakers should also avoid over-reliance on individual nations for imports of energy carriers that are key to the future energy supply, especially green hydrogen. All of these aspects should be addressed as part of an integrated strategy that incorporates e.g. circular economy initiatives with high standards for the recycling and reuse of secondary raw materials.

Appendix: Methodology and brief summary of the reports

EWI report

In its report "*Szenarien für die Preisentwicklung von Energieträgern*" (Scenarios for the Price Development of Energy Carriers), the Institute of Energy Economics at the University of Cologne (EWI) investigates the medium-term price trends (to 2026 and 2030) for gas, oil, coal and electricity. A brief summary of the methodology and key findings is presented below.

Methodology and approach

Since the medium-term price trends for gas, oil and coal are characterised by a high degree of uncertainty, the scenarios developed for this study used different values for the three most important variables:

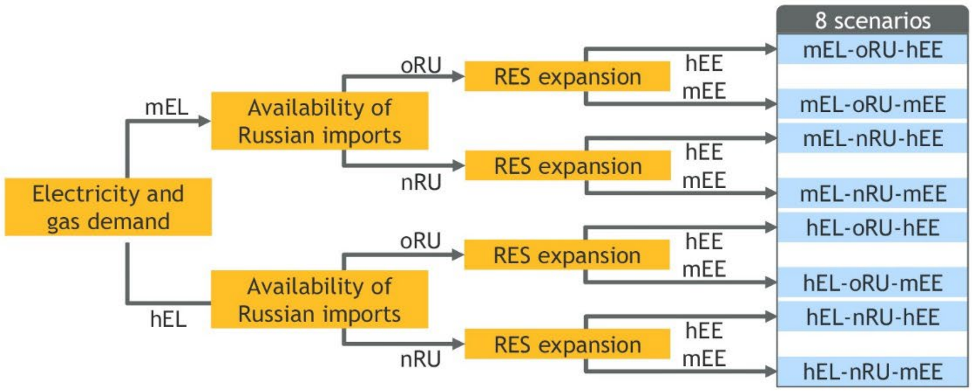
Gas and electricity demand: Electricity and gas demand trends are driven by the ambition of greenhouse gas reduction targets and, by extension, the degree of electrification of end user sectors. Efficiency gains achieved through measures such as energy retrofits of buildings also have an impact. The "moderate electrification" (mEL) parameter assumes that there will be a slight rise in electricity demand while demand for natural gas in Europe remains more or less stable. The "high electrification" (hEL) parameter assumes that there will be a large rise in national electricity demand accompanied by a fall in demand for natural gas in Europe.

Availability of Russian energy imports: On the supply side, there is considerable uncertainty regarding the level of future energy imports from Russia. The "no Russian imports" (oRU) parameter assumes that Europe will meet its energy demand without any imports of Russian gas, coal and oil. The alternative "limited Russian imports" (nRU) parameter assumes that limited Russian imports will still be available. For instance, it limits Russian gas imports to a maximum of 75 billion m^3, roughly half the level of Russian imports in 2021.

Growth of renewables: The growth of renewables in Germany is a key variable characterised by considerable uncertainty. The (hEE) parameter assumes that there will be high growth in renewable energy by the target years of 2026 and 2030, whereas the alternative (mEE) parameter assumes only moderate growth. The higher growth trajectory for solar and wind power is based on the German government's latest targets as set out in the draft 2023 Renewable Energy Sources Act (EEG 2023).

The investigation of energy carrier price trends is based on various EWI models and economic analyses of the supply and demand sides. The gas price trend simulations are based on the EWI's COLUMBUS gas market model, while the electricity price trend simulations use the EWI's DIMENSION electricity market model. The simulations of the coal and oil markets draw on economic analyses of supply, demand and market prices. Different combinations of variables produced scenarios for which energy carrier price trends and other implications for the energy sector were modelled. The prices output by the simulations informed a discussion of the potential impacts on private households and energy-intensive industries.

Figure 6 shows the variables that were investigated and the corresponding parameters in the form of a scenario tree.



Central uncertainty	Characteristic	Description
Electricity and gas demand	mEL	moderate electrification , constant gas demand
	hEL	high electrification , declining gas demand
Availability of Russian imports	oRU	without availability of Russian imports
	nRU	low availability of Russian imports
RES expansion	hEE	high expansion rate of renewable energies
	mEE	moderate expansion rate of renewable energies

Figure 6: Scenario tree for key variables (Source: EWI 2022 [1]).

Results and conclusions

Projected gas prices in Europe are strongly influenced by the availability of Russian energy imports, gas demand trends and the level of investment in liquefaction and regasification facilities around the world. The scenarios indicate that a significant percentage of lost Russian gas imports can be replaced by LNG imports, first and foremost from the US, where production and liquefaction capacity is growing faster than anywhere else in the world. If Russian gas imports cease completely (oRU), US LNG imports' share of the total EU27+UK import mix could rise from around 8% in 2021 to as much as 35% in 2030.

In the scenarios where demand for gas falls (hEL), the projected gas prices for 2030 are comparable to 2018 levels (€22/MWh (hEL-oRU) and €18/MWh (hEL-nRU)). In the short term (between now and 2026), however, gas prices in the scenario where Russian imports cease completely (hEL-oRU) are approximately €18/MWh higher (€43/MWh) than in the scenario where limited Russian imports are still available (hEL-nRU). In the scenarios with stable gas demand (mEL), the influence of Russian import availability on gas prices is also significantly higher in the long term. In the scenario with no Russian imports (mEL-oRU), the gas price climbs above €66/MWh and remains at a high level (€59/MWh) up to 2030. If limited Russian imports are available (mEL-nRU), gas prices reach €29/MWh in 2026 and fall slightly to €28/MWh in 2030.

The scenarios indicate that oil and coal prices could come down again in the next few years. After peaking in 2022, market players expect oil prices to fall back to somewhere in the upper range of 2016-2021 levels (oil = approx. €50/MWh, coal = approx. €10/MWh). If limited Russian oil imports are available (nRU), prices are projected to fall to around the average for the last five years. Coal prices are also expected to come down. However, if there are no Russian hard coal imports in the medium term (oRU), coal prices are projected to remain above historical levels. If, on the other hand, limited Russian coal imports continue (nRU), prices could fall to somewhere in the upper range of 2016-2021 levels.

All the scenarios project significantly higher wholesale electricity prices than the long-term historical levels. However, prices are still projected to come down substantially from the highs witnessed since the middle of 2021. The highest prices (average annual prices of up to €132/MWh in 2026 and €135/MWh in 2030) occur in the scenarios with a combination of factors that push prices up, such as high electricity demand (hEL), no Russian imports (oRU) and only moderate growth in renewables (mEE). Conversely, the lowest prices (€79/MWh in 2026 and €52/MWh in 2030) occur in the scenario with moderate electricity demand (mEL), limited availability of Russian imports (nRU) and high growth in renewables (hEE). Renewable energy growth is a key driver of lower wholesale electricity prices.

Energy is an essential commodity for the German economy that cannot be easily substituted. Price rises therefore have a serious impact on different actors such as (low-income) households and (energy-intensive) industries, who rely on energy carriers as a raw material and for electricity, heating and mobility. Energy prices in Europe could remain at a historically high level even in the medium to long term. High energy prices in Europe could put industry at a competitive disadvantage compared to other regions such as Asia and the US, where energy prices have not risen as much. For instance, the study projects a significant decline in the competitiveness of gas-intensive primary industries such as Germany's fertiliser industry. It also indicates that low-income households will be especially hard hit by rising energy prices. This is because energy costs will account for a larger percentage of these households' budgets and because lower-income households are less able to adapt by investing in efficient heating technologies and building retrofits.

Fraunhofer IEG et al. report

This report analyses security of supply in Europe in terms of the technical aspects of the network. It carries out a power balance analysis of natural gas flows for 2022-2026 and 2022-2030 in the event that gas flows from Russia cease. The resulting gas transports are validated using a fluid mechanical simulation of five illustrative European transmission networks in 2026.

Results and conclusions

The simulations indicate that it is possible to meet Europe's gas demand without Russian imports by making greater use of LNG and other available pipeline imports. Fluid mechanical transmission network models for Spain, France, Benelux, Italy and Germany demonstrate the technical feasibility of the changes in gas flows needed to make this possible.

This will call for close cooperation within Europe, rapid implementation of a range of infrastructure measures and a 20% reduction in gas demand compared to 2021. According to the TYNDP Distributed Energy scenario [8] used as the basis for this study, this reduction can be achieved by 2025. The necessary infrastructure measures include the implementation of currently planned pipeline projects, the expansion of existing LNG terminals and construction of new ones, and the modification of compressor stations to enable reverse flow. The latter is essential, since the gas in many network sections will no longer be flowing in the direction that the network was originally designed for. The change of flow direction between Italy and Austria is vital to enabling the onward transport of gas to Slovakia and ultimately to Ukraine. Germany's network also plays a key role in the transit of high volumes of gas to its neighbours. In the modelled scenario, Germany's planned floating storage and regasification units (FSRUs) are already operating at high capacity by 2023.

Methodology

The simulations use two variants of the TYNDP scenario – an "average" variant with average power demand and no use of stored gas, and a "winter" variant with high demand, in which gas held in storage facilities is utilised. The simulations are essentially carried out on an hourly power balance (MWh/h) basis, i.e. for one hour of "average" demand and one hour of "winter" demand.

The starting point of the analysis is a transport model for power balancing of flows between the individual countries. Constraints include the maximum capacities of the interconnectors, the upper limits for natural gas production and the LNG and pipeline imports of the individual countries, including the projected production volumes. The results of the balance optimisation are subsequently input into a pan-European flow model based on MYNTS[28]. Every country is represented as a node, and a fluid mechanical simulation of European gas flows is carried out so that inter-European gas transmission bottlenecks can be identified.

In the key final stage of this three-stage model chain, bottlenecks in selected European countries are analysed and the results of the preceding models are checked for their physical feasibility in the transmission network. The gas infrastructures of Spain, France, Benelux, Germany and Italy are modelled in detail using the MYNTS and SIMONE physical gas flow models. Natural gas demand is broken down to NUTS3 level and subsequently allocated to the individual nodes of the gas network.

28 Multiphysical network simulator; a software solution developed by Fraunhofer SCAI for the simulation, analysis and optimisation of energy networks.

The gas flow models are then adjusted so that all the regional demands and exports to adjacent networks are covered. The capacities of the individual pipelines, LNG terminals, interconnectors and storage facilities are taken into account.

Further details:

Download the EWI and Fraunhofer IEG et al. reports (only available in German) at:
https://energiesysteme-zukunft.de/publikationen/stellungnahme/energiepreise-versorgungssicherheit

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