POLICY PAPER

Case Study: How Europe Made It Through the 2022-23 Winter

Benjamin Bajema
bcbajema@efifoundation.org

While this paper was commissioned by the EFI Foundation, it does not represent the views and conclusions of the authors. EFI Foundation has not endorsed or approved the statements and conclusions contained in these documents, but rather have approved the limited sharing of these materials as part of the study process. Please do not disseminate or otherwise use this information for other than its intended purpose.

June 2023

EFI FOUNDATION

900 17th Street NW, Suite 1100, Washington, DC 20006

About Author

Benjamin Bajema

Benjamin Bajema is an Analyst at the EFI Foundation, where he leverages his background in international relations, economics, and energy policy to support EFI's hydrogen and global gas initiatives. Prior to joining EFI, Bajema supported the Economic Division of the Embassy of Japan in Washington D.C. by managing agriculture, transportation, and energy policy portfolios to advance Japan's climate ambitions and align U.S.-Japan foreign policy. Bajema holds a Bachelor of Arts in Japanese Studies from Willamette University and is pursuing a Master of Science in Sustainability Management and Analytics from American University's Kogod School of Business.

The EFI Foundation advances technically grounded solutions to climate change through evidence-based analysis, thought leadership, and coalition-building. Under the leadership of Ernest J. Moniz, the 13th U.S. Secretary of Energy, the EFI Foundation conducts rigorous research to accelerate the transition to a low-carbon economy through innovation in technology, policy, and business models. EFI Foundation maintains editorial independence from its public and private sponsors.

© 2023 EFI Foundation

Executive Summary

The Russian invasion of Ukraine created an ongoing energy crisis in Europe. The share of Russian gas in EU energy systems decreased sharply, from 41% in Dec. 2021, to 12% by Oct. 2022, as a result of European sanctions and Russia's weaponization of its natural resources.[1] To fill the supply gap, the U.S. government, aided by the lack of destination clauses in many U.S. LNG export contracts, encouraged suppliers to divert cargoes to Europe after consulting with Asian allies and other recipients of American LNG.

Due to challenges with limited supply and high demand, prices for European energy consumers increased significantly in 2022, hitting an all-time high of €339 / MWh.[2] High natural gas prices impacted residential and industrial consumers and pushed the European Commission to develop a suite of policy measures to abate the supply and price issues. Europe was able to make it through the 2022-23 winter largely due to a combination of full storage, forced dampening of demand, mild weather, and policy initiatives.[3] Although prices have come down this year, Europe is destined for a challenging winter as Asian industrial demand and price volatility could return in 2023.

This case study examines the impacts of the war in Ukraine on European energy markets from a policy perspective and analyzes key economic areas such as power generation, energy efficiency in buildings, and disruptions to the industrial sector. This case study explores three main areas:

1. What policy measures did Europe take this past winter to secure its natural gas supply amidst Russia's weaponization of piped gas?
2. What did the EU do to minimize gas demand in terms of efficiency gains and use of gas alternatives?
3. What were the economic impacts of the War and subsequent EU policies?

The main policy initiative to emerge from the war in Ukraine is the REPowerEU plan, which aims to rapidly reduce dependence on Russian fossil fuels by 2027 and accelerate the low-carbon energy transition while increasing the resilience of the EU-wide energy system. The policy focuses on accelerating the deployment of renewables and energy efficiency measures through renewable support policies and permitting reform.

The EU increased storage capacity requirements and dampened demand to prepare for a winter with a limited gas supply. The EU introduced minimum gas storage obligations in June 2022, whereby storage sites had to be filled to at least 80% of their capacity before the winter of 2022-23, and to 90% ahead of all future winters. In addition, regulation was introduced to reduce gas demand across the EU by 15% (compared with the EU's five-year average (2018-2022)) between August 1, 2022, and March 31, 2023. Additional policy measures, such as grants and preferential loans for housing retrofits and heat

pump installations, as well as campaigns to encourage behavioral change, all played a part in moderating gas demand in 2022.[4]

Regasification capacity was also increased to supplement the loss of Russian piped gas with Liquefied Natural Gas (LNG) from the United States, Qatar, Nigeria, and other gas suppliers. New floating storage regasification units (FSRUs) and the expansion of existing regasification terminals will support 25% more regasification capacity for the EU in 2023 relative to 2021 capacity.

Additionally, the EU energy ministers agreed on new rules to set market correction mechanisms for oil and gas which aim to protect citizens and the economy against excessively high prices. In December 2022, the Council decided to set an oil price cap at USD 60 per barrel of crude oil, petroleum oils, and oils obtained from bituminous minerals from Russia.[5] The European Council also implemented a market correction mechanism for natural gas that will apply to transactions on virtual gas trading platforms in the EU for one year.[6] The cap is triggered if natural gas prices exceed €180 per megawatt hour (MWh) or if the LNG price is €35 higher than a global reference price for three days on the Dutch Title Transfer Facility (TTF)[1] gas hub.

However, weather, as opposed to policy, was the single largest driver in reducing gas demand in Europe. Warmer weather accounted for reducing 18 billion cubic meters (bcm) of natural gas consumption in buildings (Figure 1, pg. 2). A mild winter allowed for less gas to be used for heating and power generation as heating degree days across the European Union were 12% lower on average in 2022 than in 2021; due to lowered space heating requirements.

Not all weather patterns, however, yielded positive results for the European energy sector. For example, low rainfall in southern Europe led to a very poor year for hydropower and increased the need for gas-fired power generation by 12 bcm. Additionally, policy drove a reduction in the use of nuclear power generation; this increased the need for gas-fired power generation by 22 bcm. Europe's power system was further disrupted when France's nuclear power fleet experienced shutdowns in November 2022. 26 of its 56 reactors were off-line for maintenance or repairs after the worrisome discovery of cracks and corrosion in some pipes used to cool reactor cores.[7] On the flip side, increases in coal and renewable generation offset natural gas generation by six bcm and 11 bcm, respectively (Figure 1).

Although the mild winter lowered natural gas demand, high prices also played a considerable role in demand reductions, especially in the gas-intensive industrial and residential sectors. In the industrial sector, gas use fell by 25 bcm, or around 25%, due to production curtailment of gas-intensive manufacturing, fuel switching from gas to oil, and efficiency gains (Figure 1). Manufacturers reduced production and imported finished products from outside the EU instead of manufacturing them domestically at a higher cost. Some industries also reduced their gas needs by increasing imports of intermediate gas-intensive goods, enabling overall output of final products to remain largely

[1] The Title Transfer Facility (TTF) is a virtual trading platform used as a reference to set the price of natural gas in the EU.

unchanged. German industry was hit particularly hard by the energy crisis as gas consumption in the industrial sector fell by 14.3% (Boxes 1, 2, 3, and 5 cover how the energy crisis impacted Germany).

In the residential and commercial building sectors, natural gas demand was reduced by seven bcm due to behavioral changes, efficiency gains, rising fuel poverty,[2] and fuel-switching in 2022 (Figure 1). Many vulnerable consumers reduced consumption because they could not afford the higher bills, leading to cold homes or shifting to cheaper and sometimes more polluting fuels such as wood pellets, charcoal, waste, or low-quality fuel oil.[8]

In the EU, GDP grew slightly more than GHG emissions in the third quarter of 2022 compared with the same quarter in 2021 (+two percent for greenhouse gas (GHG) emissions, +three percent for GDP). Most EU countries saw growth in both GDP and emissions, but some countries managed to decrease emissions while increasing GDP.[9]

The strong LNG inflow into Europe was partly enabled by an unprecedented drop in China's LNG imports due to lower procurements on the high-priced spot market, reselling U.S. LNG cargoes to Europe, and economic slowdowns as a result of the COVID-19 pandemic. China's government has asked state-owned gas importers to stop reselling LNG to buyers in Europe and Asia to ensure a stable gas supply ahead of winter 2023.[10] A return to stronger Chinese economic growth and some easing of lockdowns could bring 2023 LNG imports back to their 2021 levels (108 bcm), which would capture over 85% of next year's expected increase in global LNG supply and limit the amount of LNG available to the European market.[11]

[2] A household is said to be in fuel poverty when its members cannot afford to keep adequately warm at a reasonable cost, given their income. The term is mainly used in the UK, Ireland, and New Zealand, although discussions on fuel poverty are increasing across Europe, and the concept also applies everywhere in the world where poverty and cold may be present.

Table of Contents

1. Introduction

The supply cut of Russia's gas to the European Union put unprecedented pressure on the European and global gas markets and triggered a global gas crisis. Russia's piped natural gas exports to OECD Europe fell by an estimated 49%, or 82 bcm, y-o-y in 2022, to their lowest level since the mid-1980s.[12]

In the wake of Russia's invasion of Ukraine and a surge in energy prices, natural gas demand in the European Union (EU) fell in 2022 by 55 bcm, or 13%, its steepest drop in history (Figure 1). The decline is equivalent to the gas needed to supply over 40 million homes.[13] This memo seeks to answer three main questions:

1. What were the policy measures Europe took this past winter to secure its natural gas supply amidst Russia's weaponization of piped gas?
2. What did the EU do to use less gas in terms of efficiency and gas alternatives?
3. What were the economic impacts of those regulations?

Natural gas plays an important role in the EU's energy system. In 2021, the 27 countries of the European Union consumed 412 bcm of gas. Gas is mainly used for power generation, household heating and industrial processes. Over 30% of households in the EU use gas to heat their homes.[14]

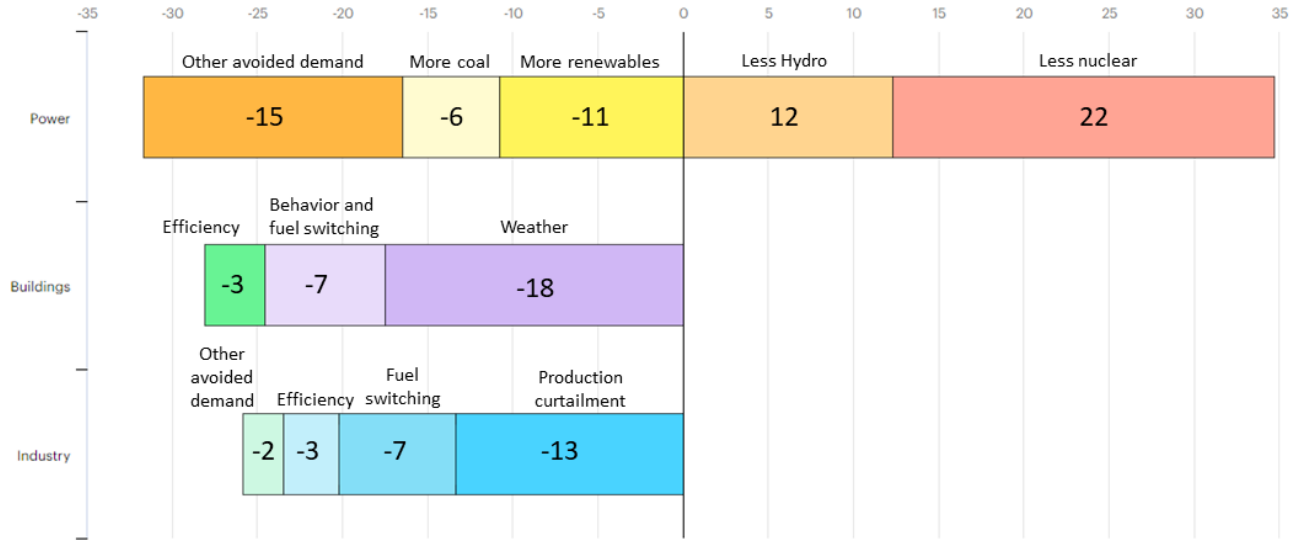
The EU is heavily dependent on imports to meet natural gas demand; imports are 83% of the EU's natural gas supply. Since Russia's invasion of Ukraine, gas imports from Russia to the EU have been significantly reduced. This has mainly been compensated for by a sharp increase in imports of LNG, particularly from the US, Qatar, and Nigeria, although volumes from the US are the largest by significant amounts.[15]

As noted, flexible US LNG played a crucial role in mitigating the shortfall in Russian piped gas supply. LNG inflows into the European Union rose by 70% or 55 bcm in 2022 compared to the previous year –almost twice the increase in global LNG production. The strong price signals provided by the European hubs led to a reconfiguration of global LNG flows to the European Union, primarily spot and destination-flexible LNG from more price-sensitive markets. Lower LNG deliveries negatively affected electricity supply security[3] in South Asian markets, including in Bangladesh and Pakistan, where load shedding schedules[4] were introduced through 2022. The strong LNG inflow into Europe was in part enabled by an

[3] Natural gas power plants use a gas turbine to produce electricity; natural gas is added, along with a stream of air, which combusts and expands through this turbine, causing a generator to spin a magnet, making electricity.
[4] Load shedding (loadshedding) is a way to distribute demand for electrical power across multiple power sources. Load shedding is used to relieve stress on a primary energy source when demand for electricity is greater than the primary power source can supply.

unprecedented drop in China's LNG imports, which declined by 21% (or 22 bcm) in 2022. China imported less LNG primarily due to lower procurements on the high-priced spot market and economic slowdowns because of the COVID-19 pandemic. A return to stronger Chinese economic growth and easing of lockdowns could bring 2023 LNG imports back to 2021 levels (108 bcm). This return of Chinese demand would represent over 85% of the expected increase of supply in 2023, thus limiting the amount of LNG available for the European market.[16]

Figure 1: Estimated drivers of change in natural gas demand in power, buildings, and industry in the European Union, 2022 vs. 2021 (Bcm)[17]



Source: IEA

China has pursued a strong LNG contracting strategy in recent years. As a result, China's reliance on LNG contracts with destination clauses is set to increase from 88 bcm in 2022 to 100 bcm in 2023. This effectively means that China will have the right-of-first refusal on an additional 12 bcm of LNG – well over half of the expected increase in global LNG supply in 2023. In mid-October 2022, it was widely reported that China's National Development and Reform Commission had asked state-owned gas importers to stop reselling LNG to buyers in Europe and Asia to ensure a stable gas supply going forward.[18]

Global LNG supply is expected to increase by 4.5% (or 23 bcm) in 2023, which is much less than the likely additional reduction of Russian pipeline deliveries to the EU. However, in 2023, Russian exports are expected to drop by half but could cease completely. If Russian pipeline gas supplies to the EU cease completely and Chinese LNG imports recover to 2021 levels then Europe could face a supply-demand gap of 30 bcm during the key summer period for refilling gas storage in 2023. This gap could represent almost half the gas required to fill storage sites up to 95% capacity by the start of the 2023-24 winter.[19]

Broadly, global energy prices may depend on how quickly China's economy emerges now the government has relaxed strict zero-COVID policies. China's reopening will boost oil and

gas demand this year, especially if the government succeeds in restimulating investment in construction and real estate. Stronger industrial activity will also increase China's natural gas imports, and a rebound in mobility will boost gasoline, diesel, and jet fuel consumption as well. Still, there are lingering questions about weak consumer sentiment and high national debt levels, which may affect demand in the longer-term.[20]

2. Guiding Policy

The European Union aims to make Europe the first climate-neutral continent by 2050, according to KPMG. On 12th December 2019, the European Council, together with the European Commission, established the European Green Deal (EGD), the core EU strategy to fight climate change and achieve climate neutrality. As a first step, the Commission proposed an initial set of 2030 targets. On 14 July 2021, the European Commission adopted "Fit for 55", a set of policy proposals preparing the implementation of the EGD. In particular, Fit for 55 aims to reduce GHG emissions by at least 55% by 2030.[21]

The main policy initiative to emerge from the war in Ukraine is the REPowerEU plan, which would rapidly reduce dependence on Russian fossil fuels by 2027 and accelerate the green transition while increasing the resilience of the EU-wide energy system. Measures related to renewable energy and energy efficiency include:

- Increasing EU's 2030 target to 45% renewables in the EU mix, up from the current target of 40% (an additional 169GW to the Fitfor55 2030 target of 1067 GW)
- Accelerating the rollout of PV energy, with a dedicated EU Solar Energy Strategy, aiming to deploy over 320 GW of new solar photovoltaic by 2025, and almost 600 GW by 2030
- Introducing the European Solar Rooftop Initiative, which is anchored around a legally binding EU solar rooftop obligation for certain categories of buildings
- Aiming at doubling the current deployment rate of individual heat pumps to reach 10 million cumulative units over 2023-2027
- Decarbonizing the industrial sector by accelerating the switch to electrification and renewable hydrogen and enhancing low-carbon manufacturing capabilities
- Increasing the EU's 2030 binding energy savings target to 13% (up from nine percent in the Energy Efficiency Directive)
- Prioritizing Investor confidence, primarily via improved auction design and wider use of renewables power purchase agreements.[22]
- Promoting the integration of renewables and distributed resources by ensuring sufficient grid capacity, both at transmission/interconnection and distribution level, to allow renewable electricity to displace gas consumption.
- Accelerating permitting of new grid infrastructure, alongside measures to boost transparency on grid status at the distribution level to help to ensure that renewables are deployed in areas where the network is able to integrate additional distributed resources in a timely, secure, and effective manner. Improving market access and removing barriers to flexibility (storage, demand response, etc.) will also enhance the grids' abilities to absorb wind and solar power.
- Introducing innovative digital solutions and eased permitting requirements, accompanied by measures to build capacity and provide financial incentives – in line

with the EU Solar Strategy - will help empower consumers to both individually and collectively produce, store and share renewable energy.[23,5]

In May 2022, the EU Commission issued calls for clean energy infrastructure projects to support the REPowerEU Plan, worth €800 million, with an emphasis on cross-border EU energy infrastructure projects, under the Connecting Europe Facility (CEF) for Energy. The call is open to projects under the list of Projects of Common Interest, published in November 2021.[24] The Commission's analysis indicates that REPowerEU entails additional investment of €210 billion between now and 2027, on top of what is needed to realize the objectives of the Fit for 55 proposals.[25]

The REPowerEU plan would result in a significant change to the energy system in terms of quantities and directions of energy flows. For example, the Trans-European energy networks (TEN-E) framework has helped establish a more resilient European gas infrastructure based that enables more diversified supplies. Once the ongoing Projects of Common Interest and Projects of Mutual Interests are implemented, all Member States and Neighboring countries will have access to at least three gas sources or to the global LNG market.[26]

Natural gas storage is also key for enhancing the security of supply. The European Commission believes that appropriate support, including financial, should be provided to those projects that aim at increasing the storage and withdrawal capacities in order to ensure an increased level of preparedness and response to risks in the security of gas supply. To import sufficient LNG and pipeline gas from other suppliers, the European Commission estimates investments at €10 billion by 2030 to realize a sufficient level of gas infrastructure, including LNG import terminals, pipelines, and reverse flow capacities. Additional investments to connect LNG import terminals in the Iberian Peninsula and the EU network through hydrogen-ready infrastructure may further contribute to diversifying gas supply in the internal market and help tap into the long-term potential for renewable hydrogen.

The combination of lower demand, a strong increase in non-Russian gas supplies, and unseasonably mild weather conditions through October and early November allowed the European Union to increase its gas storage levels by a record amount in 2022. Injections to EU gas storage facilities were over 70 bcm between April and mid-November, enabling them to reach 95% fill levels by mid-November. As of 9 December 2022, gas storage was around 15% (or 11 bcm) above its five-year average (2018-2022). High storage levels and lower demand put downward pressure on natural gas prices in October and November, reducing the risk of physical gas supply shortages for the 2022-2023 heating season.[27]

Policy measures – such as renewable support schemes, grants and preferential loans for housing retrofits, and heat pump installations, alongside campaigns to encourage behavioral

[5] The transition of the European energy system already started a decade ago, when baseload capacities using coal, gas and nuclear power started to diminish and as variable renewable energy sources expanded. However, some combination of nuclear, coal, and gas will have to be used in order to provide reliable baseload power. (IFRI, The EU's Plan to Scale up Renewables by 2030: Implications for the Power System)

change all played a part in moderating gas demand in 2022. Rapid adjustment to lower Russian gas exports and higher prices was also possible thanks to decades of reforms and policy initiatives, which enabled large consumers to lower their consumption, pursue import substitution and draw on alternative supplies across a well-meshed European gas grid.[28]

Alongside the broader structural changes targeted by the Fit for 55 package and the REPowerEU plan, major additional policy initiatives and infrastructure projects have sought to increase the resilience of European gas markets, strengthen solidarity and limit excessive price spikes. Examples include:[29]

- **Introduction of minimum gas storage obligations:** The European Union adopted a new storage regulation in June 2022, according to which storage sites had to be filled to at least 80% of their capacity before the winter of 2022-23, and to 90% ahead of all following winter periods. Several EU member states adopted more stringent regulations, aiming for fill targets above 90%. The EU intermediate storage targets for 2023 include a 45-55% fill level for February 1, which signifies the end of winter.
- **A regulation on coordinated demand reduction measures for gas:** This targets a 15% voluntary reduction in EU gas demand between August 1, 2022, and March 31, 2023, compared with its five-year average. The European Commission has adopted the European Gas Demand Reduction Plan with best practices and guidance for member states to help them reduce gas demand.
- **EU Action Plan to digitalize the energy system**: the European Commission presented an Action Plan in October 2022 on the digitalization of the energy sector to improve the efficient use of energy resources, facilitate the integration of renewables into the grid, and save costs for EU consumers and energy companies.
- **Energy diplomacy**: the European Union intensified its international outreach to strengthen energy partnerships with key natural gas and LNG suppliers. The EU and the United States announced a Joint Task Force in March 2022 to strengthen European energy security.
- **New floating storage regasification units (FSRUs) and the expansion of existing regasification terminals** will increase the European Union regasification capacity by 25% relative to 2021 capacity.
- **Several interconnectors were commissioned** ahead of the 2022-23 heating season that facilitated internal gas flows and diversification of gas supply, including between Central and Eastern European countries that have historically had a higher reliance on Russian pipeline gas.

Box 1: German Permitting Reform for LNG Import Terminals

Germany is one of the world's biggest gas importers and sources about 95% of its consumption from abroad. About one-quarter of Germany's energy demand was covered by natural gas in 2022. Before the war, gas was only imported via pipeline, 55% from Russia, and the rest from Norway and Netherlands. Germany did not have its own regasification terminals for LNG because there was no economic case for direct LNG imports since the country is so well-connected through pipelines to receive gas from neighboring countries.

Germany is accelerating the expansion of its natural gas import infrastructure, building two domestic import terminals with the first coming online in December 2022. To speed up the permitting and construction processes, the government introduced an 'LNG Acceleration Act' that allows the licensing authorities, under certain conditions, to temporarily waive some procedural requirements, especially in the area of environmental impact assessment. In addition to one or more fixed onshore terminals, the German government plans to lease five so-called Floating Storage and Regasification Units (FSRU) in the short term, two of which were installed by winter 2022/23. Germany's fixed onshore terminals could eventually be converted to handle climate-friendly gases, such as hydrogen.

Source: Clean Energy Wire, https://www.cleanenergywire.org/factsheets/liquefied-gas-does-lng-have-place-germanys-energy-future

3. Natural Gas Price Cap

August 2022 saw an unprecedented peak in EU gas prices – up by 1000% compared to prices in previous decades. Over the last ten years, the average price of gas in the EU was between €5/MWh and €35/MWh. In August 2022, TTF month-ahead and day-ahead prices hit an all-time high of over €300/MWh (Figure 2). The highest price levels were reached over five consecutive trading days from August 22-26, 2022, when they were above €265/MWh.[30]

EU countries have agreed on a market correction mechanism that will limit episodes of extraordinarily high gas prices in the EU and thus reduce the impact of price hikes on citizens and the economy. The creation of this pricing mechanism will limit extreme gas price peaks while ensuring the security of supply and market stability in the EU.[31]

Figure 2: Gas prices in the EU (2022)[32]

Source: ICE index

The significant price spike in August increased the financial burden on energy customers and challenged the security of supply for the EU market. The ongoing military aggression by Russia against Ukraine and Russia's weaponization of gas supplies continue to affect

markets and make security of supply challenging in the EU. Consequently, the excessively high gas prices have contributed to rising inflation which reached 11.5% in October 2022 in the EU.

The market correction mechanism is a regulatory tool, the functions of which is to limit episodes of excessive gas prices in the EU, while ensuring security of energy supply and the stability of financial markets. From February 15, 2023, to February 15, 2024, the cap would be triggered if prices exceed €180 ($191.11) per megawatt hour for three days on the Dutch Title Transfer Facility (TTF)[6] gas hub's front-month contract. The mechanism can also be activated if the month ahead TTF price is €35 higher than a reference price for LNG on global markets for the same three working days. The cap mechanism is designed to be temporary, applying until February 15, 2024.[33]

The market correction mechanism will apply to transactions on virtual gas trading platforms in the EU and will apply to three types of derivative contracts: 1) month-ahead, 2) three months-ahead, 3) a year-ahead.

However, the mechanism is deactivated if gas prices change according to defined parameters or if a regional or EU emergency is declared by the Commission. Furthermore, the mechanism can be suspended if risks jeopardizing gas supply, intra-EU gas flows, demand reduction efforts, or financial stability are identified.[34]

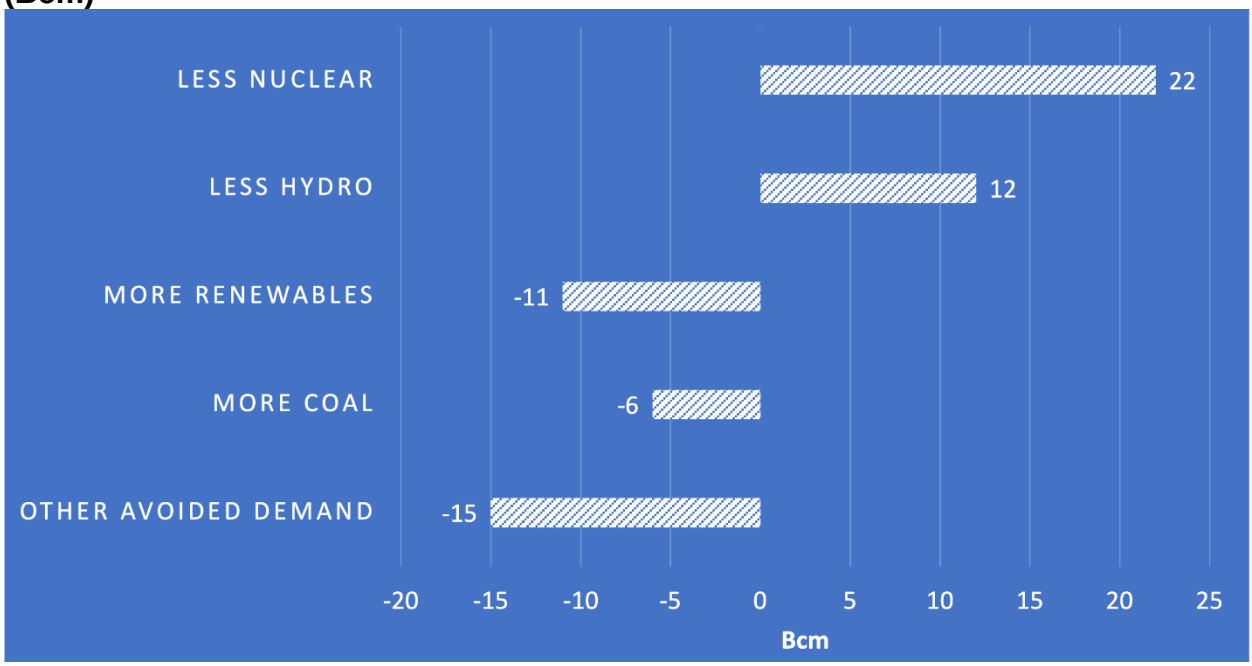
Since the introduction of the price cap, natural gas prices have come down, and the mechanism has not yet been triggered. Still, as the war in Ukraine continues and China's demand returns post-Covid, the price cap remains an important policy measure to protect European energy security and the economy.

[6] The Title Transfer Facility (TTF) is a virtual trading platform used as a reference to set the price of natural gas in the EU.

4. Power Sector

The power sector was the only segment where natural gas demand was higher in 2022 than in 2021. The change in demand was driven by several factors. Low rainfall in southern Europe led to a very poor year for hydropower and increased the need for gas-fired power generation by 12 bcm. Additionally, policy drove a reduction in the use of nuclear power generation; this increased the need for gas-fired power generation. Europe's power system was further disrupted when France's nuclear power fleet experienced shutdowns in November 2022. 26 of its 56 reactors were off-line for maintenance or repairs after the worrisome discovery of cracks and corrosion in some pipes used to cool reactor cores. Overall, the lack of nuclear and hydro for power generation increased demand for natural gas by 34 bcm. On the flip side, increases in coal and renewable generation offset natural gas generation by six bcm and 11 bcm, respectively (Figure 3).[35]

Figure 3: Estimated drivers of change in natural gas demand in power, 2022 vs. 2021 (Bcm)[36]



Source: IEA

Ongoing policy support for renewables from Fit for 55, REPower EU, and other initiatives resulted in the installation of 57.4 GW of wind and solar in the European Union in 2022, a record high. These additions avoided the need for around 11 bcm of natural gas in the power sector – the single largest structural driver of reduced natural gas demand.[37] In addition, the sharp year-on-year declines in both nuclear and hydropower generation

pushed up demand for gas-fired power, leading to a small overall net increase in natural gas generation in the power sector.[38,39,40]

At the same time, EU electricity demand fell by around three percent in 2022. This meant that around 14 bcm of gas demand was avoided. Weather played a part in reducing electricity demand, even though higher summer temperatures and drought conditions drove up gas-fired power generation in parts of Europe.[41]

4.1 Renewable Support

In the context of Russia's aggression in Ukraine and to tackle EU dependence on Russian fossil fuels, Parliament approved additional measures in December 2022 to accelerate the share of renewables in the EU well ahead of 2030. Members of the European Parliament called for permits for new or adapted renewable energy power plants to be issued faster, including solar panels and windmills.[42]

Europe's record deployment of renewables was in large part due to incentives and initiatives to decrease the cost of deployment. Support schemes for renewables can take various forms, structured in two main categories – investment support (such as investment grants, discount on loans or rebates) and operational support (such as certificate schemes, tariffs, or premiums). Across the EU, operational support is more widely applied, allocated in the case of utility-scale projects most often on a market basis through competitive tendering procedures.[43] Auctions and tendering schemes for renewable energy sources (RES) are competitive mechanisms for allocating financial support to RES projects, usually based on the cost of electricity production. The price is the only criterion to be evaluated in auctions, while tenders may include additional criteria. RES auctions and tenders are organized by public authorities who have the responsibility for the preparation of the tender documents, the publication of the tender, the evaluation of the bids, and the selection of the winning bids. Depending on the RES tender design, the bids can refer to installed capacity or electricity production.[44]

The Commission's report on the performance of support for electricity from renewable sources granted by means of tendering procedures in the Union concluded that the introduction of tenders for renewables was a clear success. The analysis of the performance dimensions shows that in many Member States, the tenders reduced the support cost significantly compared to administrative schemes, enhanced the deployment of renewable capacities, and provided a solid framework for technological improvement. Table 1 compares the yearly average volume of new renewable capacity which were added in the selected countries in the periods before and after the tender. The first year corresponds to the date when projects awarded in the tender are expected to start operation. This is the realization deadline of the first tender round, which divides the dataset into the pre-tender and post-tender periods. Table 1 includes only support schemes associated with operational support of non-household-size projects.[45]

Table 1: Comparison of yearly average new capacities in the pre- and post-tender period[46]

Country and technology	First year of completion of the tendered capacity	Average yearly capacity addition pre-tender period (MW)	Average yearly capacity addition post-tender period (MW)	Previous non-tender based operational support scheme	Change % (compared to last 3 non-tender years)
Denmark PV	2018	99.7	131.3	Feed-in premium	32%
Denmark Onshore Wind	2020	196.7	136.0	Feed-in premium	-31%
Finland Onshore Wind	2020	239.3	302.0	Feed-in tariff	26%
France PV	2014	1411.0	921.0	Feed-in tariff	-35%
Germany PV	2017	1323.0	3276.0	Feed-in tariff	148%
Germany Onshore Wind	2018	4549.0	1517.0	Feed-in tariff	-67%
Greece PV	2017	8.3	160.8	Feed-in tariff	1829%
Greece Onshore Wind	2019	242.7	622.0	Feed-in tariff	156%
Italy Onshore Wind	2015	594.7	105.2	Green certificate	-82%
Lithuania Onshore Wind	2015	25.6	37.2	Feed-in tariff	45%
Luxemburg PV	2020	12.7	35.0	Feed-in tariff	176%
Netherlands PV	2015	286.0	1534.3	Feed-in tariff	436%
Netherlands Onshore Wind	2016	320.7	223.4	Feed-in tariff	-30%
Poland PV	2019	151.3	1687.0	Green certificate	1015%
Slovenia PV	2018	9.7	6.7	Feed-in tariff	-31%
Spain PV	2020	1420.0	2812.0	None[13]	98%
Spain Onshore Wind	2019	179.0	1859.5	None	939%

Source: own calculation based on IRENA (2021)

Box 2: The German Renewable Energy Act 2023

The European Commission approved the German government's €28 billion ($29.69 billion USD) support scheme for renewable energy, which is aimed at rapidly expanding use of wind and solar power. The policy, which replaces an existing renewables support scheme, runs until 2026 and is designed to deliver Germany's target to produce 80% of its electricity from renewable sources by 2030. The scheme pays a premium to renewable energy producers, on top of the market price they receive for selling their power. Small generators can receive a feed-in-tariff providing a guaranteed price for their electricity.

Expanding clean energy production will be key to meeting Germany's goal to eliminate its net GHG emissions by 2045, as well as partially filling the energy supply gap caused by Russia's cutting off of most of its natural gas exports to Europe. However, Germany's plan is criticized for distorting competition in the EU as other member countries cannot afford such high subsidies.

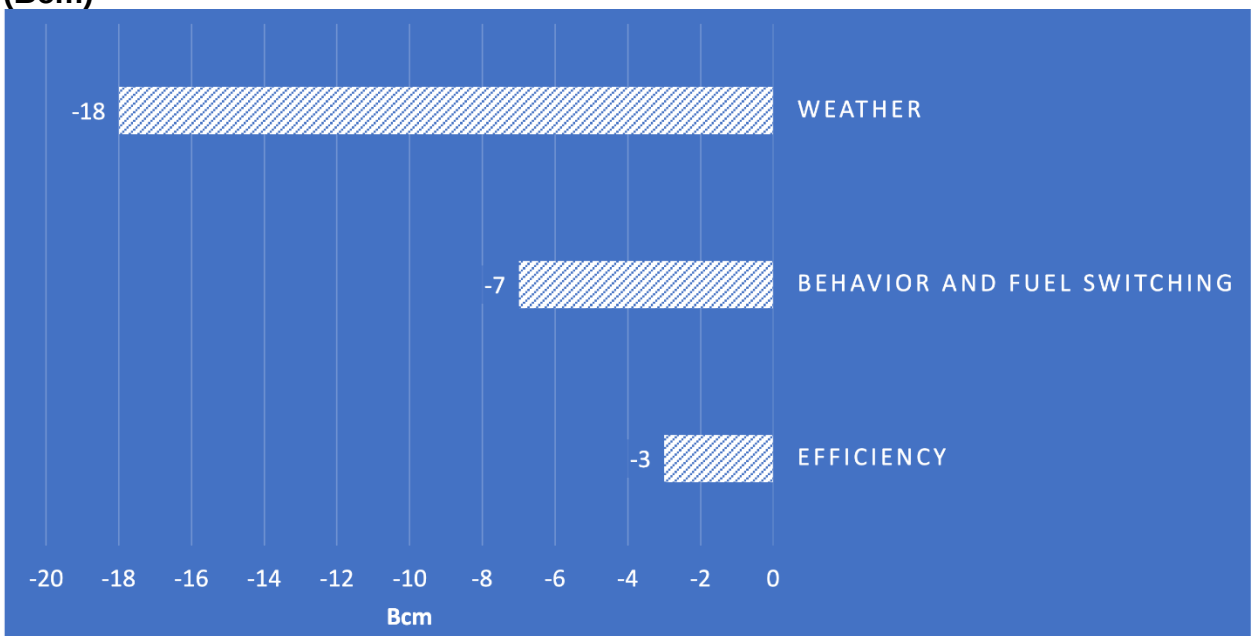
Source: Reuters, https://www.reuters.com/business/energy/eu-approves-28-bln-euro-german-renewable-energy-scheme-2022-12-21/

5. Energy Efficiency in Buildings

Energy efficiency in buildings has played a central role in reducing gas demand and reaching the climate neutrality goal set by the European Green Deal as heating buildings accounts for one-third of EU gas demand in 2022.[47] With detailed knowledge of their building stock and the profile of their occupants, regional and local authorities can forge an important link between financiers, industry professionals and homeowners to ensure the successful deployment of financial schemes that support the uptake of energy efficiency upgrades.[48]

The European buildings sector, which comprises both households and public and commercial spaces, used 28 bcm less natural gas in 2022 than in 2021, a drop of almost 20%. This drop can be attributed to three major factors: weather effects, policies to promote building efficiency, and government campaigns to change consumer behavior (Figure 4).[49]

Figure 4: Estimated drivers of change in natural gas demand in buildings, 2021 vs. 22 (Bcm)[50]



Source: IEA

Heating degree days – a measure of how much energy is required to heat a building due to colder weather – across the European Union were 12% lower on average in 2022 than in 2021, lowering space heating requirements. The IEA attributed the reduction in heating degree days to 18 bcm of the drop in natural gas consumption in buildings in 2022.[51]

Milder winter temperatures certainly played a role in reducing natural gas demand although not every weather event resulted in reduced gas demand. Diminished rainfall in southern Europe led to a very poor year for hydropower and increased the call on gas-fired power. Policy-driven changes were vital, most notably record additions of wind and solar capacity. High prices also played a considerable role in bringing down demand, especially in gas-intensive industrial sectors.[52]

Improved energy performance of buildings, including efficiency retrofits as well as boiler replacements, are estimated to have reduced natural gas demand by around 3.5 bcm. These structural reductions in natural gas use during seasonal peaks will carry over into future years. There were also efficiency gains in industry as well as in the power sector, where the efficiency of the gas-fired power plant fleet was marginally higher than in 2021.[53]

A study from the National Library of Medicine found that regional and local authorities are in a good position to utilize European structural or research funds to develop financial initiatives, as standalone programs or blended with national ones, to provide additional support and funds for major building renovations to enhance efficiency.[54]

5.1 Heat Pump Subsidies

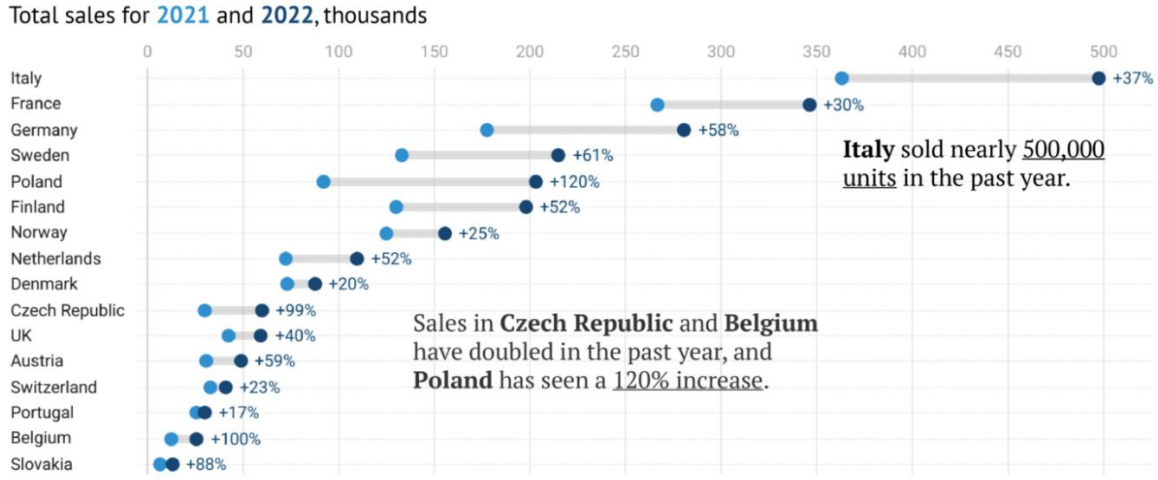
Heat pumps are widely seen as the most important technology for decarbonizing heating of buildings. Organizations, including the International Energy Agency (IEA) and McKinsey, forecast that heat pumps will meet most of Europe's heating needs on its path to net-zero emissions. Russia's invasion of Ukraine, the resulting energy crisis, and related policy interventions have boosted heat pump installations in Europe to unprecedented highs.[55] Annual sales of heat pumps in the EU could rise to seven million by 2030 (up from two million in 2021) if governments succeed in hitting their emissions reduction and energy security goals. In addition, heat pumps could reduce natural gas demand by nearly seven bcm in 2025 – roughly equal to the natural gas supplied via the Trans Adriatic Pipeline in 2021. This annual savings in natural gas demand would grow to at least 21 bcm by 2030 if EU climate targets are met.[56]

Heat pumps are becoming more economically competitive with traditional forms of residential heating due to subsidies, carbon taxes, and high fuel prices. High fossil fuel prices have changed the economics of heat pumps, sometimes making them cheaper to run than gas- or oil-fired heating. While prices for oil and gas have fallen from last year's record highs, it is unlikely that the coming years will see a return to previously low levels. Meanwhile, the EU's Emission Trading System (EUETS) is due to start putting a price on carbon from heating fuels from 2027, which will further enhance the economics of heat pumps to achieve price parity with traditional fuels.

Thanks to current policy incentives, around 2.8 million heat pumps were installed over the course of 2022, accounting for around 1.4 bcm of natural gas savings and a 38% year-on-year increase in installations (Figure 5).[57,58] Since the investment costs for low-carbon heating and cooling systems such as heat pumps are, however, still higher than fossil fuel-based heating systems, financial support initiatives will still be necessary to remove barriers

to investment. Such financial incentives could cover low-interest loans, grant programs, and tax rebates and could be different for lower and higher-income households.[59]

Figure 5: Heat pump sales in Europe have increased 38% in the past year[60]



Source: CarbonBrief

Heat pumps typically cost less over their lifetimes than fossil fuel-fired boilers, thanks to their higher efficiency. At today's energy prices, annual energy bill savings for households that switch to heat pumps can range from USD 300 in the United States to USD 900 in Europe.[61]

The share of electricity in heating for buildings and industry is projected to double between 2021 and 2030 to 16% if climate targets are met. The accelerated deployment of heat pumps will inevitably increase global electricity demand, though energy efficiency and demand response measures can greatly reduce the impact on power systems. Over that same time, global electricity demand rises by one quarter, to which heat pumps contribute less than one tenth. For households that add a heat pump without improving efficiency in parallel, this can nearly triple their peak demand during winter. Improving a home's efficiency rating by two grades, e.g., from D to B in European countries, could cut energy demand for heating in half and reduce the size of the heat pump needed, saving consumers money and reducing the growth in peak demand by one-third. Together with careful grid planning and demand-side management, this moderates the need for distribution grid upgrades caused by electrifying heat and minimizes the need for additional flexible generation capacity by 2030.[62]

Global heat pump supply and installation could require over 1.3 million workers by 2030, nearly triple the current amount, raising the potential for skilled labor shortages, especially for installers. Special training programs and the inclusion of heat pumps in certifications for plumbers and electrical engineers could help avoid the risk of shortages in skilled labor.[63]

EU Member States have been encouraged to set up subsidy schemes for heat pumps by a range of EU legislative initiatives covering the energy transition and decarbonization policies. These include the Renewable Energy Directive, the Energy Efficiency Directive, and the Energy Performance of Buildings Directive. Most recently, the REPowerEU plan

emphasized the need to focus on faster permitting procedures and double the rate of deployment of heat pumps, as well as measures to integrate geothermal and solar thermal energy in revitalized districts and communal heating systems. It also emphasized the need to accelerate the heat pump roll-out through dedicated financing and fiscal incentives and by transferring subsidies for fossil fuel boilers to heat pumps.[64]

Opportunities also exist for heat pumps to provide low-temperature heat in industrial sectors, especially in the paper, food, and chemicals industries. In Europe alone, 15 gigawatts of heat pumps could be installed across 3,000 facilities in these three sectors, which have been hit hard by recent rises in natural gas prices.[65]

5.2 Behavioral Changes

In a high-price environment, IEA analysis concluded that behavioral changes, rising fuel poverty, and fuel-switching in the residential and commercial sectors reduced natural gas demand in buildings by at least seven bcm in 2022. Data from a sampling of smart thermostat providers suggest that consumers adjusted their thermostats lower by an average of around 0.6 °C. Such adjustments were, in part, a response to government-led campaigns to reduce energy demand (as per the IEA's 10-Point Plan). Additional savings were attributed to reducing heating and hot water usage in commercial and public buildings.[66]

To reduce the EU's reliance on Russian fuel and decrease GHG emissions, on April 21, 2022, the International Energy Agency (IEA) and the European Commission outlined a range of simple steps that citizens could take to reduce their energy use and save money.[67] By following all these recommendations, a typical household in the European Union could reduce, on average, its energy bill by more than EUR 450 a year. If all EU citizens, at home and in the workplace, were to follow the recommendations outlined below, it would save 220 million barrels of oil a year, enough to fill 120 supertankers, or around 17 bcm of gas, enough to heat almost 20 million homes.[68] The nine IEA recommendations are:[69]

1. Turn down heating and use less air-conditioning
2. Adjust boiler settings
3. Work from home
4. Use cars more economically
5. Reduce speed on highways
6. Leave cars at home on Sundays in large cities
7. Walk or bike short journeys instead of driving
8. Use public transport
9. Skip the plane, take the train

Fuel poverty was another factor in reducing energy usage in buildings. Many vulnerable consumers reduced consumption because they could not afford the higher bills, leading to colder homes or shifting to cheaper and sometimes more polluting fuels such as wood pellets, charcoal, waste, or low-quality fuel oil.[70] Another fuel poverty challenge for the EU:

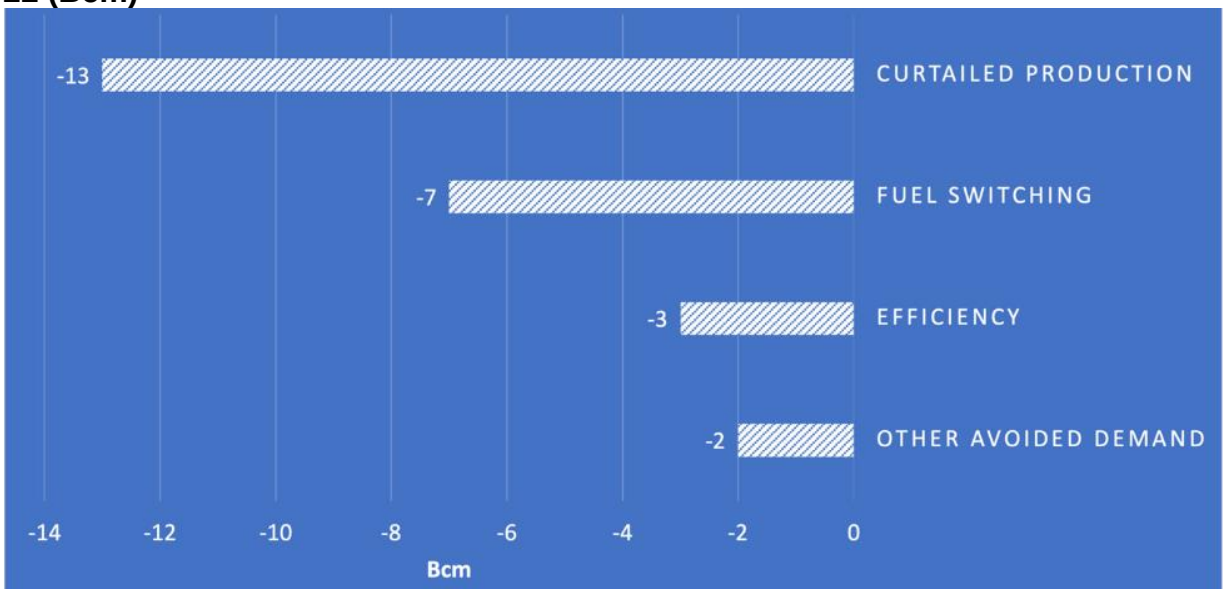
renovation policies are causing “renovictions”, as retrofits are used as a pretext to raise rents and evict tenants and low-income homeowners.[71]

6. Natural Gas Consumption Declines in the Industrial Sector

In the European Union, gas price shocks affected the industrial sector first. Some plants reduced production, but others were forced to import finished products from outside over manufacturing themselves at a higher cost. This caused a reduced demand of approximately 13 bcm of natural gas, with the fertilizer industry accounting for nearly half of this volume.

Some industries also reduced gas needs by increasing imports of goods in the mid stages of manufacturing that require gas-intensive manufacturing. These shifts from manufacturing to importing help to explain why industrial production in gas-intensive sectors (i.e., fertilizers, steel, and aluminum) fell on average by around eight percent in 2022. [72] Overall, the industrial sector used 25 bcm less gas in 2022 than in 2021, or around 25% less, due to production curtailment of gas-intensive manufacturing and fuel switching from gas to oil (Figure 6).[73]

Figure 6: Estimated drivers of change in natural gas demand in EU industry, 2021 vs. 22 (Bcm)[74]

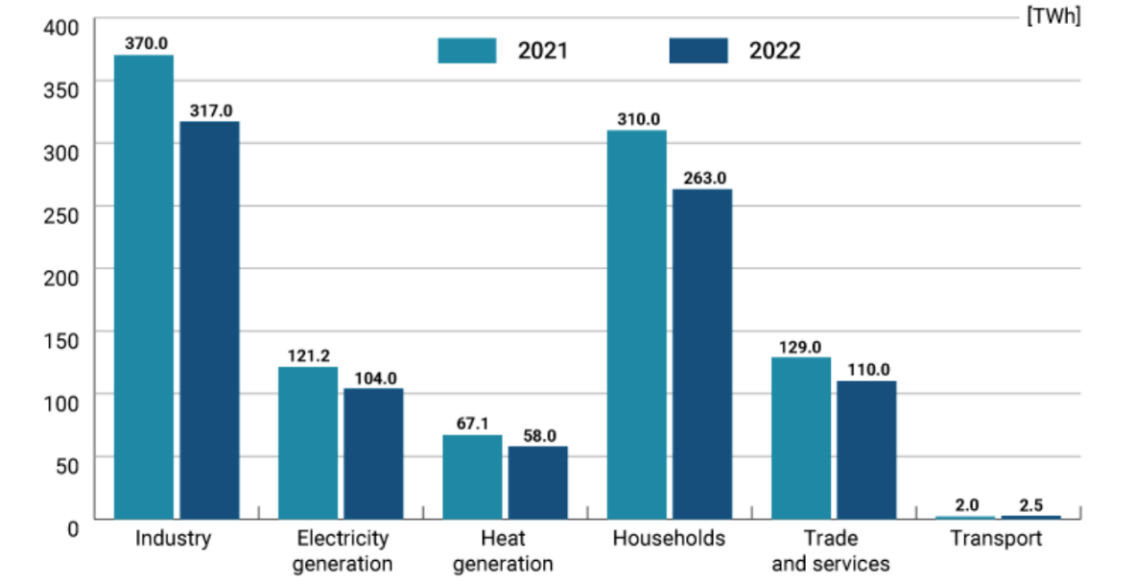


Source: IEA

Box 3: Natural Gas Decline in German Economy

Germany's drop in natural gas consumption (down 14.8%) in 2022 was the biggest since the beginning of the 21st century due to high gas prices. A gradual decline in gas consumption was recorded in all sectors of the economy (excluding transport): industrial production (-14.3%); electricity generation (-14.2%); heat generation (-13.5%); and the commerce and services sector (-14.7%). The industrial sector made efforts to reduce its gas consumption and replaced gas with other energy carriers (mainly coal and oil) whenever possible. In addition, Germany worked to increase its manufacturing efficiency by reducing production or relocating production to other countries, especially in the chemical sector.

Figure 7: Changes in Germany's natural gas consumption structure by sector (2021-22)



Source: German Association of Energy and Water Industries, https://www.osw.waw.pl/en/publikacje/osw-commentary/2023-01-12/germany-how-gas-sector-changed-crisis-year-2022

Box 4: Industrial Emissions

In the third quarter of 2022, EU economy-wide GHG emissions totaled 854 million tons of CO_2-equivalents (CO_2-eq), a two percent increase compared with the same quarter of 2021. This increase was largely related to the effect of the economic rebound leading to gross domestic product (GDP) growth after the sharp decrease in activity due to the COVID-19 crisis. In comparison with the pre-pandemic third quarter of 2019, EU economy GHG emissions decreased by four percent (from 889 to 854 million tons of CO_2-eq).

Most EU countries saw growth in both GDP and emissions, but some countries managed to decrease emissions while increasing GDP. In the third quarter of 2022, the economic sectors responsible for the most GHG emissions were manufacturing (23%), electricity, gas supply (21%), households and agriculture (both 14%), followed by transportation and storage (13%). Emissions in the third quarter of 2022 increased in 16 of the 27 EU members when compared with the same quarter of 2021, indicating a recovery from the COVID-19 pandemic. Among the EU countries with increased emissions in the same comparison period were Ireland (+17%), Estonia and Malta (both +eight percent). On the flip side, the largest decreases in emissions were recorded in Lithuania (-six percent), Slovakia, and the Netherlands (both -five percent).[1] In Germany, natural gas consumption decreased by 14.8% y-o-y and GHG emissions increased by 3.5% y-o-y (Q3 2022) in 2022 compared to 2021 (Box 1, 2, 3, and 5 cover how the energy crisis impacted Germany).

Source: Eurostat, https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_AIGG_Q__custom_4845170/bookmark/table?lang=en&bookmarkId=d454f847-b238-4c4a-b3da-9ffe6cf04467

6.1 Fertilizer

The sharp increase in natural gas prices in Europe led to widespread cutbacks in ammonia production, an important input for nitrogen fertilizers. Ammonia is made by reducing natural gas molecules to carbon and hydrogen. The hydrogen is then purified and reacted with nitrogen to produce ammonia.[75]

About 70% of European ammonia production capacity was offline in August 2022, which reduced natural gas demand by about six bcm; as of October, that year, around 40% had not come back on line.[76,77] Input costs, however, declined in early 2023 due to increased imports of LNG; the mild winter, as noted, also lowered natural gas demand. These factors enabled some of the offline nitrogen fertilizer production facilities in Europe to resume operations.[78]

Following Russia's invasion of Ukraine in February 2022, several economies (including the EU and the U.S.) imposed sanctions on Russia and Belarus, both important fertilizer suppliers. The trade sanctions, however, had specified "carve-outs" for the food and fertilizer sectors to avoid adverse impacts on global food security and enabled continued fertilizer exports from Russia. Potash[7] exports (potash is also used to make fertilizer) from Belarus, however, have fallen by more than 50% due to the restriction on using EU territory for transit

[7] Potash is used primarily in fertilizers (95%) to support plant growth, increase crop yield and disease resistance, and enhance water preservation. Small quantities are used in manufacturing potassium-bearing chemicals, such as detergents.

purposes. Lithuania has halted the use of its railway network to transport Belarusian potash to the port of Klaipeda, which typically handles 90% of Belarus' exports.[79]

6.2 Steel

Steel is produced across the EU, primarily by using two types of blast furnaces: a Basic Oxygen Furnace (BF-BOF) 'primary' steelmaking route; and via the 'secondary' Electric Arc Furnace (EAF). There are thousands of different grades of steel produced through these processes, in a range of qualities, from carbon non-alloy to stainless and specialty steels for specific applications.

The war in Ukraine and the disruption of natural gas trade flows affected the EU's steel production. According to the World Steel Association, steel production in EU countries fell by 10.5% year-on-year to 136.7 million tons in 2022. In general, steel production in the world fell by 4.3% year-on-year to 1.83 billion tons.

The European steel industry was affected by the following factors in 2022, caused in part by the war in Ukraine:[80]

1. **High prices for energy resources**. This factor led to an increase in production costs and the shutdown of several steel plants. The lowering energy prices in the fall of 2022 after sharp increases earlier in the year enabled some production to resume.
2. **High volatility of prices and demand**. Demand rose sharply in March-April when Russia's war invasion of Ukraine caused panic in the market where buyers, despite soaring prices, stockpiled steel products. From mid-April 2022, steel demand declined sharply, however, demand started to rebound in January 2023.
3. **Decrease in steel exports from the EU**. Rising energy prices made European steel less competitive in the second half of 2022.

6.3 Aluminum

In addition to reduced steel production in the EU, there have also been production curtailments in the aluminum sector, where high gas and electricity prices led to a ten percent drop in production in the ten first months of 2022 compared with the same period in 2021.[81] Aluminum, often called "congealed electricity," is the most energy-intensive base metal to produce, requiring about 40 times more energy than copper. One ton of aluminum requires about 15 megawatt-hours of electricity.

Even before Russia's invasion of Ukraine, European aluminum smelters experiences several output cuts, which started in December 2021. Europe suspended about 1.4 million tons of capacity by the end of 2022, accounting for two percent of the global total. Falling energy costs in Europe have recently eased fears of a deep recession; TTF prices broke below EUR50/MWh in February, the lowest level seen since August 2021, after reaching an all-time high of EUR345/MWh in August 2022.[82]

According to the latest data from the International Aluminum Institute (IAI), Western European aluminum output was at an annualized 2.73 million tons in December, down by 540,000 tons from December 2021, the lowest production rate this century.[83] Restarting an aluminum smelter is a long and costly process; this suggests that some of the production halts since 2021 might be permanent.

While London Metal Exchange (LME) aluminum prices have fallen by 40% since reaching historic highs a year ago, production costs remain high for many aluminum smelters in Europe. Electricity is the largest single expense for producers, typically accounting for about 40% of production costs. Given the uncertainty of natural gas markets in 2023, operators/owners of smelters may be reluctant to ramp up production too quickly. Given the uncertainty over energy prices in the remainder of 2023, additional smelter closures and production curtailments cannot be ruled out.[84]

Smelter shutdowns in Europe threaten climate goals as the EU will become more reliant on purchasing finished products from China and Russia to build the infrastructure needed for green transition. European smelters generate three times less CO_2 than those in China, where coal is most often used to generate electricity.

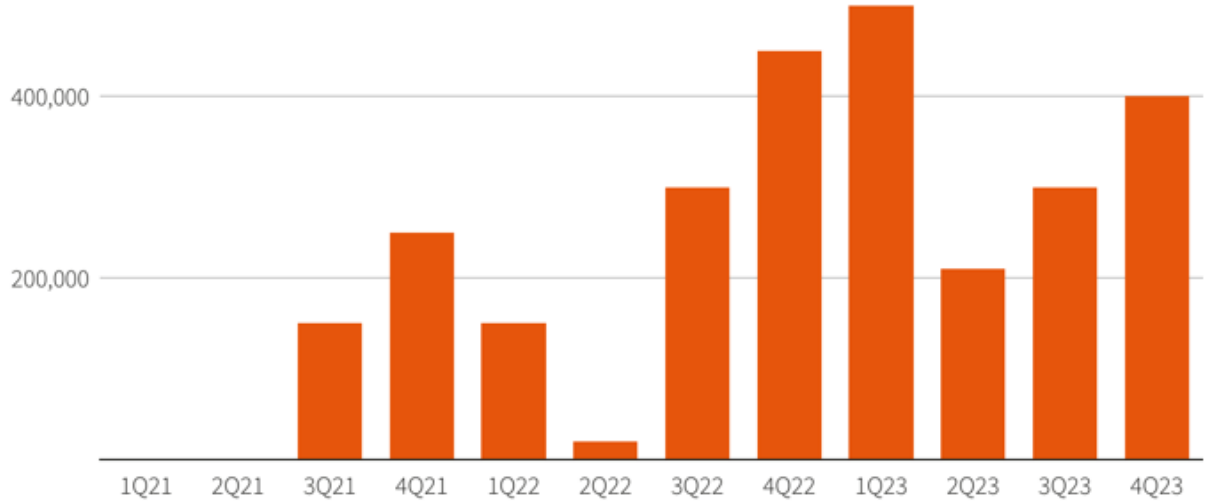
Aluminum is key in mobility and transport, buildings, construction, packaging, aerospace, and defense. It is also used in almost all energy generation, transmission, and storage technologies, particularly those that will deliver the energy transition, such as wind and solar power, alternative fuel cells, hydrogen production, high-voltage cables, and batteries. As a result, Europe's 2030 energy transition will require four million tons of additional aluminum per year, rising to almost five million tons in 2040, equivalent to an additional 30% of Europe's aluminum consumption today. Satisfying the increased demand via imports instead of producing in Europe would generate at least an additional 40 million tons of CO_2 yearly.[85] Also, the EU's carbon border adjustment mechanism covers aluminum and will discourage imports by making them more expensive.

On March 16, 2023, European Commission published the Critical Raw Materials Act, which will attempt to lessen the dependence on covered materials imported from non-democratic states and help ensure that the EU has access to materials needed to meet the bloc's target of net-zero GHG emissions by 2050.[86,87]

6.4 Fuel Switching

As firms work to cut production costs in the face of high energy prices, the ability of Europe's industrial sector to switch from natural gas to diesel and fuel oil is limited by high infrastructure costs and strict environmental regulations.[88] In spite of these headwinds, the IEA estimates that around seven bcm of gas consumption was avoided via gas-to-oil switching in the industrial sector in 2022.[89] IEA also concludes that the increased use of oil for power generation and gas-to-oil fuel switching are increasing the demand for oil. IEA's estimates that gas-to-oil switching in the EU increased oil demand by 300,000 barrels per day (bpd) in the third quarter of 2023 and could reach 450,000 bpd in the fourth quarter, almost twice the amount in the same periods last year (Figure 8).[90]

Figure 8: Estimates on gas-to-oil switching in Europe[91]



Source: IEA

Fuel switching from gas to oil increased emissions in the industrial sector, as combustion of distillate fuel oil is 31% more carbon intensive than natural gas combustion.[8] Global CO_2 emissions from natural gas fell in 2022 by 115 million tons, with the European Union alone accounting for more than 100 million tons of this total. These reductions were, however, more than offset by an increase in coal and oil-related emissions (it should be noted that the global rise in overall energy-related CO_2 emissions would have been three times higher without 2022's rapid rate of clean energy deployment).[92]

Despite the positive – albeit likely temporary – economic advantages of burning oil instead of gas, there are limitations on volumes that can be switched due to strict environmental regulations and the high dependency of some industrial processes on natural gas. In addition, a switch to oil is not technically possible in all industrial facilities. While some large industrial plants can run combined heat and power (CHP) or backup electricity generators on diesel instead of gas, they are limited in number. According to Eurelectric, European industries' capacity to switch from gas to liquid fuels is around two gigawatts (GW), or two percent of total installed capacity.

Falling gas prices in early 2023 have provided an incentive for quicker coal-to-gas switching in power production. Additionally, gas-fired power plants have higher efficiency rates than coal plants, 55-59%, and 38-40%, respectively. However, due to the small efficiency gains, German 50%-efficient gas plants remain uncompetitive against modern 45%-efficient coal plants. The combined share of coal in Germany's power generation from fossil fuels declined slightly to 69% of total in the first half of March 2023, compared to 73% and 76% from January to March 2022.[93]

[8] About 117 pounds of CO_2 are produced per million British thermal units (MMBtu) equivalent of natural gas compared with more than 160 pounds per MMBtu of distillate fuel oil. (EIA)

Box 5: Impact on the German Economy

Germany's economy was heavily impacted by the energy crisis because of its dependence on cheap Russian pipeline gas to support its large energy-intensive industrial sector. Industry makes up a higher share of the economy in Germany than in many other countries, and therefore German industry has been especially impacted by a surge in energy prices. German industry is forecast to pay about 40% higher energy prices in 2023 than in 2021.

The war and its impact could cost Germany four percent of its GDP between the start of the invasion in February 2022 to the end of 2023. Overall, the economy will generate about €160 billion less over this time period, a reduction of €2,000 per German resident. While the federal government has initiated relief packages for households and companies, the German economy is on the brink of recession as it contracted in the last quarter of 2022. Germany's central bank predicted that the country's economy will likely enter a technical recession in the near future.

The war also led Berlin to end its military pacifism, with large increases in defense spending and arming Ukraine with advanced weapons such as the Leopard 2 battle tanks.[1] The Ukraine war will have cost the German economy around €160 billion ($171 billion USD), or some four percent of its gross domestic output, in lost value creation by the end of the year.

Source: Reuters, "Ukraine War Expected to Cost Germany 160 Billion Euros by Year-End," Reuters, February 19, 2023, sec. Europe, https://www.reuters.com/world/europe/ukraine-war-expected-cost-germany-160-bln-euros-by-year-end-2023-02-19/.

"1 Year on: How Ukraine War Has Changed Germany," accessed May 5, 2023, https://www.aa.com.tr/en/europe/1-year-on-how-ukraine-war-has-changed-germany/2828955.

7. Economic Impact

The war in Ukraine triggered a massive shock to the global economy, especially to energy and food markets, squeezing supply and pushing up prices to unprecedented levels; Europe has been particularly vulnerable to the economic consequences of Russia's invasion of Ukraine. This is largely due to Europe's dependence on energy imports; total energy imports accounted for more than half of its energy use in 2020. Russia and Ukraine also played a large role in euro zone imports of food and fertilizers before the Russian invasion. More generally, European economies writ large are highly open for trade, which may leave them vulnerable to disruptions in global markets and value chains. The war in the Ukraine has added additional inflationary pressures in Europe during the post-pandemic recovery and pushed up consumer prices, especially for energy and food. Headline inflation[9] increased from 0.3% in 2020 to 2.6% in 2021 and then to 8.4% in 2022. Energy and food inflation accounted for more than two-thirds of this record-high inflation in 2022.[94]

While in 2022, energy inflation was by far the most significant driver of overall inflation, most recently, the largest contribution has come from higher food prices, which were 14.1% in January 2023 compared to the previous year. As food production is energy-intensive, the high rates of food inflation reflect in part the indirect and lagged effects of high energy prices, for which the war has played a key contributing role.

A more detailed review of inflation rates of different food commodities and types underscores the many impacts of the war. Prices for food products such as wheat or oilseeds, for which European imports from Ukraine and Russia were significant before the war. Prices of sunflower oil and other edible oils were, for example, over 47% higher for European consumers in January 2023 than a year earlier.[95]

Overall, Europe has shown remarkable economic resilience to the effects of the war. While the *Eurosystem* and many analysts expected a contraction in the euro area economy at the turn of last year, real GDP grew 0.1% quarter-on-quarter in the fourth quarter of 2022. Estimates continue to point towards weak growth in the near term, even with marginally lower energy costs and fiscal measures aimed at mitigating the impacts of high inflation on real incomes.

Recovering labor markets in Europe are a bright spot. In line with the overall economic resilience to the effects of war, the unemployment rate declined to its lowest level since 1992, reaching 6.6% in December 2022. This strong labor market performance supports the euro area economy and may increase employment opportunities in Europe for Ukrainian refugees.[96]

[9] Headline inflation is an economic term used for consolidated inflation figures within the economy that affect consumers, i.e., CPI. These figures usually include leading indicator commodities like energy, food, and beverages.

Regrettably, EU sanctions on Russian energy resources are significantly impacting Europe. A Laboratory of Environmental and Urban Economics (LEURE) study found that the current EU embargo on coal and oil imported from Russia will have adverse supply effects, substantially increasing energy prices and welfare costs for EU residents. Although the embargo reduces emissions, extending it to include natural gas doubles this welfare cost. Given the current constraints of additional import capacities from non-Russian producers, the use of coal in electricity generation has increased. If the EU extends sanctions to natural gas, the effects may be more detrimental to the EU than Russia. According to LEURE, Russian welfare costs would increase by less than 50%, indicating that extending the current restriction to boycott Russian gas is a costly policy option for the EU.[97]

Subsidies to help mitigate the impacts of high energy costs on consumers and industry has put an economic strain on European countries, costing nearly €800 billion. European Union countries have now earmarked or allocated €681 billion in energy crisis spending, while Britain allocated €103 billion and Norway €8.1 billion since September 2022, according to the analysis by think-tank Bruegel. Germany spent €270 billion subsidizing energy costs, more than any other country in the EU.[98] Key data on energy subsidies for 2022 have not yet been released by the European Commission. However, it is expected that 2022 will see large increases in subsidies for renewables, energy efficiency, and LNG imports.

The IEA has tracked more than USD 500 billion in extra spending to reduce energy bills in 2022, mainly in advanced economies, with around USD 350 billion of this in Europe. Prices for consumers rarely move in lockstep with international prices because of various buffers, contractual provisions, or other mechanisms to smooth volatility. In many cases, estimated subsidy levels increased in 2022 simply because of the gap between fixed end-user prices and international reference levels. In the exceptional circumstances of 2022, governments found multiple ways to avoid passing on high and volatile prices to consumers. Countries in Europe employed a suite of options to reduce the burden of high energy costs on consumers, such as fixing prices or capping price increases, exemptions from various taxes and levies, easing payment terms or banning disconnections for non-payment, and compensation mechanisms for different affected groups of consumers, including households, businesses, and industrial consumers.[99]

Phasing out fossil fuel subsidies is a fundamental ingredient of successful clean energy transitions, as underscored in the Glasgow Climate Pact. However, today's global energy crisis has also highlighted some of the political challenges of doing so. In an energy crisis, governments prioritize shielding consumers from damaging price impacts over commitments to phasing out subsidies. This was very visible in 2022 and resulted in a sharp rise in fossil fuel consumption subsidies and other measures to limit the impacts on energy bills. This reduced hardships but also diminished incentives for consumers to save energy or to switch to alternative sources of energy. It also drained public funds that could have been spent in other areas, including on clean energy transitions.[100]

The jump in fossil fuel consumption subsidies in 2022 brings some important lessons on the prospects for orderly and people-centered transitions:[101]

1. High fossil fuel prices are not the best way to drive clean energy transitions.

2. High fossil fuel prices hit disadvantaged communities hardest, but subsidies are rarely well-targeted to protect vulnerable groups and benefit segments of the population that can afford increased prices.
3. It is better to spend on structural changes that promote lasting solutions rather than on emergency relief. Spending on a thoughtful, sequenced transition that accommodates near term energy security and affordability needs as well as ongoing decarbonization technologies is one of the key lessons learned from this crisis.

8. Conclusion

Tensions in Europe's gas market have abated in the first half of 2023 due to favorable weather conditions and timely policy actions. However, natural gas supply will remain tight for the rest of 2023 considering an unusually wide range of uncertainties and risks. Some of the factors that helped Europe in 2022 are unlikely to be as favorable in 2023. Russian deliveries are likely to be considerably lower, and competition from China for available LNG cargoes considerably higher as the country's economy recovers from Covid shutdowns.

Global LNG supply is expected to increase by 20 bcm in 2023, supported mainly by the ramp-up of the Calcasieu Pass LNG facility in the United States and the Coral South LNG facility in Mozambique, as well as the return of the Freeport LNG facility in the United States. However, this increased LNG supply will not be sufficient to offset the likely decline in Russia's pipeline deliveries to the European Union.[102] Weather-related factors, such as a dry summer or a cold winter later in 2023, could put further pressure on gas markets by increasing demand for gas-fired power generation.

The IEA's roadmap for securing Europe's gas balance for the 23-24 winter include:

1. Speeding up investments in energy efficiency improvements.
2. Faster deployment of renewables.
3. Accelerated installation of heat pumps.
4. Identifying remaining fuel-switching options in industry and the power sector.
5. Behavioral changes.

The gas industry remains critical for some high-profile and capital-intensive clean energy technologies. The resources and skills of the natural gas industry can play a central role in helping to tackle emissions from some of the hardest-to-abate sectors. This includes the development of carbon capture storage and utilization (CCUS), low-carbon hydrogen, biofuels, and offshore wind. Scaling up these technologies and bringing down their costs will rely on large-scale engineering and project management capabilities, qualities that are a good match to those of large oil and gas companies.[103] Furthermore, the clean energy transition requires manufacturing infrastructure that has its roots in hard-to-abate sectors such as concrete, steel, and aluminum; natural gas remains a critical fuel for many of these industries.

Europe's energy transition will require low- and zero-emission solutions to these difficult-to-decarbonize sectors. The lack of accessible and affordable natural gas, as well as the Carbon Border Adjustment Mechanism (CBAM), set to come into effect in 2026, could make Europe more dependent on carbon-intensive manufacturing in other nations and impede the continent's clean energy transition.

The following is a list of Europe-specific questions adapted from the prospectus and Jan 19th workshop to be asked during the EU Roundtable discussion:

The Role of U.S. Natural Gas:

- How does Europe perceive the role of U.S. gas in supplying global markets?
    - Is U.S. gas perceived as a green source of LNG? (Given that natural gas supply chains are less emissions intensive than Russia's)

Natural Gas in the Decarbonization Context

- How will EU decarbonization policies impact near and long-term LNG demand?
    - REPowerEU, CBAM, volatile prices/price cap, EU Corporate Sustainability Reporting Directive (CSRD), etc.
    - Are countries in the region on track to meet their Nationally Determined Contributions as part of the Paris Agreement? Have regional approaches been discussed or designed to address climate change mitigation? If not, what are significant factors that impact efforts to meet targets?
    - Are countries in your region focused on policies to limit stranded assets from legacy natural gas infrastructure?
    - What role do natural gas emissions abatement technologies (such as carbon capture and sequestration, advanced leak detection and repair, enhanced management of methane emissions) and emerging gas technologies (such as renewable gases) must play in the region's energy transition outlook?

Natural Gas Demand

- What are Europe's gas needs for power generation, industrial usage for the clean energy transition, and agriculture usage through 2050?
- Some forecasts predict that Europe will experience a 30% gas demand reduction by 2030 – how does this affect EU's energy transition and reliance on hydrogen? (Citi)
- How could LNG contracts be structured to meet Europe's near-term demand without impeding decarbonization goals?
    - EU timetable to increase LNG import capacity vs. Timeline for decarbonization.
    - Will new regasification infrastructure and midstream infrastructure currently under construction to meet EU near-term gas demand be compatible with hydrogen?

9. Citations

[1] Servet Yanatma, "Europe's 'Energy War' in Data: How Have EU Imports Changed since Russia's Invasion of Ukraine?," euronews, February 24, 2023, https://www.euronews.com/green/2023/02/24/europes-energy-war-in-data-how-have-eu-imports-changed-since-russias-invasion-of-ukraine.
[2] "EU Natural Gas - 2023 Data - 2010-2022 Historical - 2024 Forecast," accessed June 5, 2023, https://tradingeconomics.com/commodity/eu-natural-gas.
[3] Stanley Reed, "Why Natural Gas Prices in Europe Are Suddenly Plunging," *The New York Times*, October 25, 2022, sec. Business, https://www.nytimes.com/2022/10/25/business/europe-gas-prices-winter.html.
[4] International Energy Agency (IEA), "How to Avoid Gas Shortages in the European Union in 2023: A Practical Set of Actions to Close a Potential Supply-Demand Gap," International Energy Agency, December 2022, https://iea.blob.core.windows.net/assets/96ce64c5-1061-4e0c-998d-fd679990653b/HowtoAvoidGasShortagesintheEuropeanUnionin2023.pdf.
[5] European Council, "Impact of Russia's Invasion of Ukraine on the Markets: EU Response," March 31, 2023, https://www.consilium.europa.eu/en/policies/eu-response-ukraine-invasion/impact-of-russia-s-invasion-of-ukraine-on-the-markets-eu-response/.
[6] European Council, "A Market Mechanism to Limit Excessive Gas Price Spikes," February 15, 2023, https://www.consilium.europa.eu/en/infographics/a-market-mechanism-to-limit-excessive-gas-price-spikes/.
[7] Liz Alderman, "As Europe Quits Russian Gas, Half of France's Nuclear Plants Are Off-Line," *The New York Times*, November 15, 2022, sec. Business, https://www.nytimes.com/2022/11/15/business/nuclear-power-france.html.
[8] International Energy Agency (IEA), "Europe's Energy Crisis: What Factors Drove the Record Fall in Natural Gas Demand in 2022? – Analysis," March 14, 2023, https://www.iea.org/commentaries/europe-s-energy-crisis-what-factors-drove-the-record-fall-in-natural-gas-demand-in-2022.
[9] Eurostat, "Air Emissions Accounts for Greenhouse Gases by NACE Rev. 2 Activity - Quarterly Data," February 6, 2023, https://ec.europa.eu/eurostat/databrowser/view/ENV_AC_AIGG_Q__custom_4845170/bookmark/table?lang=en&bookmarkId=d454f847-b238-4c4a-b3da-9ffe6cf04467.
[10] International Energy Agency (IEA), "Never Too Early to Prepare for Next Winter – Analysis," IEA, accessed May 17, 2023, https://www.iea.org/reports/never-too-early-to-prepare-for-next-winter.
[11] International Energy Agency (IEA), "Natural Gas Supply-Demand Balance of the European Union in 2023 How to Prepare for Winter 2023/24," February 15, 2023, https://iea.blob.core.windows.net/assets/227fc286-a3a7-41ef-9843-1352a1b0c979/NaturalgassupplyandbalanceoftheEuropeanUnionin2023.pdf.
[12] International Energy Agency (IEA), "Natural Gas Supply-Demand Balance of the European Union in 2023 How to Prepare for Winter 2023/24."
[13] International Energy Agency (IEA), "Europe's Energy Crisis."
[14] European Council, "Where Does the EU's Gas Come from?," February 7, 2023, https://www.consilium.europa.eu/en/infographics/eu-gas-supply/.
[15] European Council, "Where Does the EU's Gas Come from?"
[16] International Energy Agency (IEA), "Natural Gas Supply-Demand Balance of the European Union in 2023 How to Prepare for Winter 2023/24."
[17] International Energy Agency (IEA), "Europe's Energy Crisis."
[18] International Energy Agency (IEA), "Never Too Early to Prepare for Next Winter – Analysis."
[19] International Energy Agency (IEA).

[20] Ben Cahill, Ilaria Mazzocco, and Chen Huang, "China Holds the Key to Global Energy Demand," Center for Strategic and International Studies (CSIS), February 8, 2023, https://www.csis.org/analysis/china-holds-key-global-energy-demand.
[21] KPMG, "The European Green Deal & Fit for 55 - KPMG Global," November 16, 2021, https://kpmg.com/xx/en/home/insights/2021/11/the-european-green-deal-and-fit-for-55.html.
[22] International Energy Agency (IEA), "Natural Gas Supply-Demand Balance of the European Union in 2023 How to Prepare for Winter 2023/24."
[23] International Energy Agency (IEA).
[24] "REPowerEU," Text, European Commission - European Commission, May 18, 2022, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3131.
[25] European Commission, "REPowerEU Plan: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS," May 18, 2022, https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF.
[26] European Commission.
[27] International Energy Agency (IEA), "The Need for Action – How to Avoid Gas Shortages in the European Union in 2023 – Analysis," accessed April 12, 2023, https://www.iea.org/reports/how-to-avoid-gas-shortages-in-the-european-union-in-2023/the-need-for-action.
[28] International Energy Agency (IEA), "Europe's Energy Crisis."
[29] International Energy Agency (IEA), "The Need for Action – How to Avoid Gas Shortages in the European Union in 2023 – Analysis."
[30] European Council, "A Market Mechanism to Limit Excessive Gas Price Spikes."
[31] European Council.
[32] European Council.
[33] European Council.
[34] European Council.
[35] International Energy Agency (IEA), "Europe's Energy Crisis."
[36] International Energy Agency (IEA).
[37] International Energy Agency (IEA).
[38] International Energy Agency (IEA).
[39] Beatriz Santos, "Europe Added 41.4 GW of New Solar in 2022," pv magazine International, December 19, 2022, https://www.pv-magazine.com/2022/12/19/europe-added-41-4-gw-of-new-solar-in-2022/.
[40] "Europe Built 19 GW of New Wind Capacity in 2022, Including 16 GW in the EU | Enerdata," Enerdata, March 1, 2023, https://www.enerdata.net/publications/daily-energy-news/europe-built-19-gw-new-wind-capacity-2022-including-16-gw-eu.html.
[41] International Energy Agency (IEA), "Europe's Energy Crisis."
[42] European Parliament, "How the EU Is Boosting Renewable Energy | News | European Parliament," November 29, 2022, https://www.europarl.europa.eu/news/en/headlines/society/20221128STO58001/how-the-eu-is-boosting-renewable-energy.
[43] European Commission, "REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Performance of Support for Electricity from Renewable Sources Granted by Means of Tendering Procedures in the Union," November 15, 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0638&from=EN.
[44] Energypedia, "Renewable Energy Tendering Schemes," accessed April 12, 2023, https://energypedia.info/wiki/Renewable_Energy_Tendering_Schemes.
[45] European Commission, "REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Performance of Support for Electricity from Renewable Sources Granted by Means of Tendering Procedures in the Union."

[46] European Commission, "REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Performance of Support for Electricity from Renewable Sources Granted by Means of Tendering Procedures in the Union."
[47] International Energy Agency (IEA), "The Global Energy Crisis Is Driving a Surge in Heat Pumps, Bringing Energy Security and Climate Benefits - News," IEA, accessed June 1, 2023, https://www.iea.org/news/the-global-energy-crisis-is-driving-a-surge-in-heat-pumps-bringing-energy-security-and-climate-benefits.
[48] Marina Economidou et al., "The Role of European Municipalities and Regions in Financing Energy Upgrades in Buildings," *Environmental Economics and Policy Studies*, February 27, 2023, 1–33, https://doi.org/10.1007/s10018-023-00363-3.
[49] International Energy Agency (IEA), "Europe's Energy Crisis."
[50] International Energy Agency (IEA).
[51] International Energy Agency (IEA).
[52] International Energy Agency (IEA).
[53] International Energy Agency (IEA).
[54] Economidou et al., "The Role of European Municipalities and Regions in Financing Energy Upgrades in Buildings."
[55] Carbon Brief Staff, "Guest Post: How the Energy Crisis Is Boosting Heat Pumps in Europe," Carbon Brief, March 21, 2023, https://www.carbonbrief.org/guest-post-how-the-energy-crisis-is-boosting-heat-pumps-in-europe/.
[56] International Energy Agency (IEA), "The Global Energy Crisis Is Driving a Surge in Heat Pumps, Bringing Energy Security and Climate Benefits - News."
[57] International Energy Agency (IEA), "Europe's Energy Crisis."
[58] Staff, "Guest Post."
[59] European Heat Pump Association, "Subsidies for Residential Heat Pumps in Europe," March 19, 2023, https://www.ehpa.org/wp-content/uploads/2023/03/EHPA_Subsidies-for-residential-heat-pumps-in-Europe_FINAL_March-2023.pdf.
[60] Staff.
[61] International Energy Agency (IEA), "The Global Energy Crisis Is Driving a Surge in Heat Pumps, Bringing Energy Security and Climate Benefits - News."
[62] International Energy Agency (IEA), "The Future of Heat Pumps," accessed June 1, 2023, https://iea.blob.core.windows.net/assets/4713780d-c0ae-4686-8c9b-29e782452695/TheFutureofHeatPumps.pdf.
[63] International Energy Agency (IEA), "The Global Energy Crisis Is Driving a Surge in Heat Pumps, Bringing Energy Security and Climate Benefits - News."
[64] European Heat Pump Association, "Subsidies for Residential Heat Pumps in Europe."
[65] International Energy Agency (IEA), "The Global Energy Crisis Is Driving a Surge in Heat Pumps, Bringing Energy Security and Climate Benefits - News."
[66] International Energy Agency (IEA), "Europe's Energy Crisis."
[67] European Commission, "Playing My Part," accessed April 11, 2023, https://energy.ec.europa.eu/topics/markets-and-consumers/action-and-measures-energy-prices/playing-my-part_en.
[68] "Playing My Part – Analysis," IEA, accessed April 11, 2023, https://www.iea.org/reports/playing-my-part.
[69] "Playing My Part – Analysis."
[70] International Energy Agency (IEA), "Europe's Energy Crisis."
[71] "Social Safeguards: The Key to a Successful Renovation Wave," accessed April 11, 2023, https://sustainable-energy-week.ec.europa.eu/news/social-safeguards-key-successful-renovation-wave-2023-03-06_en.
[72] International Energy Agency (IEA), "Europe's Energy Crisis."
[73] International Energy Agency (IEA).
[74] International Energy Agency (IEA), "Europe's Energy Crisis."
[75] EPA, "AP-42, CH 8.1: Synthetic Ammonia," accessed May 5, 2023, https://www3.epa.gov/ttnchie1/ap42/ch08/final/c08s01.pdf.
[76] International Energy Agency (IEA), "Europe's Energy Crisis."

[77] International Energy Agency (IEA), "Baseline European Union Gas Demand and Supply in 2023 – How to Avoid Gas Shortages in the European Union in 2023 – Analysis," IEA, accessed June 1, 2023, https://www.iea.org/reports/how-to-avoid-gas-shortages-in-the-european-union-in-2023/baseline-european-union-gas-demand-and-supply-in-2023.
[78] John Baffes and Wee Chian Koh, "Fertilizer Prices Ease but Affordability and Availability Issues Linger," World Bank Blogs, January 5, 2023, https://blogs.worldbank.org/opendata/fertilizer-prices-ease-affordability-and-availability-issues-linger.
[79] Baffes and Chian Koh.
[80] Yuriy Grigorenko, "European Steelmakers Cut Steel Production by 10.5% in 2022," *GMK Center* (blog), February 1, 2023, https://gmk.center/en/posts/european-steelmakers-cut-steel-production-by-10-5-in-2022/.
[81] International Energy Agency (IEA), "Baseline European Union Gas Demand and Supply in 2023 – How to Avoid Gas Shortages in the European Union in 2023 – Analysis."
[82] Ewa Manthey, "Aluminium Smelter Shutdowns Threaten Europe's Green Transition," ING Think, accessed April 13, 2023, https://think.ing.com/articles/aluminium-smelter-shutdowns-threaten-europes-green-transition/.
[83] Manthey.
[84] Manthey.
[85] Manthey.
[86] European Commission, "European Critical Raw Materials Act," Text, European Commission - European Commission, March 16, 2023, https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661.
[87] European Commission.
[88] Bozorgmehr Sharafedin and Bozorgmehr Sharafedin, "Europe's Industrial Gas-to-Oil Switch Stifled by Capacity Constraints," *Reuters*, December 1, 2022, sec. Energy, https://www.reuters.com/business/energy/europes-industrial-gas-to-oil-switch-stifled-by-capacity-constraints-2022-12-01/.
[89] International Energy Agency (IEA), "Europe's Energy Crisis."
[90] Sharafedin and Sharafedin, "Europe's Industrial Gas-to-Oil Switch Stifled by Capacity Constraints."
[91] Sharafedin and Sharafedin.
[92] International Energy Agency (IEA), "Europe's Energy Crisis."
[93] Kira Savcenko and Sarah Matthews, "Low Natural Gas Prices Drive Stronger Fuel Switching in Europe," S&P Global Commodity Insights, March 17, 2023, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/electric-power/031723-low-natural-gas-prices-drive-stronger-fuel-switching-in-europe.
[94] Óscar Arce, Gerrit Koester, and Christiane Nickel, "One Year since Russia's Invasion of Ukraine – the Effects on Euro Area Inflation," February 24, 2023, https://www.ecb.europa.eu/press/blog/date/2023/html/ecb.blog20230224~3b75362af3.en.html.
[95] Arce, Koester, and Nickel.
[96] Arce, Koester, and Nickel.
[97] Sigit Perdana, Marc Vielle, and Maxime Schenckery, "European Economic Impacts of Cutting Energy Imports from Russia: A Computable General Equilibrium Analysis," *Energy Strategy Reviews* 44 (November 1, 2022): 101006, https://doi.org/10.1016/j.esr.2022.101006.
[98] Kate Abnett, "Europe's Spend on Energy Crisis Nears 800 Billion Euros," *Reuters*, February 13, 2023, sec. Energy, https://www.reuters.com/business/energy/europes-spend-energy-crisis-nears-800-billion-euros-2023-02-13/.
[99] International Energy Agency (IEA), "Fossil Fuels Consumption Subsidies 2022 – Analysis," IEA, accessed June 1, 2023, https://www.iea.org/reports/fossil-fuels-consumption-subsidies-2022.
[100] International Energy Agency (IEA).
[101] International Energy Agency (IEA).
[102] International Energy Agency (IEA), "Never Too Early to Prepare for Next Winter – Analysis."
[103] International Energy Agency (IEA), "The Oil and Gas Industry in Energy Transitions – Analysis," IEA, January 2020, https://www.iea.org/reports/the-oil-and-gas-industry-in-energy-transitions.