PHASING OUT RUSSIAN GAS IN THE DANUBE REGION

Final study

REKK

2022

Phasing out Russian gas in the Danube Region

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DANUBE REGION strategy

REKK

2022

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ABBREVIATIONS

BCM	billion cubic meters
CEE	Central Eastern Europe
DR	Danube Region: Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, Serbia, Slovakia, Slovenia, Ukraine
DSO	Distribution System Operator
EnC	Energy Community
EGMM	European Gas Market Model
ENTSO-E	European Transmission System Operator for Electricity
EPMM	European Power Market Model
EU	European Union
IEA	International Energy Agency
LNG	Liquified Natural Gas
MS	Member states of the EU
NZI	Net-Zero Industries Mission
NEFI	New Energy for Industry
PCI	Project of Common Interest
RES	Renewable energy sources
TAP	Trans Adriatic Pipeline
TSO	Transmission System Operator
UNIDO	United Nations Industrial Development Organization

COUNTRY CODES

AL	Albania	CY	Cyprus
AT	Austria	CZ	Czechia
AZ	Azerbaijan	DE	Germany
BA	Bosnia and Herzegovina	DK	Denmark
BE	Belgium	DZ	Algeria
BG	Bulgaria	EE	Estonia

ES	Spain
FI	Finland
FR	France
GE	Georgia
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LT	Latvia
LU	Luxemburg
LV	Lithuania
ME	Montenegro
MD	Moldova
MK	North Macedonia
MT	Malta
NL	Netherland
PL	Poland
PT	Portugal
RO	Romania
RU	Russia
RS	Serbia
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UA	Ukraine
UK	United Kingdom

EXECUTIVE SUMMARY

The study investigates the Russian gas dependency of the Danube Region (DR) and the potential to reduce this dependency on the short term (next winter 2022/23) and on the longer term (2030). The first part (Chapter 2) is a comparative analysis of the countries based on supply and demand side indicators with the aim of setting the scene and providing a baseline for the analysis. The fact sheets summarizing each indicator for each DR country is annexed to this report (Annex 2) The second part (Chapter 3) investigates the demand reduction potential by sectors using different methods, while Chapter 4 utilizes gas market modelling to assess the supply and demand side measure's impact on the supply mix and the gas bill of the Danube Region.

Chapter 2 analyses available statistics on supply and demand side measures and formulates the demand and supply side dependencies of the individual countries comparing them to absolute thresholds and in some cases to EU average values as benchmarks. The main conclusion of the analysis is that there is a considerable negative relationship between the demand-side and the supply-side dependencies, meaning that those countries that rely heavily on gas have taken significant efforts to ensure the security of supply by adequate infrastructure capacities (Figure 1). There is one exception, Moldova, where both demand- and supply side dependency is very high, therefore it can be named as the most dependent country of the Danube Region.

Roughly half of the countries can be classified into the group of "highly gas-dependent countries with mostly sufficient supply options": Hungary, Slovakia, Romania, Austria, the Czech Republic, Ukraine, Croatia and Germany can be listed here, with the latter being the most dependent within the group. Bulgaria, Slovenia and Serbia are moderately gas-dependent countries with weaker supply options, while Bosnia and Herzegovina is not gas-dependent but have very limited options to find alternative supply sources. In sum, none of Danube Region countries are fully independent, as either their high gas consumption or their weak supply options pose a challenge.

FIGURE 1. DEMAND- AND SUPPLY SIDE DEPENDENCIES IN THE DANUBE REGION

Legend: The supply and demand dependencies are classified based on a detailed assessment of a large set of supply and demand indicators measuring the vulnerabilities of the countries and comparing their results to and average EU27 dependency ratio. Green cells mean that most of the demand / supply indicators of a country are better than the EU average, yellow means that it is close to the average, and red means that most of the indicators are worse than the EU average.

When looking into the saving potentials on the demand side, the power sector and the industry sector were analysed separately. According to the electricity market modelling short-term gas phase-out potential of the power sector depends to a large extent on the availability of nuclear and hydro plants in the European power system. When this availability is low there is much higher need for gas-based power generation both in the EU and in the Danube Region countries. The overall gas demand reduction potential is 60 to 100 TWh compared to the consumption level of the period from September 2021 to August 2022. By 2030 renewables can substitute most of the gas need in the EU27 and phase out coal at the same time. This happens despite the additional flexibility need that comes together with variable renewable capacities. The minimum overall gas consumption of the power sector in the Danube Region can be reduced to 67-89 TWh depending on renewable capacity developments if gas is only used as a last resort.

In the industrial sector, in the short-term, most of the investments aimed at long-term gas substitution cannot be realized, or only can be realized at a very high cost, so as a demand response, the reduction of consumption and, at the same time, the reduction of production is the only available option. From this point of view, we examined which sectors have the lowest value added (GVA) per MWh of gas consumption, because in these cases the reduction of natural gas demand causes the least economic damage in the short-term. In the Danube Region countries these sectors were the same: non-metallic minerals; paper, pulp and printing; wood and wood products; chemical and petrochemical and the iron and steel sector. It is important to note that the shutdown or partial shutdown of these sectors may adversely affect other sectors, which is not taken into account by this indicator. Decision-makers should also consider whether the uninterrupted operation of the economy or the heat supply of households should be ensured in the event of a crisis. In the long term, changes in gas demand in the industrial sector depend on many country, subsector and company specifics. The amount of savings largely depends on the development of the currently used technologies, the currently known alternative technologies of each sub-sector and other characteristics related to the given country. For this reason, it is not possible to determine exact region- and country-specific gas consumption reduction potentials within the framework of the current research. In the future, however, in the case of energy- and gas-intensive industries, it may be worthwhile to assess the possibility and cost of replacing gas, which can primarily be assessed by collecting more detailed industry data with questionnaire research, and interviews with key market participants.

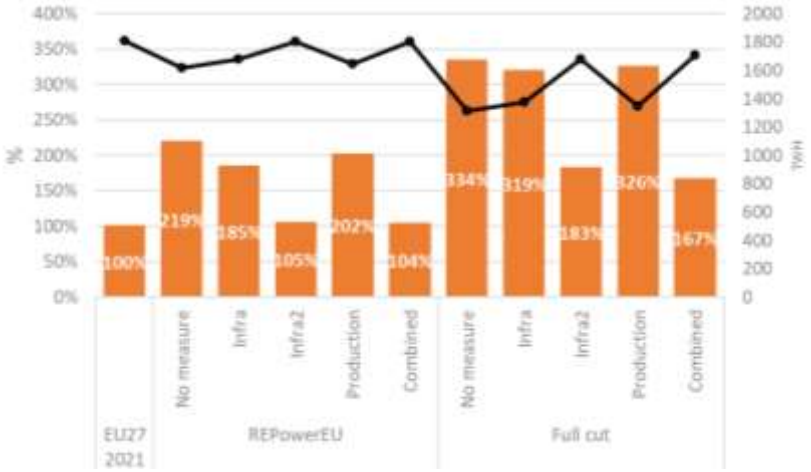
The short-term demand response of the households depends on their access to switching options (like firewood or coal). Besides that, there are limited sufficiency options available on the short run, that might not result in long-term savings, just temporary reductions (turning down indoor temperature). The price responsiveness of households can be assumed based on IEA estimates of savings related to lower indoor temperature and on the examples of Western European consumers that already faced high gas prices at the beginning of 2022 (UK, BE). The savings of the building sector can be in the magnitude of 2.5-7% consumption reduction in an average winter. The comparison of measures applied on national level to protect vulnerable consumers from the high energy prices revealed that in the Danube Region the use of regulated prices is the most widely applied tool. In some countries gas price in October 2022 was above 20 c€/kWh (DE, AT, CZ), while on the other end in some countries household paid around 5 c€/kWh (PL, BA, HR, SK) or even less (RS, UA, HU). Protection of the end users from market prices reduces their willingness to save energy or switch fuel to RES alternatives.

The gas modelling is built on two base scenarios, the REPowerEU scenario (when about 55 bcm/yr Russian gas was still in the mix) and the FULL CUT scenario (with 0 RU gas). Implementing a 55 bcm/yr (as set in the REPowerEU) constraint on Russian gas would force Europe to curtail 355 TWh or 9% of current demand. A complete cessation would lead to a demand decrease of 900 TWh or 23% of the

demand compared to a 2021 (before the war) baseline. Modelling results show that the region most seriously impacted is East from Germany until Ukraine. The Balkan is somewhat better supplied from the South than the landlocked countries of Central Europe.

Modelling tested the impact of new infrastructure (LNG terminals and pipelines) and of additional domestic natural gas and RES gas production. We found that in the REPowerEU scenario supply side measures can to a large extend substitute the missing Russian volumes, however in the Full cut scenario there is a large voluntary demand response need (or put it in other way there might be unserved consumers) and at the same time the European gas bill would remain in a higher range (more than 300%) compared to the 2021 baseline. In a Full cut scenario the infrastructure that was additionally proposed (especially the LNG terminals in Germany) are key to mitigate the full cut crisis effect. (Figure 2)

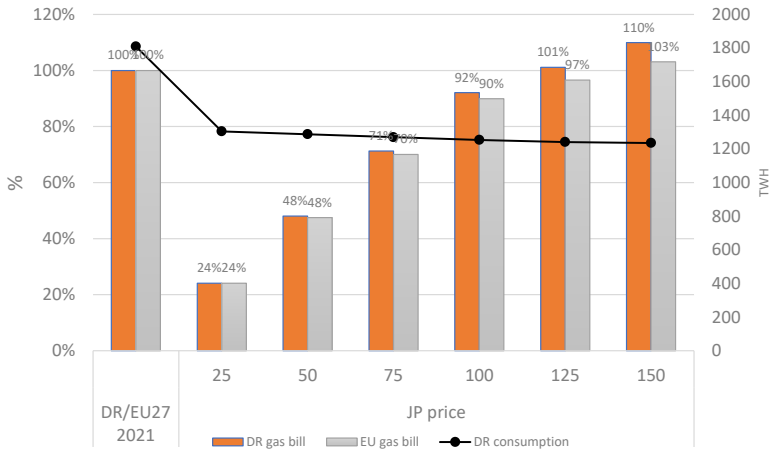
FIGURE 2. COMPARISON OF DANUBE REGION GAS BILL AND CONSUMPTION, % AND TWH



Note: EU27 2021 is the baseline pre war scenario that is the basis for comparison of the total Danube Region gas bill (100%). The consumption of the Danube Region is depicted on the right axis in TWh-s. The "infra" scenario is based on the (PCI) projects already under construction in 2022 the "infra2" covers additional projects proposed after the war started (mainly new LNG terminals the "production" scenario adds limited domestic natural gas and RES gas sources, and the "Combined" scenario adds all these measures at the same time.

The long-term modelling assumes that besides the supply measures that are implemented on the short term (infrastructure and RES gas production increase) the Danube Region countries invest in energy efficiency and save gas in the buildings sector, reduces gas consumption of the industry and builds more RES power generation that allows for less gas use in the power sector. All together we assumed a 20% demand reduction for all EU and Danube Region countries by 2030. Figure 3 depicts the gas bill change compared to 2021 of the Danube Region and of the EU and the gas consumption of the Danube Region. The modelling was performed under different global market circumstances, characterised by the Japanese gas price.

FIGURE 3. EU27 AND DANUBE REGION GAS BILL AND CONSUMPTION IN DANUBE REGION.



Note: Low Japanese prices mean abundant global supply, while high prices mean scarcity of global supply where Europe has to compete for LNG with the Asian market.

Source: EGMM

Overall, the total gas bill in Danube Region countries moves together with the EU gas bill. However, in a market environment where Japanese prices are extremely high (as it was the situation in the latest months) there is risk for Danube Region countries to suffer from higher price increase and total gas bill than the EU on average. The vicinity of large Turkish market would be risky for Balkan countries: if they do not reduce their demand significantly Turkey can cause a supply deficit in the region resulting is higher prices.

1 INTRODUCTION

The Danube Region Strategy has since its foundation been focusing on energy matters that are key priority areas. Security of supply and gas dependency has been studied around 2014 with a special focus on the gas infrastructure development options on supply diversification and on storage use.

With the Green Deal Strategy[1] attention and focus shifted more to the decarbonization and renewable development options after 2021. Due to the price increase following the COVID pandemic attention shifted to gas again, and with the war in Ukraine security of supply became a priority area in the Danube region again. The average import dependency of the Danube Region on Russian gas is 50%, much higher than the EU average 30%. The dependency however varies on a large scale.

This study aims to set the scene and evaluate the gas dependency of each Danube Region country along different supply and demand indicators. For this task, as a first step data has been collected form public data bases to develop country fact sheets to allow for quantifying the natural gas related vulnerabilities of the individual countries. The country fact sheets are an Annex to this document. The indicator-based assessment of the Danube Region countries rests on data mainly from 2019 and 2020.

The second part of the study is estimating the demand reduction potential of the power sector the industrial and for the households. First the demand side options (for reducing the demand) are estimated for the power sector with the European Electricity Market model, for the industry sector a statistical method is used to identify the sectors and their gas consumption that are most exposed to gas price increase and therefore might be temporarily stopped. For the household and services sector building heating is the main use of natural gas. In the short term we assume that only sufficiency measures can be taken (like reducing the indoor temperature or reducing the heated floor area) that do not result in long term switch or savings. In a separate chapter we investigated the actions taken by Danube Region countries to protect their most vulnerable consumers from the energy crisis between May and August 2022. Based on those measures and the policy goals collected form media sources on the same time horizon we estimate that on the long run a similar level of demand reduction can be assumed in the Danube Region household sector as in the EU, given that final consumers also get a price signal. The supply side alternatives are evaluated using the European Gas Market Model (EGMM). The question is how far substitution of the Russian gas deliveries is possible on the existing infrastructure and on the ones that are coming online in the course of 2022. Increase of domestic production and accelerated RES gas deployment is also assessed. Taking all these factors into account we set up combined supply scenarios, estimating what can be done in the short-term (2022/23). On the longer (2030) time horizon supply options are combined with demand reduction, and we model how this will impact the gas markets of the Danube Region. It is our hypothesis that after the energy crisis and related turmoil due to the Covid pandemic and the war on Ukraine the gas markets will find a new equilibrium with lower gas demand modest gas prices and more healthy supply structure for Europe. The current study contributes to better understanding how different measures can contribute to this final goal, what lessons we can learn from the early actions of Danube Region countries and what risk factors we must be aware of on the road to decarbonization and full independence of Russian gas.

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

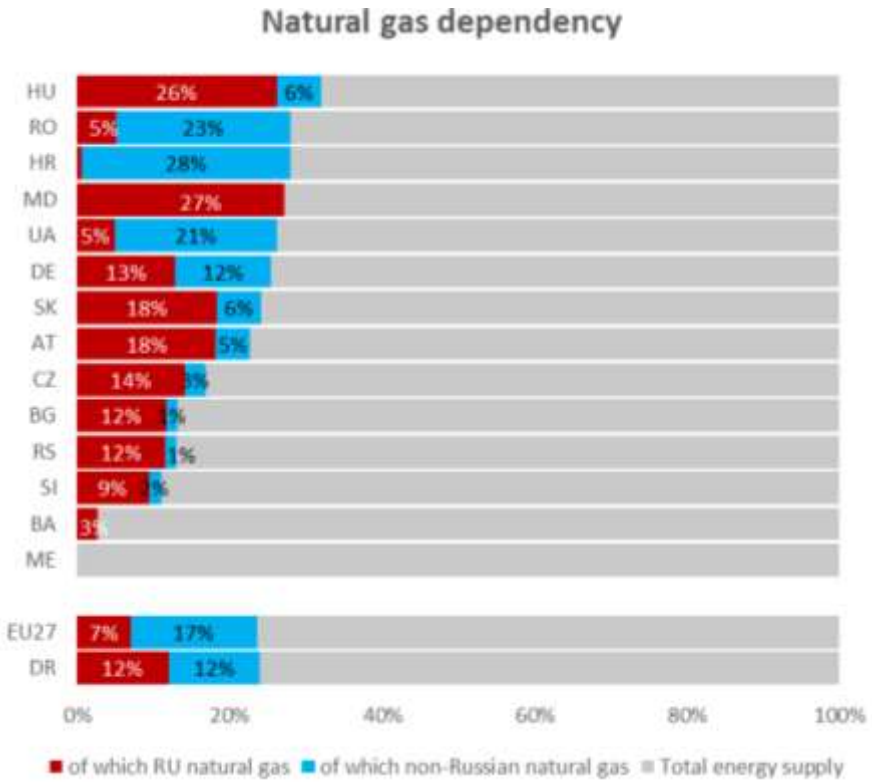
2 GAS DEPENDENCY IN THE DANUBE REGION

Russian gas dependency can be indicated with two types of indicators. First, it must be calculated how important is gas in the energy mix of the country. Economies relying on gas-intensive industries like chemical sector, a strong gas-fired power plant fleet and buildings predominantly heated with gas are more prone to depend on gas. Secondly, the dependency is determined by the supply options a country can rely on, such as own production, interconnector pipeline capacities, as well as liquified natural gas (LNG) and storage facilities. The supply and demand side indicators were calculated for each DR country and summarized in country fact sheets in Annex 2 of this report. For benchmarking purposes this chapter introduces the most important indicators for the Danube Region countries depicting also the DR average and the EU average for comparison.

2.1 THE IMPORTANCE OF GAS IN THE ENERGY MIX

To show the importance of gas in the energy mix, a simple calculation was performed on the share of gas in the total energy supply (TES).[2] Within the gas consumption, we indicated the share of Russian natural gas relative to the total energy supply on Figure 4.

FIGURE 4. NATURAL GAS AND RUSSIAN GAS DEPENDENCY IN THE DANUBE REGION COUNTRIES IN 2020, %



Source: ACER Estimated number and diversity of supply sources, 2020

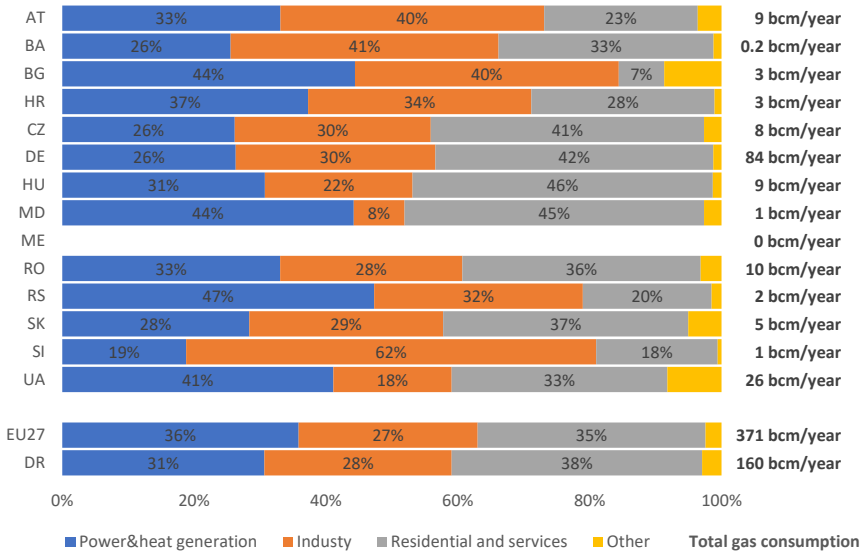
[2] Total energy supply represents the quantity of energy necessary to satisfy inland consumption (inland fuel deliveries) of the country. Gas and total energy supply were derived from Eurostat Simplified Energy Balances 2020 [nrg_bal_s].

Figure 4 tells that the role of gas in the Danube Region is identical to the EU, accounting for 24% of total energy supply. 50% of gas consumed in the Danube Region comes from Russia[3], as opposed to 30% in the EU27, as Danube Region markets are geographically closer to Russia and have limited alternatives compared to Western European counterparts. In 2020, nearly all gas consumed in the country was of Russian origin in Bosnia and Herzegovina, Bulgaria and Moldova (~90-100%). In Austria, the Czech Republic, Hungary, Serbia, Slovakia and Slovenia, Russian gas was accounting for around 80% of all gas used. Due to available domestic production, the role of Russian gas is more limited in Romania and Ukraine. Croatia successfully replaced Russian gas with LNG from 2021. Statistics tell that Russian gas was a major part of regional gas supply, and in most countries, it was the sole source of supply (BA, MD, BG), in the majority of DANUBE REGION countries Russian gas had the greatest market share (AT, CZ, HU, RS, SI, SK).

2.2 DEMAND OF MAIN GAS CONSUMING SECTORS

Natural gas is mainly used in three sectors: Power and district heat generation, industry and building heating. Figure 5 presents the total volume and the sectoral breakdown of the gas consumption in the Danube Region.

FIGURE 5. MAIN CONSUMING SECTORS OF NATURAL GAS AND MARKET SIZE, 2019 % AND BCM/YR



Source: Eurostat Simplified energy balances

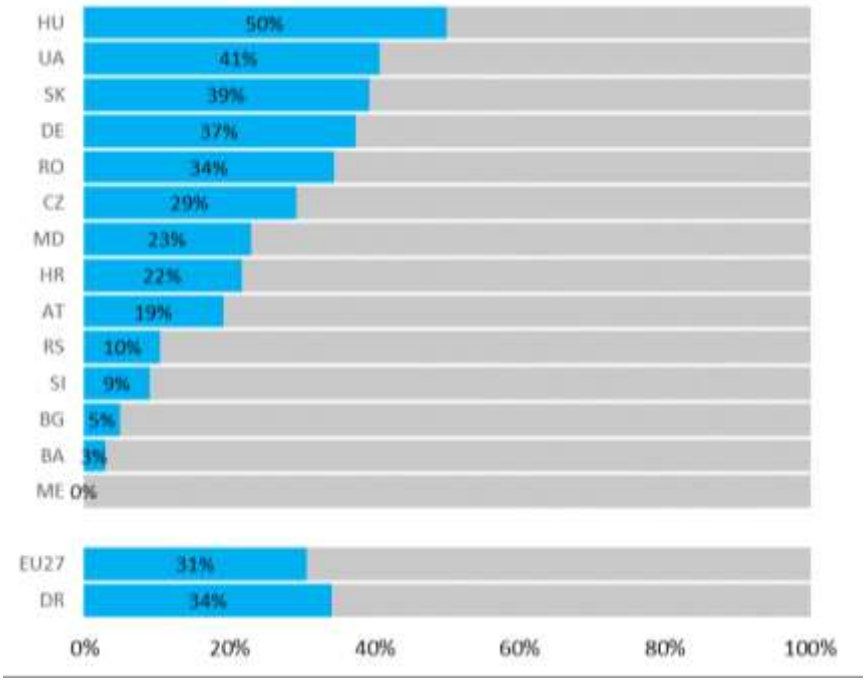
[3] The share of Russian gas in gas was derived from ACER data Estimated number and diversity of supply sources 2020 (https://aegis.acer.europa.eu/chest/dataitems/214/view.) As many Danube Region countries noted their sourcing to originate from another European country, in some cases the dependency of Russian gas indicated by ACER might be lower that the actual value. To illustrate this effect: Austria reported 64% Russian gas, 32% Germany and 4% domestic production. Based on this figure, one could argue that Austrian dependency is 64% from Russia. In fact, gas of German origin is made up of 49% Russian gas, therfore to estimate the correct share of Russian gas in Austria, the appropriate weighting of German gas was performed. This results in 80% of Russian gas in the total Austrian mix. The same calculation for performed for all Danube Region countries. Share of Russian gas reported in the study therefore may be higher than the one reported by ACER.

Comparing the EU27 and the Danube Region, the share of the sectors in total gas consumption is similar. In the Danube Region the weighted average share of building heating is 38%, while the share of power and district heat generation and the industry sector is similar 31% and 28%. Although the values are similar for the two regions, larger differences can be observed between Danube Region countries. However, it is important to point out that the volume of total gas consumption in each Danube Region country differs significantly, with Germany and Ukraine accounting for almost 70% of total consumption, while the annual consumption of 7 countries does not exceed 3.5 TWh/year (BA, BG, HR, MD, ME, RS, SI).

2.2.1 BUILDINGS

Buildings consume natural gas mainly for space heating, domestic hot water production and cooking. Figure 6 shows the share of natural gas in total energy consumed for the building sector.[4] Within the Danube Region and within the EU27, the share of gas consumption in the building sector does not differ significantly (34% and 31%), however, there are countries in the Danube Region where the share of natural gas is significant. This ratio is the highest in Hungary (50%), followed by Ukraine (41%) and Slovakia (39%).

FIGURE 6. SHARE OF GAS IN BUILDINGS ENERGY CONSUMPTION, 2019 %



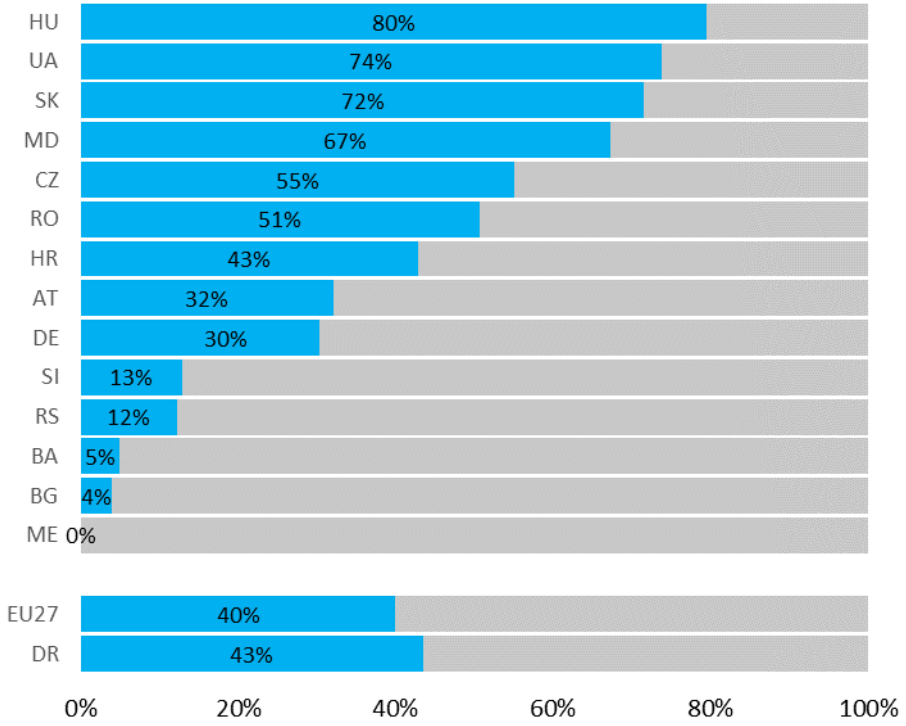
Source: Eurostat Simplified energy balances

A good indicator of household gas dependence is the proportion of households connected to the natural gas network (Figure 7). As gas is primarily used in space heating for households, secondary heating systems and switching from gas in a country where this ratio is high might be a serious challenge. The

[4] In this case building sector means the sum of "Final consumption - other sectors - households - energy use" and "Final consumption - other sectors - commercial and public services - energy use" in the simplified energy balances. It is important to note that this ratio refers to the total energy consumption of the buildings, including electricity use for lighting and appliances and not just to the amount of energy consumed for heating.

indicator was calculated by dividing the number of household gas consumers[5] with the total number of households.[6] This ratio is exceptionally high in Hungary (80%), Ukraine (74%), Slovakia (71%) and Moldova (67%), compared to the EU27 average of only 40%.

FIGURE 7. SHARE OF HOUSEHOLDS USING GAS, 2020 %



Source: Eurostat Simplified energy balances

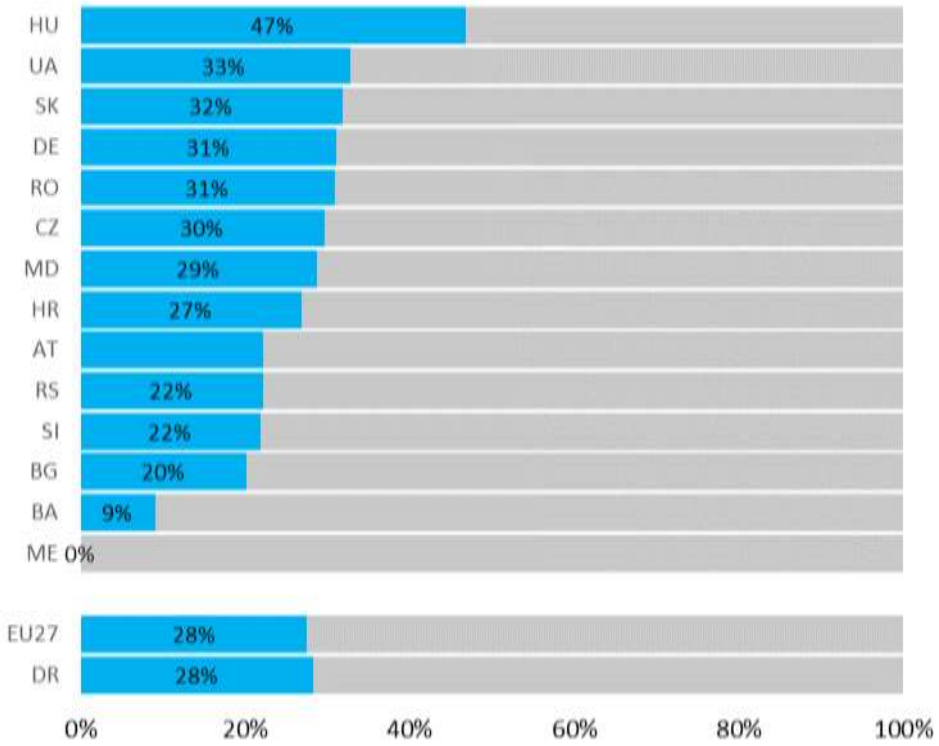
2.2.2 INDUSTRY

Industry uses gas as feedstock, for heating industrial premises and for producing industrial heat for processes (e.g. in the cement industry). In the case of industrial gas consumption, the proportions of the Danube Region countries are much more similar, except for two countries (BA, HR), gas consumption rates vary between 20% and 33%. The share of the EU27 value and the Danube Region is the same (28%), the share of Croatia differs the most, it is 47%. Industrial gas use cannot be shifted quickly, processes and machinery may need to be re-adjusted and replacement of feedstocks is problematic on the short run. (Figure 8)

[5] CEER National Reporting 2019 was consulted for the number of household gas consumers https://www.ceer.eu/national-reporting-2020

[6] Eurostat 2019: Number of private households by household composition, number of children and age of youngest child

FIGURE 8. SHARE OF GAS IN INDUSTRY ENERGY AND FEEDSTOCK CONSUMPTION, 2020 %



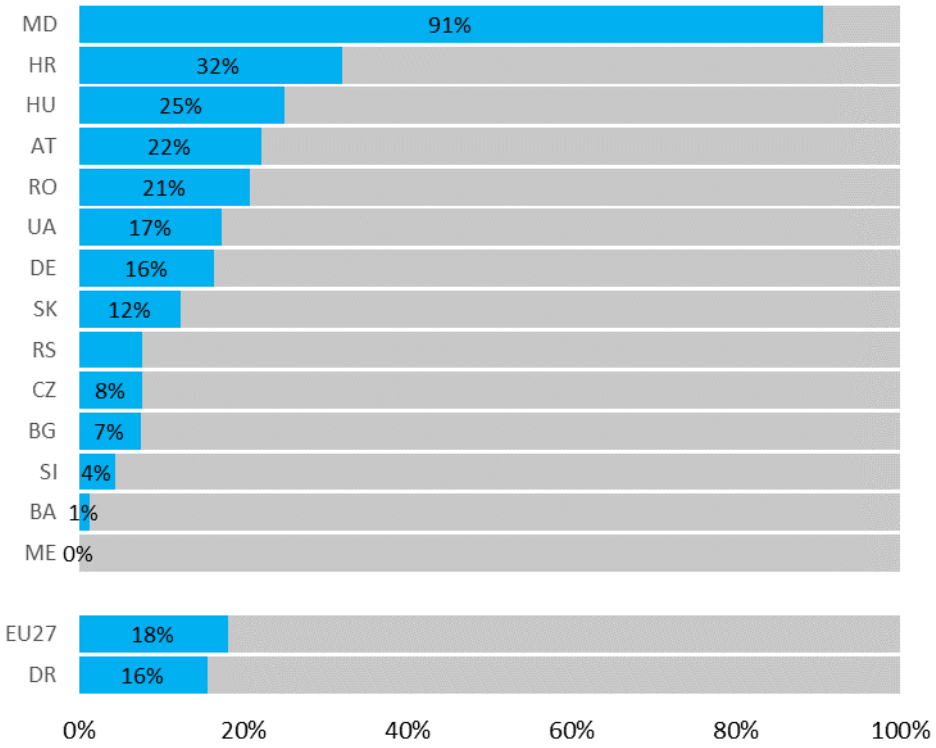
Source: Eurostat Simplified energy balances

2.2.3 POWER AND HEAT GENERATION

Gas-fired power and heat generation is an important part of the energy mix. Figure 9 shows the share of natural gas in this sector.[7] In the EU27, 18% of energy consumed in the sector comes from natural gas. Danube Region countries have a similar share of 16%. In terms of volume, gas plays a significant role in the electricity and heat sector in Moldova alone, where 91% of the sector's total energy consumption stems from natural gas. In Moldova, almost 100 percent of total electricity generation is produced by gas-fired units. At the same time, gas-fired power plants play a significant role in the ancillary and balancing energy markets in several countries. The importance of this is not highlighted by this indicator. Nevertheless, the European electricity network is a well-interconnected system with ample space capacities of power plants, allowing for switching from natural gas to alternate fuels such as locally produces coal and lignite.

[7] This indicator was calculated as natural gas use in total energy for „Transformation input - electricity and heat generation - energy use" from the simplified energy balances of Eurostat.

FIGURE 9. SHARE OF GAS IN POWER AND HEAT SECTOR ENERGY CONSUMPTION, 2019 %



Source: Eurostat Simplified energy balances

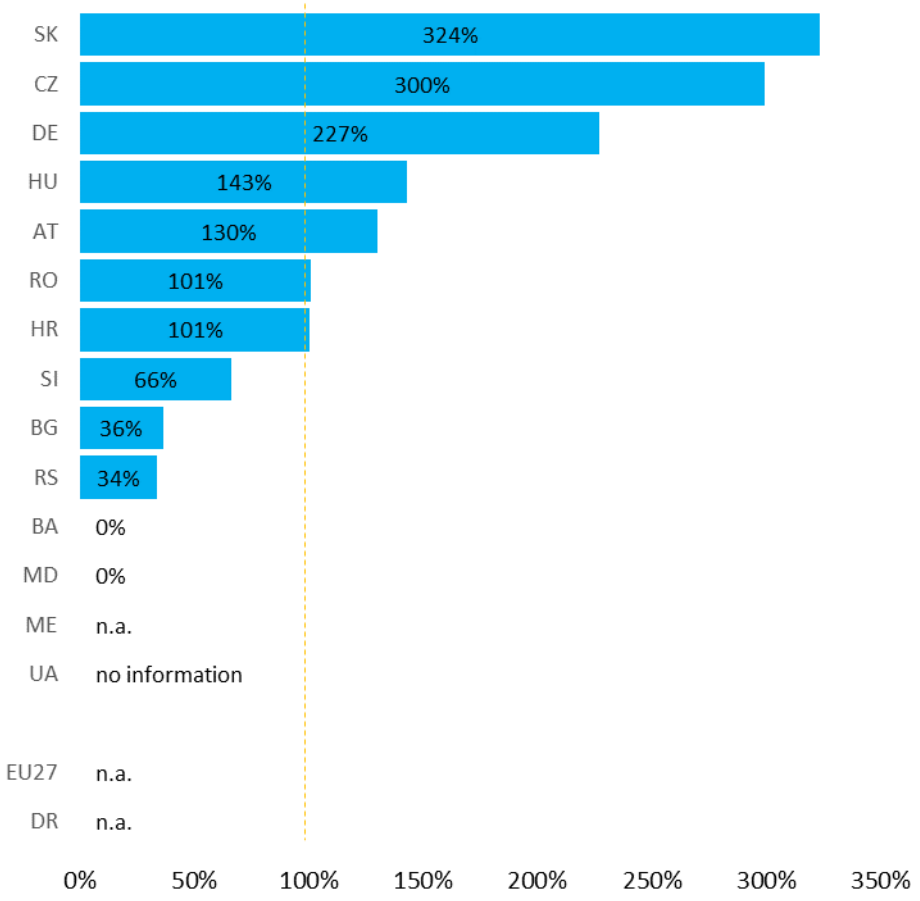
2.3 SUPPLY OPTIONS

2.3.1 INFRASTRUCTURE ADEQUACY

The exposure of the countries' gas infrastructure can be compared and quantified with the help of the N-1 indicator. This is an indicator of infrastructure adequacy that indicates whether the gas infrastructure is able to meet the total daily peak gas demand if the single largest element of the gas infrastructure is interrupted. It is expressed as a percentage of the total demand that can be met by the remaining gas infrastructure. The indicator is calculated by the Member States and collected by the European Commission, instead of our own calculation, we use these values. Figure 10 shows the collected N-1 ratios for each Danube Region country.[8] Based on the available data, the N-1 values of several countries in the Danube Region are adequate, with Slovakia (324%), the Czech Republic (300%) and Germany (227%) having the best values (i.e., the most stable infrastructure). At the other end of the list are Moldova and Bosnia and Herzegovina with 0%. In the case of these countries, gas enters the country through a single pipeline, and they do not have their own production, which means significant risk in security of supply. It is also important to note in the case of countries that perform well in the n-1 indicator, this only shows the possibility of secure care. If the infrastructure is still available after the failure of the largest element, so that the theoretical capacity is available to meet the demand, it does not mean that the actual amount of gas is physically available.

[8] This indicator is not applicable for regions (DR, EU27).

FIGURE 10. N-1 INDICATOR, 2020 %

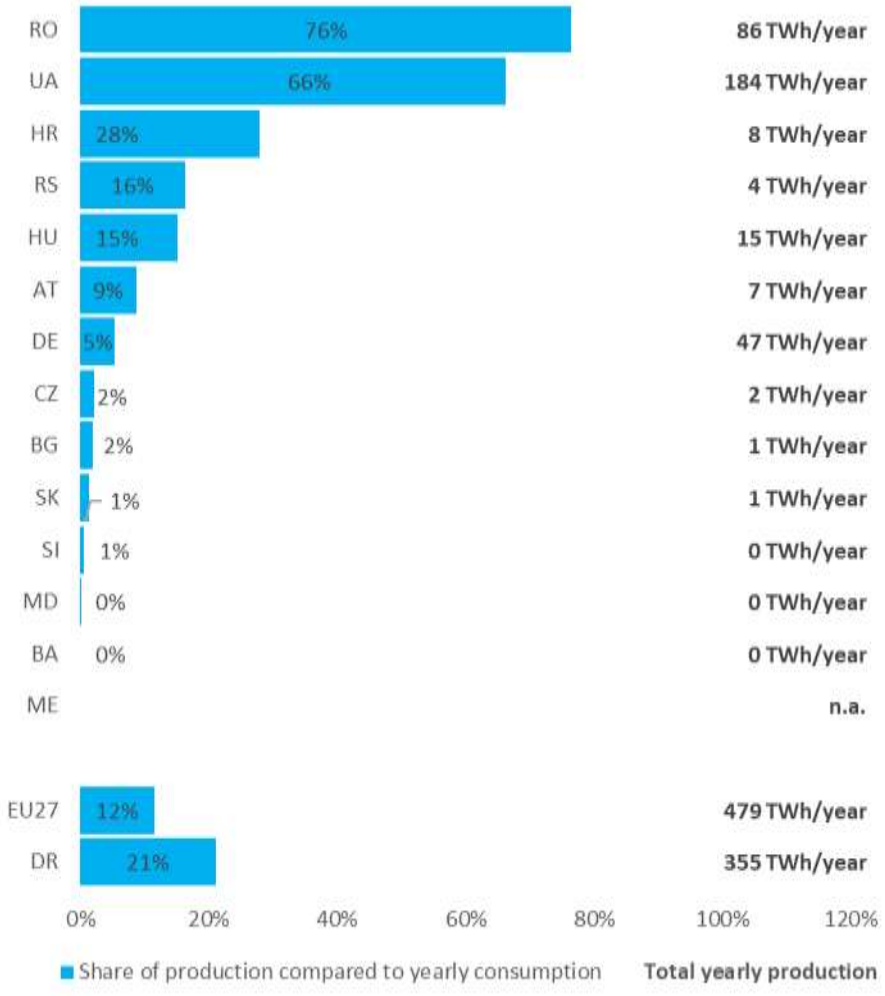


Source: European Commission, Energy Union Indicators

2.3.2 PRODUCTION

Although the level of gas production/yearly consumption rate in the Danube Region is higher than in the EU27 (21% compared to 12%), in fact, the average is significantly raised by the outstanding production rate of two countries, Romania (76%) and Ukraine (66%). The combined production of the two countries (270 TWh) accounts for more than 75 percent of the region's total production. In contrast, there are 6 countries (BA, BG, CZ, MD, SK, SI) in the region that are unable to extract even 2.5 percent of their own annual consumption. Examining the values of all countries in the region, it can be concluded that in the event of a decrease in supply from other sources, most countries will not be able to cover the lost supply with the help of their own production. (Figure 11)

FIGURE 11. GAS PRODUCTION IN THE DANUBE REGION, 2019 % OF GAS CONSUMPTION AND TWH/YEAR



Source: Eurostat Simplified energy balances; BP Statistical Review

2.3.3 STORAGE

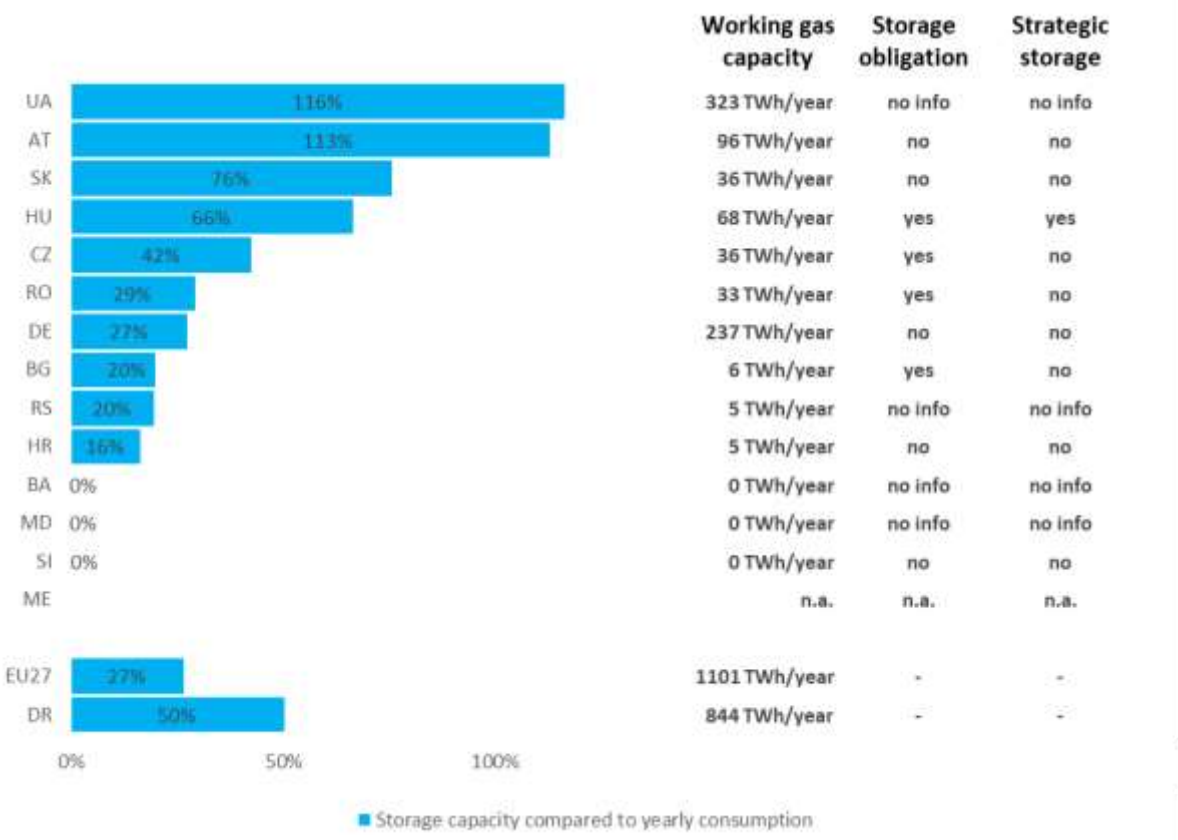
Underground natural gas storages provide seasonal flexibility, temporally arbitrage, security of supply and other services for the market. Figure 12 depicts the size of the available underground gas storage facilities relative to the annual consumption of the Danube Region countries. Absolute storage working gas capacity is also listed, as well as presence of storage obligations and strategic storage. In the EU27, 1101 TWh of working gas capacity was operational in 2020, while in the Danube Region 844 TWh. The working gas capacity compared to the annual consumption was 27% in the EU27, while it was 50% in the Danube Region. This capacity is distributed unevenly, as most of the underground gas storages were developed on site of depleted natural gas fields. Storage facilities in Austria and Ukraine may stockpile more gas than their annual consumption and even provide services to neighbouring countries. In some countries, such as Bosnia and Herzegovina, Moldova and Slovenia, storage is not in place and therefore the seasonal flexibility is supplied by pipelines.

Storage obligations require market participants (traders, gas suppliers or transmission system operators (TSOs)) to fill up the storages as required by regulation. Such regulation was in place in Bulgaria,

the Czech Republic, Hungary and Romania. For the winter of 2022/2023, European Commission proposed a Regulation which will require all Member States (MSs) to fill up their storages to 80% of their capacity, and to 90% in the coming years.[9] This is a requirement which is stricter than any current national regulation.

Strategic storage refers to a dedicated storage infrastructure, which can be released in case of emergency. In the DR, so far only Hungary developed such infrastructure.

FIGURE 12. WORKING GAS VOLUME COMPARED TO YEARLY GAS CONSUMPTION IN THE DANUBE REGION, 2021 % AND TWH/YR



Source: Eurostat; BP Statistical Review; ACER

2.4 PRICES AND PRICE REGULATION

Comparing household and industrial gas prices in the first half of 2020 and the first half of 2022[10], with one or two exceptions, we can see an increase in both sectors. Figure 13 shows the change in the household gas prices in different European countries, while Figure 15 shows the change in the price of

[9] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EU) 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and Regulation (EC) n°715/2009 of the European Parliament and of the Council on conditions for access to natural gas transmission networks. COM/2022/135 final

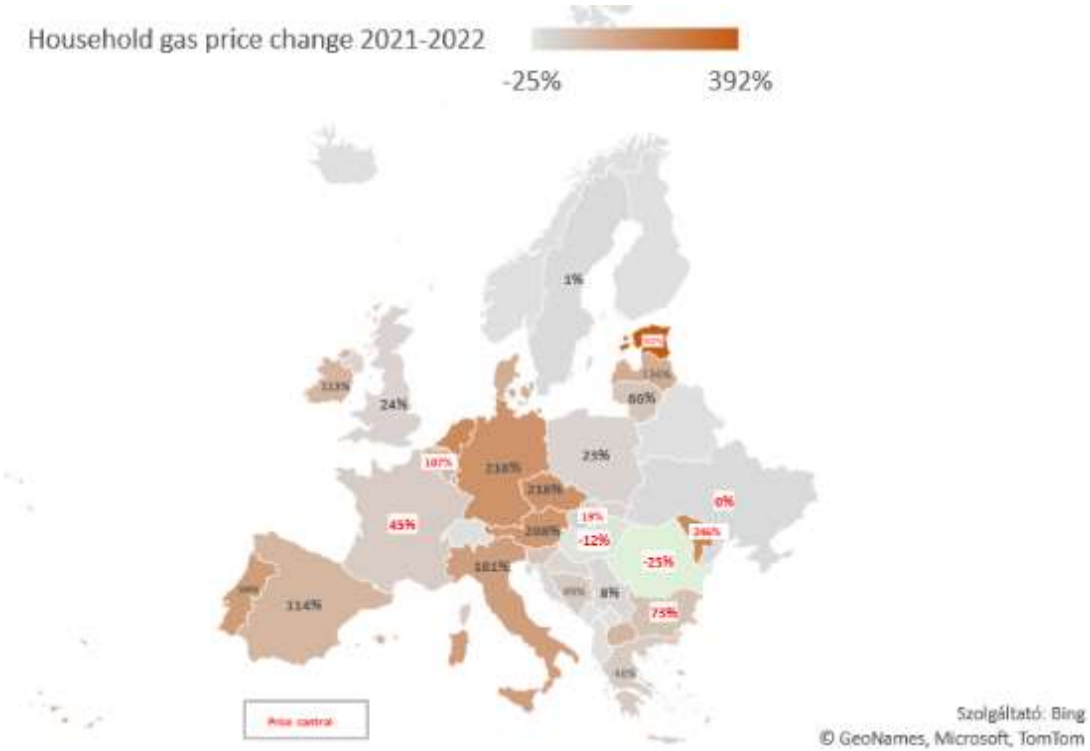
[10] Eurostat: Gas prices for household consumers [nrg_pc_202]

industrial gas. In Figure 13, the values for countries with price regulation are marked in red[11]. For both sectors, the rate of price increase varies significantly across countries.

During the observed period, the most significant price increase was observed among countries located in the central part of Europe and in Estonia, where even higher price increases were observed (392%). Household gas prices rose by more than 200% in Austria, the Czech Republic, Germany and in the Netherlands. The price increase was similar in Moldova, which is completely dependent on Russian gas (248%). The price increases were more moderate but also significant in most Western countries (between 24-184%).

Price regulation does not seem to have a slowing effect on price growth in all countries. While in Slovakia, Hungary, Serbia and Ukraine, there was little or no change in prices for households, in Bulgaria, Bosnia and Herzegovina, France, Estonia and Belgium despite price controls, prices rose significantly. Besides this, in some countries in the Danube Region, price control is effective in protecting household consumers. Thus, they would be hit hard by a sudden rise in prices, so they are much more vulnerable to changes in gas prices. In Hungary, the increase in residential gas prices for consumers with higher-than-average consumption has already begun, and its rate depends on the level of above-average consumption. The main problem of the retail price regulation is that there is a lack of price signal to the household consumers to invest into demand reduction or savings.

FIGURE 13. HOUSEHOLD GAS PRICE CHANGE 2021-2022, %

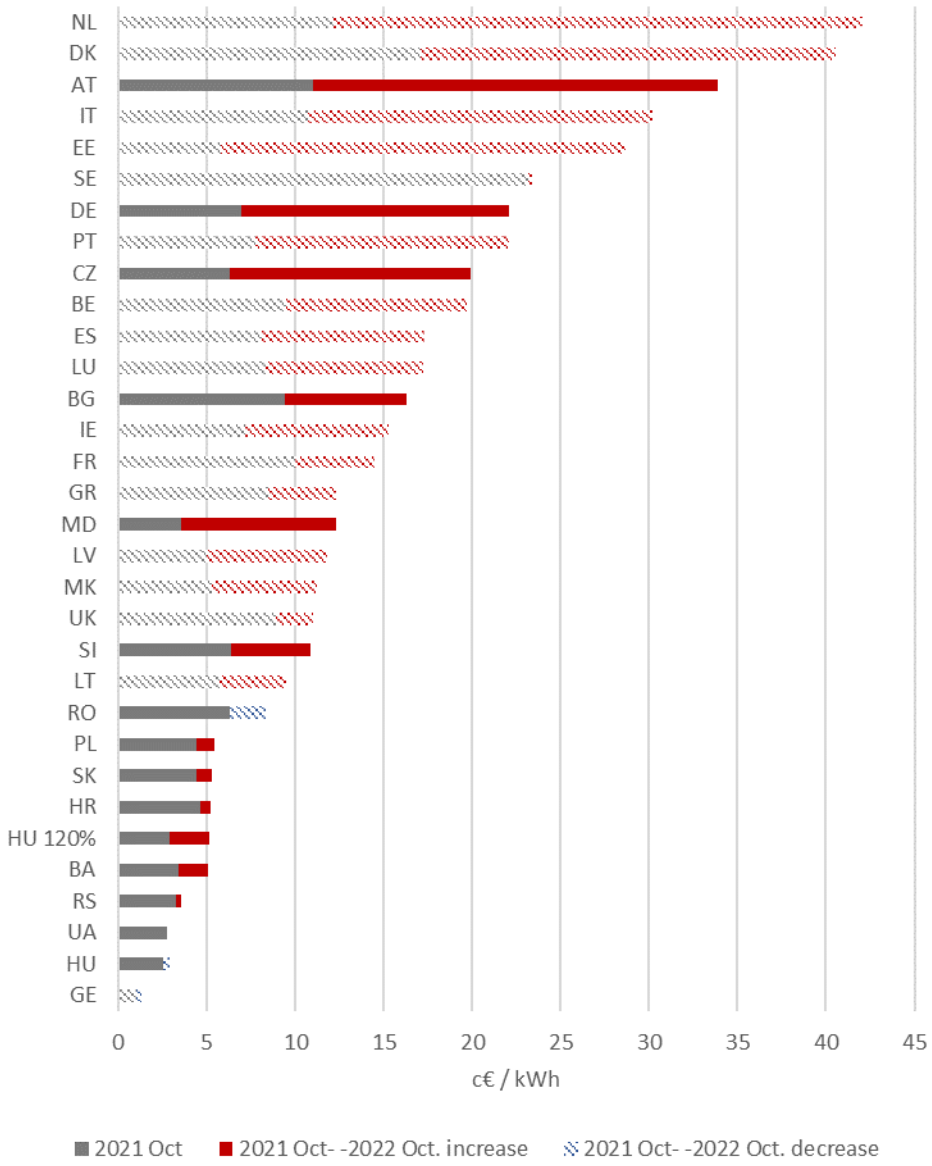


Source: Eurostat; Energy Community Secretariat, 17 Gas Forum in Ljubljana, 5 October 2022

The following chart depicts the household year on year price change in the EU and Danube Region countries:

[11]ACER/CEER: Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2020;
ECRB Market Monitoring Report: Gas and Electricity Retail Markets in the Energy Community (2020-2021)

FIGURE 14. HOUSEHOLD NATURAL GAS PRICE INCREASE BETWEEN 2021 OCTOBER AND 2022 OCTOBER, C€/KWH*

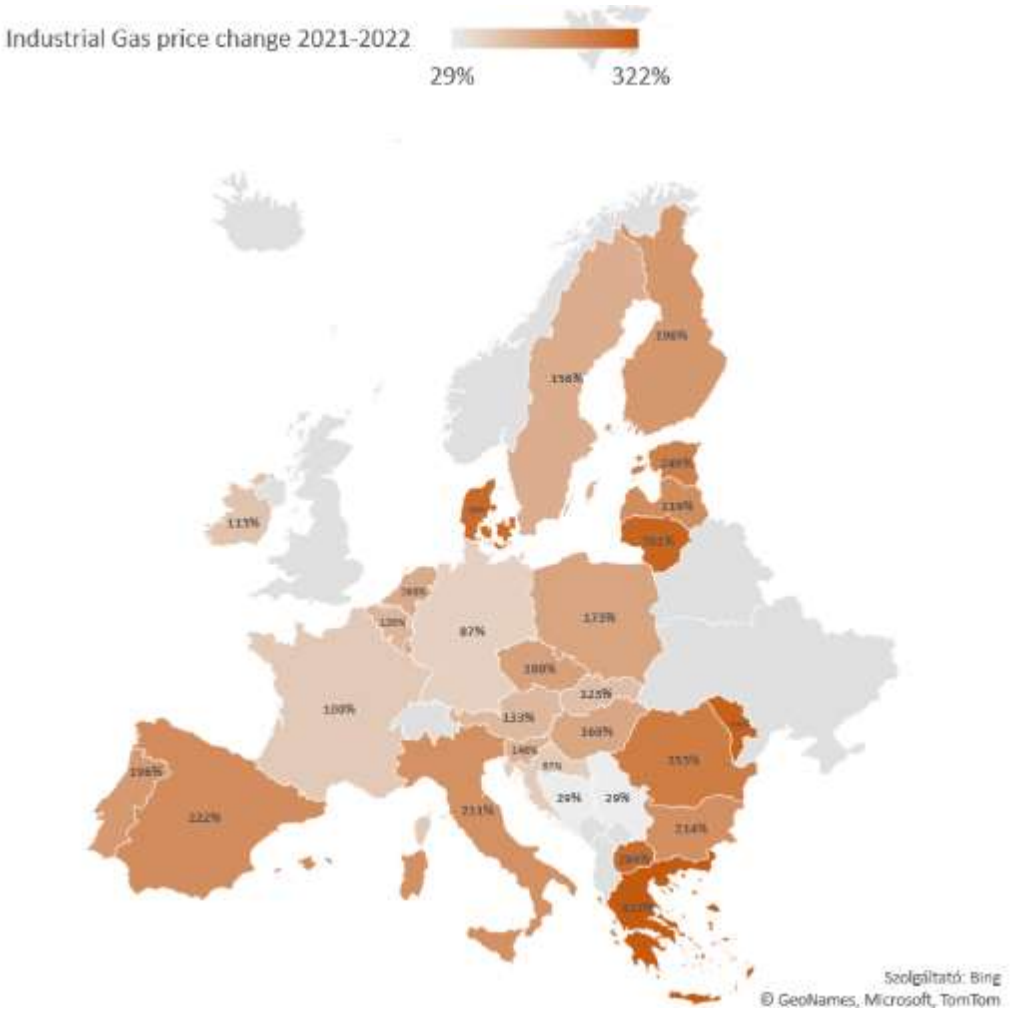


Note: HU 120%: the average price calculated with a value exceeding the average consumption by 20 percent

Source: Hungarian Energy and Public Utility Regulatory Authority (HEA); Energy Community Secretariat, 17 Gas Forum in Ljubljana, 5 October 2022

If, in addition to the rate of price change, we also examine how household gas prices have evolved in absolute terms in the countries of the European Union and the Danube Region. then we see that prices in Western Europe are still higher than in Eastern Europe. Most of the countries of the Danube Region are in the lower third, except for Austria, the Czech Republic, Germany, Bulgaria and Moldova. It is clear that the price increase was significant in the case of these Danube Region countries. **(**Figure 14**)**

FIGURE 15. INDUSTRIAL GAS PRICE CHANGE 2021-2022, %



Source: Eurostat

In the case of industrial gas prices, the differences between countries are smaller, but the price increase is even more significant in most of the countries.

According to Eurostat, the most significant price increase occurred in the South-Eastern European region, but the price increase was similar in the case of the Baltic countries as well. The growth is over 200 percent or close to it in the following countries: Portugal, Spain, Italy, Greece, Bulgaria, Romania, Moldova, North Macedonia, Latvia, Lithuania, Estonia and Denmark. It is important to note that the growth rate of industrial gas prices exceeded 100% for almost all countries. The increase in industrial gas prices means a significant risk primarily to countries in which the petrochemical sub-sector plays a larger role. In this field, gas is not only used as an energy source for heating and other processes, but also as a raw material, for example in the fertilizer industry.

2.5 SUMMARY

Table 1 summarizes the indicator-based assessment on the gas-dependency of the Danube Region. The indicator values are classified into low, medium and high categories based on thresholds presented in Table 2. The thresholds are defined based on general principles (such as N-1 indicator should exceed

100%) but relative positions compared to the regional and EU average values are also considered, especially in the case of demand-side indicators.

TABLE 1. SUMMARY OF DEPENDENCY INDICATORS

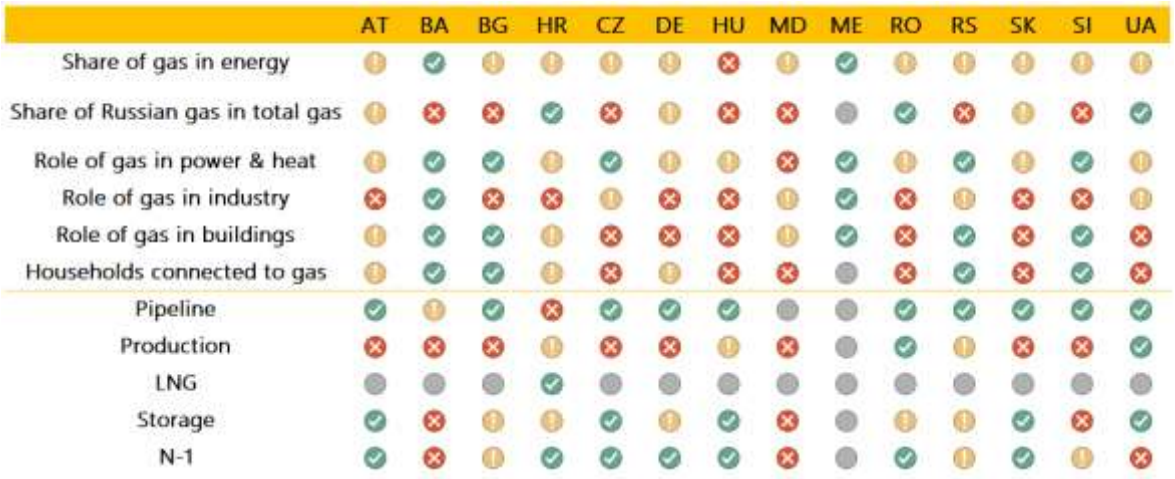


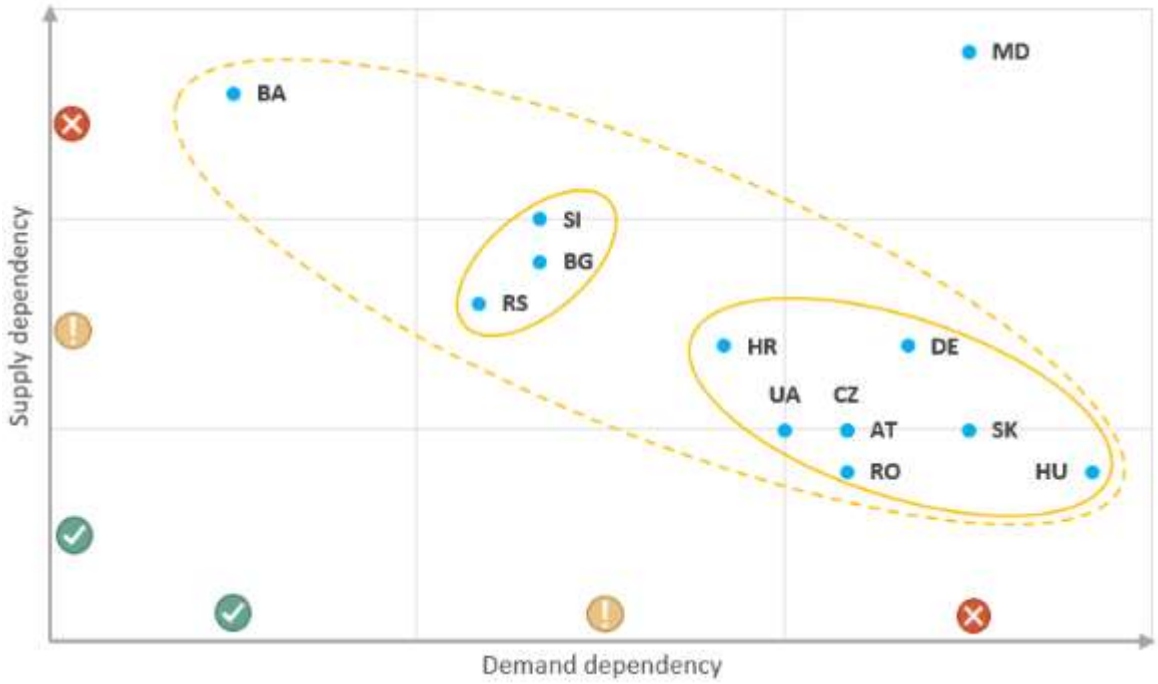
TABLE 2. TRESHOLDS FOR INDICATOR-BASED ASSESSMENT

Share of gas in energy	-	Under 10%	10-30%	Over 30%
Share of Russian gas in total gas	no gas cons.	Under 50%	50-80%	Over 80%
Role of gas in power & heat	-	Under 10%	10-40%	Over 40%
Role of gas in industry	-	Under 10%	10-25%	Over 25%
Role of gas in buildings	-	Under 15%	15-25%	Over 25%
Households connected to gas	no gas cons.	Under 25%	25-50%	Over 50%
Pipeline	no gas cons.	Over 110%	80-110%	Under 80%
Production	no gas cons.	Over 50%	15-50%	Under 15%
LNG	no LNG	LNG in place	-	-
Storage	no gas cons.	Over 40%	10-40%	Under 10%
N-1	no gas cons.	Over 100%	1-100%	0%

The main conclusion of the analysis is that there is a considerable negative relationship between the demand-side and the supply-side dependencies, meaning that those countries that rely heavily on gas have taken significant efforts to ensure the security of supply by adequate infrastructure capacities (Figure 16). There is one exception, Moldova, where both demand- and supply side dependency is very high, therefore it can be named as the most dependent country of the Danube Region.

Roughly half of the countries can be classified into the group of “highly gas-dependent countries with mostly sufficient supply options”: Hungary, Slovakia, Romania, Austria, the Czech Republic, Ukraine, Croatia and Germany can be listed here, with the latter being the most dependent within the group. Bulgaria, Slovenia and Serbia are moderately gas-dependent countries with weaker supply options, while Bosnia and Herzegovina is not gas-dependent but have very limited options to find alternative supply sources. In sum, none of Danube Region countries are fully independent, as either their high gas consumption or their weak supply options pose a challenge.

FIGURE 16. DEMAND- AND SUPPLY SIDE DEPENDENCIES IN THE DANUBE REGION



Legend: The supply and demand dependencies are classified based on a detailed assessment of a large set of supply and demand indicators measuring the vulnerabilities of the countries and comparing their results to and average EU27 dependency ratio. Green cells mean that most of the demand / supply indicators of a country are better than the EU average, yellow means that it is close to the average, and red means that most of the indicators are worse than the EU average.

3 POTENTIAL FOR GAS DEMAND REDUCTION IN THE DANUBE REGION

3.1 POWER SECTOR DEMAND REDUCTION POTENTIAL

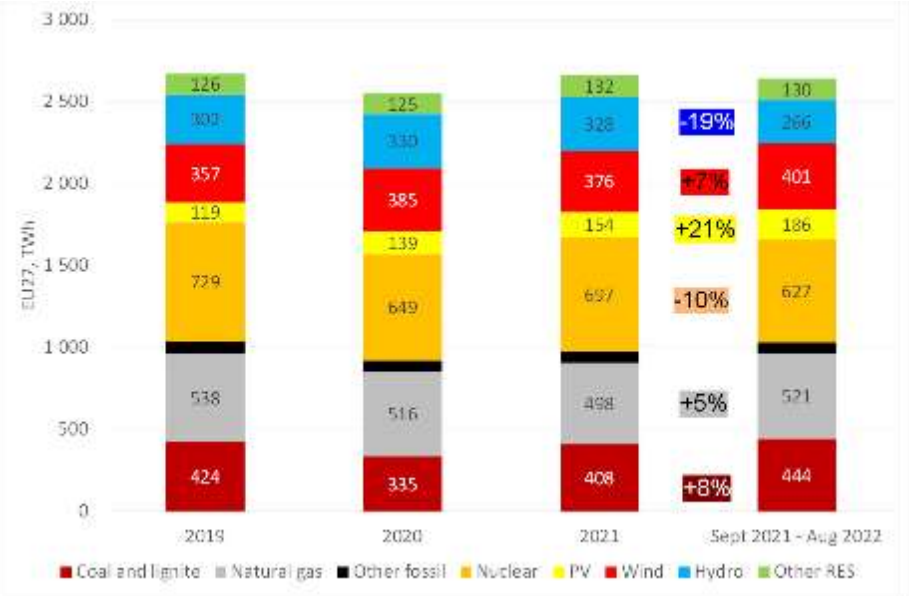
The following chapter presents the results of a modelling-based assessment carried out by the European Power Market Model (EPMM). EPMM is a unit commitment and economic dispatch model that endogenously models 38 countries in the European electricity system (ENTSO-E). During the optimization process it satisfies the electricity consumption and spinning reserve needs in the modelled countries at minimum system costs. Constraints on production (power plant capacities on a unit level) and trade (cross-border transmission capacities) are both considered. The model simultaneously optimizes all 168 hours of a modelled week, and provides equilibrium wholesale electricity and reserve prices, electricity mix and trade data. Modelling is performed for 12 different weeks of each modelled year.

3.1.1 SHORT-TERM GAS CONSUMPTION REDUCTION POTENTIAL IN THE POWER SECTOR

To assess the gas consumption reduction potential of the power sector, we used the following logic. As a starting point, we assessed the developments in the power sector in the last 3 years and identified the most important drivers that might influence gas consumption. Then we calibrated the model to reflect the overall gas consumption of the power sector for the period 2021 September – 2022 August. For the sake of consistency, and as fact individual country level gas consumption data of the power sector was not available for each country this modelled gas consumption was the basis of comparison when we calculated the consumption reduction potential. We modelled a Base case that reflects the best estimate for the next 12 months period (September 2022 – August 2023), where we assumed around 80 €/MWh natural gas price level, and no special measure to be taken. Then we tried to measure what is the minimum gas consumption level in the power sector, with which it can still operate safely – all consumers and flexibility need is served. To model that we assumed very high gas prices, so gas-based production is always the most expensive option on all markets, gas is only to be used when there is no other option (nor import, neither any further domestic plants are available). This is reflected in the MinGas scenario. Finally, we carried out sensitivity analyses assuming different level of hydro and nuclear availability.

The first step is to assess the current state of play. It is surprising that gas-based electricity production - despite the skyrocketing gas prices of 2022 - even increased in the first 9 months of 2022 compared to the previous year (Figure 17). However, the main reason behind that is that the availability of nuclear units (especially in France) and hydro plants across Europe was way below historical production due to unexpected technical issues and severe weather conditions. This led to a much higher demand for fossil-based electricity, so even such a high price environment on the gas market could not result in a year-on-year decrease of gas-based power generation.

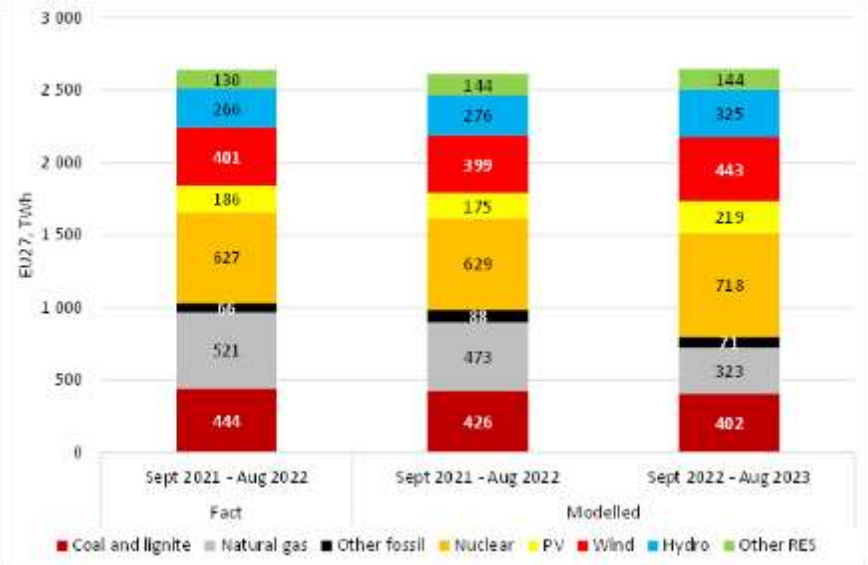
FIGURE 17. HISTORICAL GENERATION MIX OF THE EU27 POWER SECTOR, TWH/YEAR



Source: EPMM modelling

As these conditions are rare, but might occur later, as well in the short-term outlook we reflect the availability of both nuclear and hydro capacities. In the Reference scenario we assume that French nuclear capacities come back online, the German nuclear closure is delayed to 2023 H2, and we calculate with a historical average hydro availability. While the model already shows somewhat lower fossil-based generation than the fact data for 2021-2022 (coal and lignite, natural gas and other fossil based generation was modelled 5% lower for the period Sep 2021-Aug 2022 than fact values – see first two columns of Figure 18), a significant change is visible already in the Base case, covering the next 12 months (2022 September – 2023 August). This is mostly the result of the higher assumed availability of hydro and nuclear capacities. This means, that we can expect a lower gas consumption in the power sector for the next 12 months compared to the last 12 months without any additional measure or effort, just as a result of higher hydro and nuclear availability.

FIGURE 18. ACTUAL AND MODELLED GENERATION MIX OF THE EU27 POWER SECTOR, TWH



Source: EPMM modelling

To control for the effect of hydro and nuclear availability, we carried out 3 sensitivity runs: Low hydro, Low nuclear and Low hydro and nuclear. Results are depicted on Figure 19. In the Base cases we show what would be the gas consumption without any additional measures, while the MinGas scenarios always show the minimum natural gas amount needed in the power sector to safely operate.

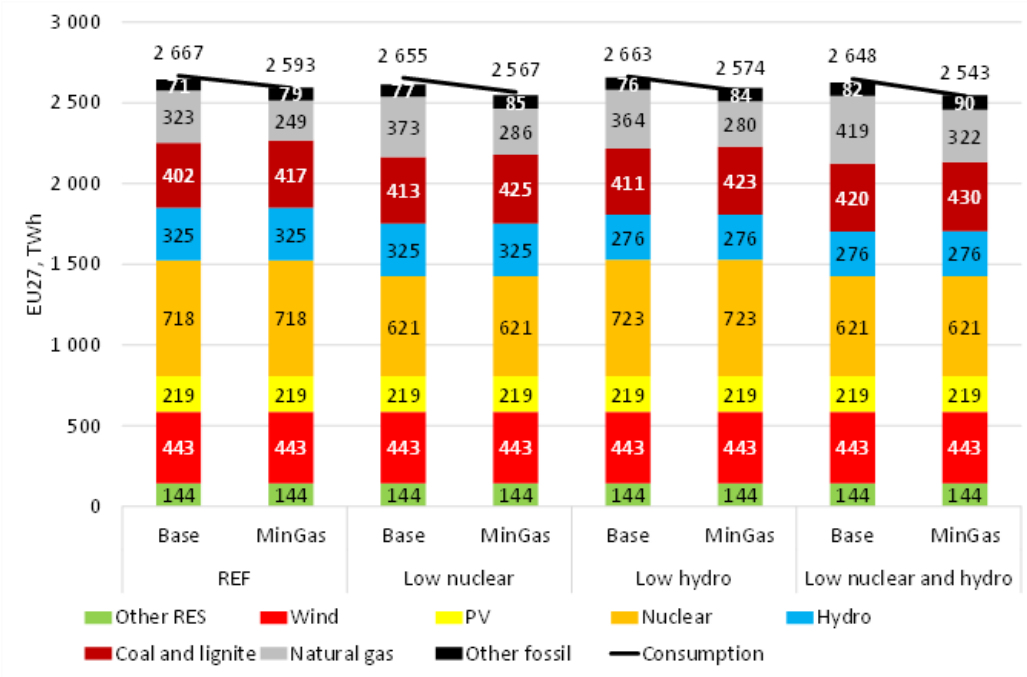
In the Reference scenario nuclear production in France is 422 TWh, and in Germany it is 17 TWh. Same values in the low nuclear scenarios are 331 and 11 TWh. Overall hydro production is 325 TWh in the Reference scenario, and in the low hydro scenarios it is only 276 TWh (same as in the past 12 months).

The combination of these dimensions results in 4x2 distinct scenarios. The Reference scenario - Base case is our best estimate for 2022 Sept – 2023 August, MinGas reference is estimating the minimum gas need for Europe when other capacities are available according to the Reference Base case. All other scenarios are sensitivities to these results.

Experiences of the summer in 2022 show that the short-term gas phase-out potential of the power sector depends to a large extent on the availability of nuclear and hydro plants in the European power system. The most likely (Reference) scenario shows that when nothing is done 150 TWh gas-based generation decrease is expected in the EU27 from the last 12 months to the next 12 months, just because of hydro and nuclear generation coming back to normal levels. An additional 74 TWh decrease can be reached along these conditions if gas is only used in the power sector as a last resort.

When we assume lower nuclear and/or hydro availability we see a decrease of 54 to 19 TWh in the Base case (no special measures), and an additional 84 to 97 TWh in the MinGas cases (gas used only as last resort) – meaning altogether the total natural gas consumption reduction potential for the EU27 is somewhere between 284 and 430 TWh depending on nuclear and hydro availability. Part of the saving comes from the elasticity of the power sector – in case of very high prices, demand reacts quite intensively, so the overall power consumption in Europe is likely to decrease as well.

FIGURE 19. EU27 ELECTRICITY MIX IN THE DIFFERENT SCENARIOS, 2022 SEPTEMBER TO 2023 AUGUST, TWH

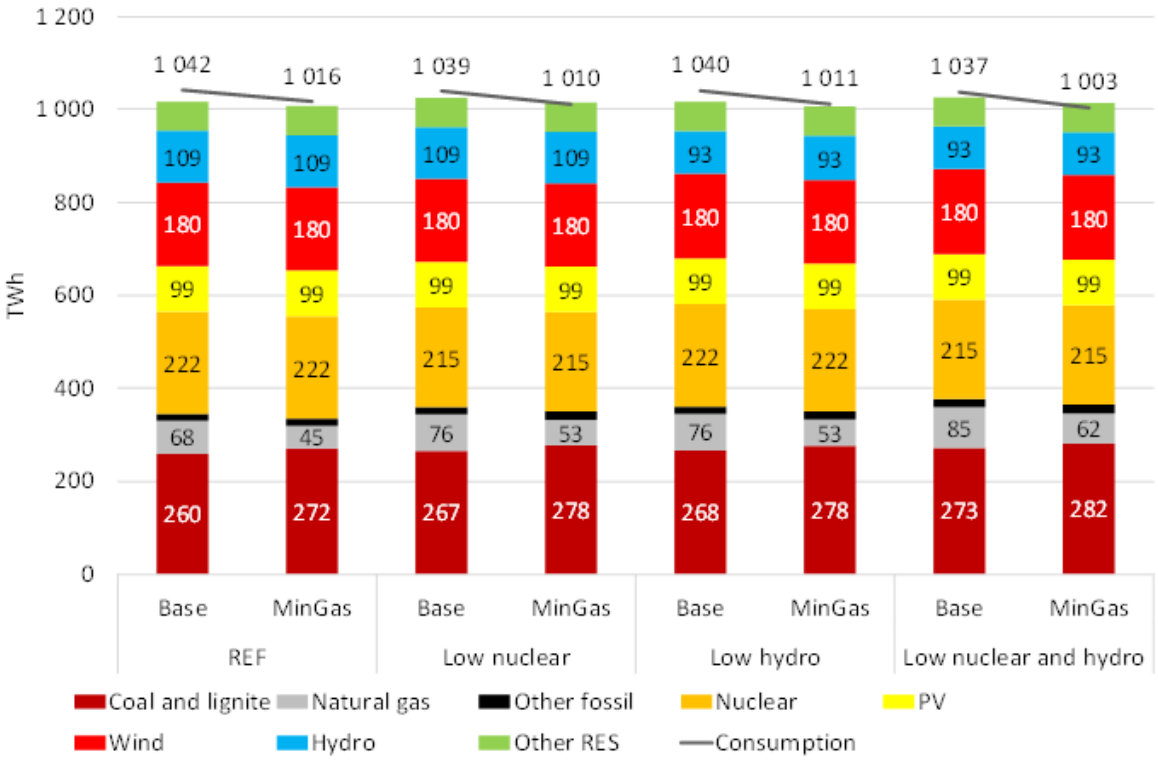


Source: EPMM modelling

In the Danube Region countries the share of natural gas-based electricity consumption is much smaller than in the EU27 on average. Gas-based generation satisfies 12% (323 TWh) of total electricity consumption in the EU27, in the Danube Region this value is 6.5% (68 TWh) (in the Reference - Base scenario, which is our best estimate for 2022 Sept – 2023 August).

If we assume average hydro and nuclear availability, then with no measures taken the gas-based power generation is 68 TWh in the Danube Region countries. If gas in only used as a last resort (MinGas), then this can be further reduced to 45 TWh. The situation is worse if we assume both hydro and nuclear availability will be as low as in the past 12 months, this case the total gas-based generation in the Danube Region is 85 TWh in the Base case and can be reduced to 62 TWh if the minimum amount of gas is used. In the Danube Region countries gas-based electricity production is partly replaced by coal- and lignite-based generation, and part of the reduction also comes from demand response, due to the high electricity prices, just like in the EU27. (Figure 20)

FIGURE 20. DANUBE REGION ELECTRICITY MIX IN THE DIFFERENT SCENARIOS, 2022 SEPTEMBER TO 2023 AUGUST, TWH



Source: EPMM modelling

Table 3 shows the gas consumption of the power sector in the Danube Region countries, where four scenarios are depicted: Reference and a pessimistic (Low nuclear and low hydro) scenario, and for both Base Case and MinGas case. Also, the modelled gas consumption for the period September 2021 – August 2022 is demonstrated (Modelled 2021/2022, first column). In the Reference-Base case the total gas consumption of the Danube Region countries is 140 TWh for the next year, which could be decreased to 95 TWh in the MinGas case. Gas consumption reduction could be much lower (even negative!) if the pessimistic scenario is assumed. In this case the natural gas consumption of the region is between 130-175 TWh.

Most of the gas consumption comes from Germany (36-54 % dependent on the scenario), and from Romania (5-24%). In some countries there is no need to use natural gas for electricity production, like

in Bosnia and Herzegovina, Moldova, Montenegro, and Ukraine. While in the first two countries there were no gas consumption in the power sector in the last year, in Moldova and in Ukraine significant gas was used for power generation. However, the modelling results show, that this consumption could be replaced by other sources in such a way that the electricity demand is satisfied, and the needed balancing reserve requirements are fulfilled.

TABLE 3. GAS CONSUMPTION OF POWER PLANTS IN DANUBE REGION COUNTRIES IN DIFFERENT SCENARIOS, 2022-2023, TWH/YR[12]

TWh	Modelled	2022-2023 – Reference		2022-2023 - Pessimistic	
	2021/2022	Base case	MinGas	Base case	MinGas
AT	13.4	8.9	10.1	12.2	13.5
BA	0.0	0.0	0.0	0.0	0.0
BG	14.7	12.6	2.2	14.0	2.8
CZ	6.1	3.7	3.4	5.4	5.9
DE	84.9	50.8	49.1	73.2	70.8
HR	10.8	7.3	6.2	9.5	7.7
HU	13.0	10.0	10.6	12.1	12.4
MD	0.0	0.0	0.0	0.0	0.0
ME	0.0	0.0	0.0	0.0	0.0
RO	34.8	33.4	4.9	34.4	7.1
RS	6.7	6.7	1.7	6.7	2.2
SI	3.1	2.7	2.9	3.0	3.2
SK	5.9	3.9	4.1	4.8	5.8
UA	0.0[13]	0.0	0.0	0.0	0.0
Total Danube Region	193.4	139.9	95.1	175.2	131.4
Total EU27	941.6	645.7	511.3	835.7	657.6

Source: EPMM modelling

According to our modelling the total gas consumption of the power sector in the last year (from the period between September 2021 to August 2022) is 193 TWh in the Danube Region countries. To sum up, gas demand reduction potential ranges from 18 TWh/year (Pessimistic, base case) to almost 100 TWh/year (Reference, MinGas case) in the short run.

[12] In some countries (e.g. Austria, or Slovakia) the gas consumption is higher in the extreme high gas price scenario than in the Reference, which seems contradictory at first glance. The reason behind that phenomenon is that the gas price differs country-by-country in the Reference scenario, but in the Extreme high gas price scenario we assume a uniform - 300€/MWh - price for all countries. Let's assume that in country "A" a gas-based unit has a higher efficiency than a gas-based unit in country "B", but the marginal cost of the generator in country "A" could be higher, if the cost of gas is higher in this country. But in the extreme high gas price scenario, the marginal cost is lower in country "A", due to the efficiency advantage.

[13] In Ukraine gas consumption of the power sector is zero, because the consumption is satisfied fully by coal, nuclear and RES sources. Both in 2021/2022 and in 2022/2023 the gas price is so high, while and the CO2 tax is very low, coal is much cheaper than the gas-based electricity production.

TABLE 4. SHORT TERM GAS REDUCTION POTENTIAL IN THE POWER SECTOR, TWH/YR

TWh	Gas consumption	Gas consumption reduction compared to the Modelled 2021/2022			
	Modelled	2022-2023 - Reference		2022-2023 - Pessimistic	
	2021/2022	Base case	MinGas	Base case	MinGas
AT	13.4	-4.5	-3.3	-1.2	0.1
BA	0.0	0.0	0.0	0.0	0.0
BG	14.7	-2.1	-12.5	-0.7	-11.9
CZ	6.1	-2.4	-2.7	-0.8	-0.2
DE	84.9	-34.1	-35.9	-11.8	-14.1
HR	10.8	-3.5	-4.6	-1.3	-3.1
HU	13.0	-3.0	-2.3	-0.8	-0.6
MD	0.0	0.0	0.0	0.0	0.0
ME	0.0	0.0	0.0	0.0	0.0
RO	34.8	-1.4	-29.9	-0.4	-27.7
RS	6.7	0.0	-5.0	0.0	-4.4
SI	3.1	-0.4	-0.2	-0.1	0.0
SK	5.9	-2.1	-1.8	-1.1	-0.1
UA	0.0	0.0	0.0	0.0	0.0
Total Danube Region	193.4	-53.5	-98.4	-18.2	-62.0
Total EU27	941.6	-295.9	-430.4	-105.9	-284.0

Source: EPMM modelling

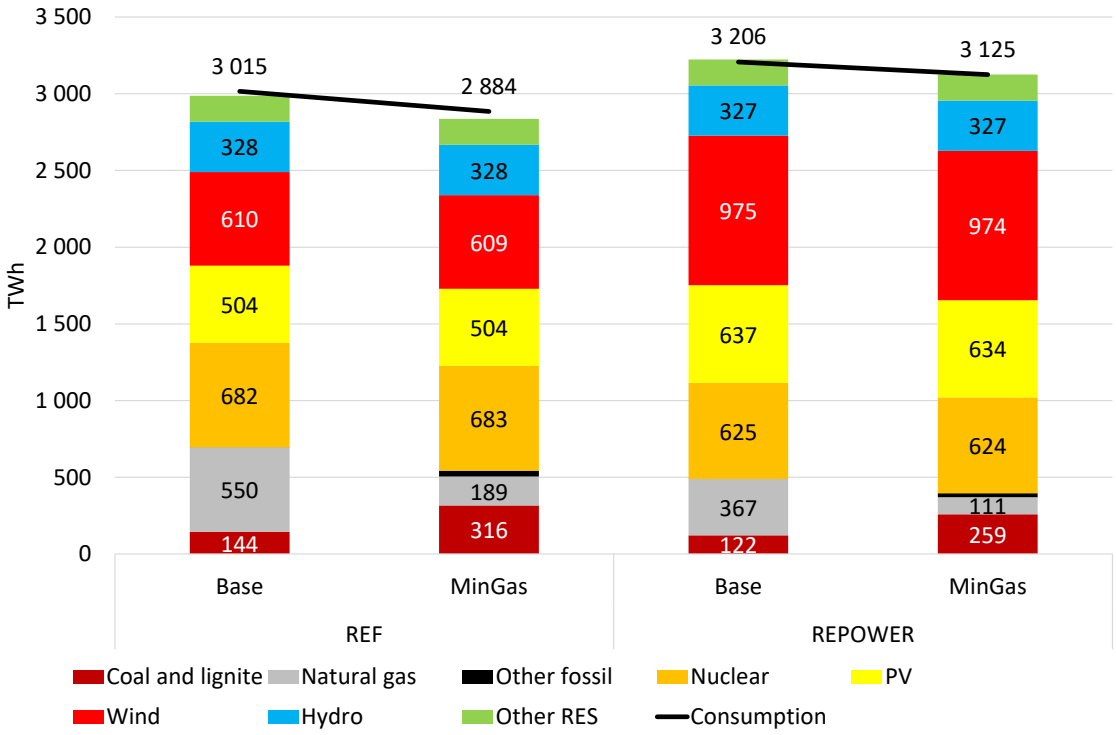
3.1.2 LONG-TERM GAS CONSUMPTION REDUCTION POTENTIAL IN THE POWER SECTOR

The short-term reduction potential in the power sector was based on already available capacities, which are part of the European power plant fleet and operational. On the longer term, newly commissioned power plants and closures of fossil plants may alter the available generation mix and shift the gas saving potential. For this reason, an alternative power plant fleet must be envisaged to 2030.

The long-term forecast (2030) is based on increased RES penetration. The highest uncertainty arises for renewable capacities. To assess that, we assumed two different renewable pathways: a somewhat slower uptake (Reference), and a more ambitious one, as envisaged by the REPower EU Strategy (REPOWER). For both capacity mixes we modelled the Base case, which is a normal functioning of the power sector and the MinGas case, when gas is only used as a last resort.

As shown on the Figure 21, overall fossil-based production is much lower in both Base cases than in 2021-2022, it goes down from 1000 TWh to around 700 or 500 TWh. Most of this is provided from gas-based production (550 and 367 TWh). When gas is only used when there is no other option, overall EU gas-based power generation can be reduced to even 189 or 111 TWh in the two scenarios, Reference and REPOWER, respectively. This translates to around 370 and 220 TWh overall gas consumption in the EU27.

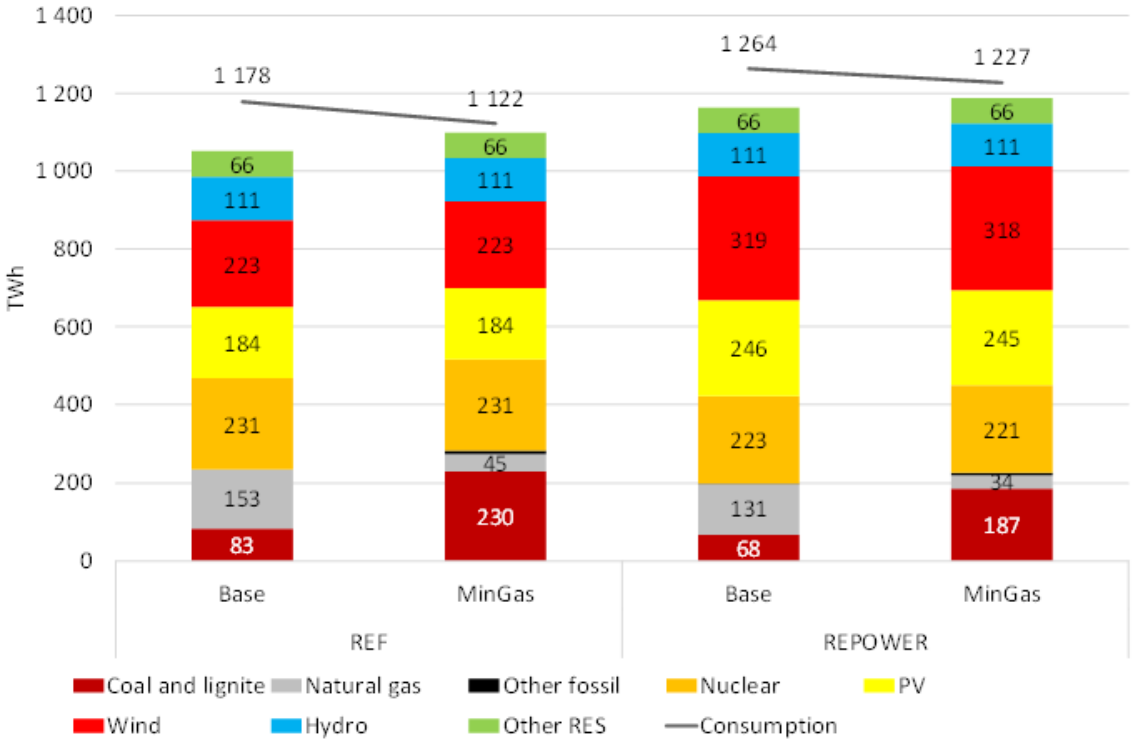
FIGURE 21. GENERATION MIX AND GAS DEMAND REDUCTION POTENTIAL OF THE EU27 POWER SECTOR IN 2030, TWH/YR



Source: EPMM modelling

Just like in the EU27 countries, natural gas-based electricity production increases by 2030 in the Reference scenario Base case in the Danube Region countries as well, due to the high consumption growth, and the competitiveness over coal. It is assumed that the electricity consumption increases by 1.5 %/year on average. The consumption growth in the REPOWER scenario is much higher; the yearly growth rate is 2.5% on average in the Danube Region countries. While in 2022/2023 the total fossil-based power generation is 343 TWh in the Danube Region countries according to the modelling results, in 2030 it decreases to 235 TWh in the Reference scenario, while in the REPOWER scenario it is below 200 TWh. Fossil-based power generation is mainly replaced by RES generation. Due to the coal phase-out, and the decreased competitiveness of coal (gas prices are assumed to go back to the level of 30 €/MWh) the coal and lignite generation drops significantly. In the Base cases natural gas-based power production is only 153 TWh in the Reference scenario, while 131 TWh in the REPOWER scenario. Due to the lower gas prices and the relatively high CO_2 prices, producing electricity from natural gas will be cheaper than coal-based power production, that results in a much higher share of gas-based electricity production in the fossil generation. If the gas remains very expensive, then this coal-to-gas switch will not happen, and the production of natural gas decreases very significantly, to 45 TWh in the Reference scenario, and to an even lower level, 34 TWh in the REPOWER scenario. (Figure 22)

FIGURE 22. GENERATION MIX AND GAS DEMAND REDUCTION POTENTIAL OF THE DANUBE REGION POWER SECTOR IN 2030, TWH/YR



Source: EPMM modelling

Both in the Reference and in the REPOWER scenario, the natural gas consumption of power plants increases significantly by 2030 compared to the 2022/2023 figure. While in the next 12 months, according to our modelling in a non-extreme (but still realistically high) gas price scenario the consumption of gas power plants is 140 TWh, this figure increases to 290 TWh (Reference) and 250 TWh (REPOWER) (Table 5). However, if the gas price is extremely high, then the gas consumption of this sector decreases significantly, and becomes lower compared to the number we see in the next 12 months. This is partly because by 2030 natural gas-based power plants are less important in the balancing markets than they are today, due to the increasing demand side management, increasing storage capacities (especially batteries) and the higher RES participation in the balancing market.

Germany will give the same shares (~40%) in total Danube Region gas consumption as in 2022/2023. High gas consumption growth is visible in Hungary (due to the new assumed gas-based capacities), in Austria and in Ukraine.

TABLE 5. GAS CONSUMPTION OF POWER PLANTS IN DANUBE REGION COUNTRIES IN THE REFERENCE AND IN EXTREME HIGH GAS PRICE SCENARIO, 2022/2023 AND 2030, TWH/YR

TWh	Modelled	2030 - Reference		2030 - REPOWER	
	2021/2022	Base case	MinGas	Base case	MinGas
AT	13.4	33.2	8.7	26.1	5.3
BA	0.0	0.0	0.0	0.0	0.0
BG	14.7	8.3	3.4	6.0	1.7
CZ	6.1	16.2	4.2	12.9	2.8
DE	84.9	119.9	34.0	107.6	27.3
HR	10.8	9.1	5.5	7.6	4.1
HU	13.0	23.0	7.3	18.4	7.4
MD	0.0	0.5	2.6	0.6	1.9
ME	0.0	0.0	0.0	0.0	0.0
RO	34.8	41.9	11.0	37.0	7.8
RS	6.7	14.4	5.0	12.4	3.2
SI	3.1	1.8	2.8	1.4	2.1
SK	5.9	8.1	2.1	6.3	1.5
UA	0.0	14.4	2.2	14.8	1.7
Total Danube Region	193.4	290.8	88.9	251.1	66.9
Total EU27	941.6	1031.9	369.4	690.9	219.9

Source: EPMM modelling

Table 6 sums up, that on the long run the gas demand reduction potential of the power sector could be also negative, which means the gas consumption of this sector will be higher compared to the situation in 2021/2022. In the Reference-Base case, the total gas consumption increase is 97 TWh, while in the REPOWER-Base case, this increase is 57 TWh. But if we assume that the gas price will remain in a very high price level, then the reduction is positive compared to the modelled situation in 2021/2022 (104 and 126 TWh decrease is visible).

TABLE 6. LONG TERM GAS REDUCTION POTENTIAL IN THE POWER SECTOR, TWH/YR

TWh	Gas consumption	Gas consumption reduction compared to the Modelled 2021/2022			
	Modelled	2030 - Reference		2030 – REPOWER	
	2021/2022	Base case	MinGas	Base case	MinGas
AT	13.4	19.8	-4.7	12.7	-8.1
BA	0.0	0.0	0.0	0.0	0.0
BG	14.7	-6.4	-11.3	-8.7	-13.0
CZ	6.1	10.1	-1.9	6.8	-3.4
DE	84.9	34.9	-50.9	22.7	-57.6
HR	10.8	-1.6	-5.3	-3.1	-6.6
HU	13.0	10.0	-5.6	5.4	-5.5
MD	0.0	0.4	2.5	0.6	1.8
ME	0.0	0.0	0.0	0.0	0.0
RO	34.8	7.1	-23.8	2.2	-27.0
RS	6.7	7.7	-1.7	5.8	-3.5
SI	3.1	-1.3	-0.3	-1.7	-1.0
SK	5.9	2.2	-3.8	0.4	-4.4
UA	0.0	14.3	2.2	14.8	1.7
Total Danube Region	193.4	97.3	-104.6	57.7	-126.6
Total EU27	941.6	90.3	-572.3	-250.7	-721.7

Source: EPMM modelling

3.1.3 POLICY CONCLUSIONS

Short-term gas phase-out potential of the power sector depends to a large extent on the availability of nuclear and hydro plants in the European power system. The reason is, that in the most pessimistic scenario – when the French and German nuclear availability and the hydro availability is low – there is much higher need for gas-based power generation both in the EU and in the Danube Region countries. Both in the Base case and in the MinGas scenario the net import in the Danube Region countries decreases compared to the situation when the availability of hydro and nuclear plants is higher – meaning that the cheaper nuclear and hydro based generation is mostly produced outside the region. The overall gas demand reduction potential in the power sector in the next 12 months (compared to the consumption level in the last 12 months) is 60 to 100 TWh.

Our modelling results show that on the long run, renewables can substitute most of the gas need in the EU27 and phase out coal at the same time. This happens despite the additional flexibility need that comes together with variable renewable capacities. In a renewable dominated future world, where lower gas prices are assumed, there is more room for gas to coal switch when we talk about gas demand reduction. This is true even if we calculate with the already announced coal phase-out plans. The reason is that most of the fossil-based production comes from gas in 2030 in the Base case. The minimum overall gas consumption of the power sector in the Danube Region can be reduced to 67 to 89 TWh from 193 TWh depending on renewable capacity developments.

3.2 INDUSTRY SECTOR DEMAND REDUCTION POTENTIAL

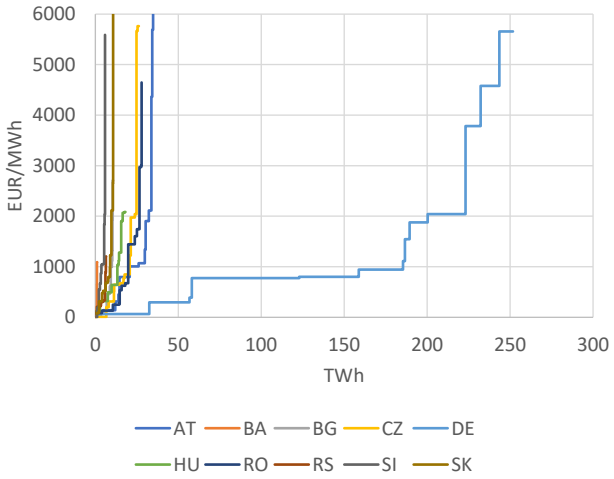
Natural gas accounts for 28% of total final energy consumption of the industry in the Danube Region. Industrial processes use natural gas either as a feedstock or as heat for processes and heating premises. On the short term, industrial gas consumption may only react by curtailing demand and stopping production. Longer term options include energy efficiency investments and fuel switching.

3.2.1 SHORT-TERM GAS CONSUMPTION REDUCTION POTENTIAL IN INDUSTRY

Curtailing industry gas demand means the limiting of production and decreasing industrial output. In many sub-sectors, natural gas is an important part of the production value chain and is needed to generate outputs. We have linked the sub-sectoral gross value added and sub-sectoral natural gas consumption to estimate the economic impact of 1 MWh reduction in gas consumption in each sub-sector of the industry.[14] This allows the definition of a "supply cost curve" for the Danube Region countries, showing how much economic value is not produced by curtailing industry gas demand.

The methodology for assessing the cost of not producing (~curtailment cost) in each sub-sector is calculated as simply dividing the Gross Value Added (GVA) of the sub-sector with the natural gas consumption of the sub-sector. Plotting this value with the gas consumption of the sub-sector, so-called abatement cost curves can be constructed. Figure 23 below shows these curves for the Danube Region countries.

FIGURE 23. CURTAILMENT COST: GROSS VALUE ADDED PER UNIT OF GAS CONSUMED (Y AXIS) AND TOTAL GAS CONSUMPTION (X AXIS) OF THE SUBSECTOR, €/MWH AND TWH



Source: REKK based on Eurostat

Some general observations may be identified based on the plots:

Relative size of the market determines savings potential. The industry in Germany consumes far more natural gas than the industries of the other Danube Region countries (sans Ukraine and Moldova,

[14] The following datasets were linked: Energy balances: consumption of gas by sub-sectors – feedstock (chemical and petrochemical sector) and fuel consumption (TJ/year);
Energy balances: total energy consumption (TJ/year);
National accounts: GVA by industrial subsectors (million EUR/year)

which were omitted for data availability reasons) Curtailment costs shown are extremely costly compared to the wholesale cost of gas. Saving 200 TWh/year in Danube Region industry sector would cost over 750 EUR/MWh. Weighted average curtailment cost of the Danube Region industry is over 1000 EUR/MWh and would result in 400 TWh reduction of gas demand for the Danube Region (Sans UA and MD).

The curtailment cost in each sub-sector and country could serve as an indicator of willingness-to-pay for not shutting down or investing in energy efficiency/fuel switching where possible. This means that industries with lower curtailment costs should react faster and phase out production, while ones with higher curtailment costs are expected to produce even at higher gas prices. Subsectors with low curtailment costs are expected to curtail their consumption first. In the Danube Region countries these sectors were the same, namely:

- Non-metallic minerals
- Paper, pulp and printing
- wood and wood products
- chemical and petrochemical
- iron and steel

Curtailing the whole Danube Region industry would mean the destruction of over 430 Bn€ and the reduction of industry gas demand by 400 TWh. High curtailment costs of the industry sector mean that any kind of energy efficiency investment, process innovation or such saving is worth for the industry. Even though it is rational to cut costs, there may be the problem of missing money and financing for energy efficiency investments. In some cases, natural gas used for processes may not even be replaced with alternatives. Destruction of industrial production has overarching effects on the economy and society and should be avoided.

3.2.2 LONG-TERM REDUCTION POTENTIAL OF THE INDUSTRY

On the long term, industry sector may be able to invest in fuel switching, replace process heat or reduce industry gas demand. The cost of switching is unique for each industrial process and possibilities may even be limited.

Industry heat demand can be categorised by the temperature of heat needed for the process. According to a recent study,[15] 50% of heat needed by industrial processes used low-temperature heat under 150 °C, 19% used medium-temperature heat up to 500 °C and the remaining 36% was high-temperature heat over 500 °C.

Due to the specificity and complexity of sub-sectors and companies, it is not possible to name tools that can be applied to all sectors and all countries. At the same time, there are general technological directions that may play a greater role in the future in the process of replacing gas. Low-temperature heat may easily be replaced with industrial size heat pumps and demand may be curbed by insulation of industrial buildings as well as better use of waste heat. Gas use in high-temperature heat production

[15] Agora Energiewende: Regaining Europe's Energy Sovereignty: 15 Priority Actions for RePowerEU. 253/04-I-2022/EN https://www.agora-energiewende.de/en/publications/regaining-europes-energy-sovereignty/

can replaced with hydrogen or e-gases, or in the short run other fossil fuels. Direct electric solutions may also serve as an option.

The Ukrainian case study of the United Nations Industrial Development Organisation (UNIDO), UN specialised organization whose mandate is to promote industrial development and cooperation, could be presented as an example of enhancing resource efficiency of the industry sector with further gas demand reduction. The project was aimed at reaching the climate change goals of the Paris Agreement and Sustainable Development Goal 9 “Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation” and Goal 12 “Ensure sustainable consumption and production patterns”. The enterprises involved in the project were receiving the onsite services of complex technical assessment under the resource efficient and cleaner production methodology developed by UNIDO. As a result of assessment, the companies were provided with justified solutions to improve their resource efficiency and to decrease the demand of natural gas which was in most cases the main energy source. Participation in the research was voluntary for the companies. 78 companies in 6 regions of Ukraine had participated the UNIDO project and represented the following branches of the industry:

- Wood processing (including furniture production);
- Manufacture of paper, printing;
- Manufacture of textile and leather;
- Construction industry;
- Iron and Steel;
- Manufacture of chemicals and pharmaceuticals;
- Manufacture of machinery;
- Manufacture of food product, beverages;
- Other companies (including services sector: transport, tourism).
- The number of service providers applied to participate in the UNIDO project was 3-4 times higher every year than the number of industrial companies with production sites. Based on this attitude we think that in the case of companies providing services, there is a huge demand for an energy efficiency assessment carried out by outside company professionals and for related consulting work.

Several options aimed at reducing energy efficiency and gas consumption were developed for each company. These options differed in terms of their costs and the savings that could be realized if they were implemented. The gas saving potential of the companies has been recalculated in USD equivalent (using the tariff as well as the currency rate of the year of project implementation) to compare the cost of one option implementation in every branch of industry. Due to the previously mentioned specificity by company and country, the savings values determined during the case study can only be interpreted in the case of specific companies, so they are not presented in the following.

The following general lessons can be drawn on the individual level evaluations of the companies and the developed gas reduction scenarios:

- If the established energy efficiency proposals are implemented, the energy and gas consumption of individual subsectors can be significantly reduced. The amount of savings can differ significantly even for companies belonging to the same sub-sector, if the level of development, modernity, and efficiency of the currently used technology differs. Of course, the savings potential is greater for companies in a worse situation.
- The cheapest saving options were defined in the wood processing, manufacturing of chemicals and machinery. All these branches do not require high-temperature as well as high-pressure pro-cesses. Their potential to be implemented by industrial companies is the highest.
- At the same time to reach the highest level of gas reduction in industry the following branches should be identified as the main contributors: manufacturing of paper and packaging, construction and iron and steel. However, the options of these branches are among the most expensive to implement.

An important general conclusion is that the cost of implementing the savings and the amount of gas thus saved are not necessarily consistent. That is why it is crucial that individual industry players choose among the options aimed at reducing gas consumption in the future, tailored to their own possibilities and needs.

3.2.3 POLICY CONCLUSIONS

In the case of the industrial sector, short-term gas demand reduction may primarily mean limiting production and industrial output, since only a small part of the investments aimed at energy efficiency can be realized in the short term. In this case, the amount of gas not consumed has a negative effect on the GDP of the given sector. If it is absolutely necessary to limit the gas demand of the industrial sector, it is more rational to restrain and limit demand in those sectors where the added value per gas quantity consumed is lower. In the DR countries these sectors were the same:

- Non-metallic minerals;
- Paper, pulp and printing;
- wood and wood products;
- chemical and petrochemical and the
- iron and steel sector.

Reducing the gas consumption of these sectors causes less economic damage overall. However, if there is a gas shortage, the decision-makers must consider the situation: whether they want to ensure gas supply to households or to constrain the gas use of companies, hitting the economy. This trade-off can basically appear in an extreme situation.

In the long term, the gas reduction potential differs significantly between individual countries, sub-sectors and companies, so a general reduction target cannot be determined without the specific situation of the given actor. This sector would need a more thorough analysis in the future, potentially based on interviews and workshops if necessary.

3.3 HOUSEHOLD SECTOR DEMAND REDUCTION POTENTIAL

3.3.1 SHORT TERM GAS CONSUMPTION REDUCTION POTENTIAL OF THE HOUSEHOLDS

Based on the available data of the International Energy Agency (IEA)[16] and historical evidence on the correlation between heating degree days and household sector gas consumption we can estimate that the short-term adjustment of the heating need of households can be mostly adjusted by the indoor temperature that the buildings are heated to. The IEA estimated that about 10 bcm can be saved in Europe if indoor temperature is reduced by 1 Celsius. That is about 2.5% of the yearly gas consumption. The Save gas for a safe winter communication of the Commission in July 2022 suggested to set ceiling temperature on the heating of public buildings and encouraged the households also to take savings seriously. In the Danube Region this has been picked up to different extent by the EU member states. In Germany there are several rules targeting the service sectors heating patterns as well, in other countries the restrictions are only applied to the public buildings (e.g., in Hungary government buildings are not heated above 18 Celsius). A serious limitation to this voluntary temperature reduction is that some countries of the Danube Region are already considered to be underheated, therefore the potential for lowering the temperature without serious public health damages is lower than in Western Europe.

Furthermore, increasing prices gas can also incentivise households to reduce gas consumption by reducing the heated floor area, typically by shutting down the heating in rooms that are not used. In the Danube Region it is also typical that many of the households have secondary heating device in place like a wood stove or furnace. Using these devices can also reduce the gas consumption (fuel substitution). In Moldova it is estimated that about 50% of the households in the countryside have secondary wooden furnace this number is probably much lower in other countries, However, we do not have exact number and reliable statistics on these heating devices.

As we have seen in chapter 2.4 on Prices and price regulation the wholesale price increase is very differently reflected in the household gas prices in the Danube Region. In some countries gas price in October 2022 was above 20 c€/kWh (DE, AT, CZ), while on the other end in some countries household paid around 5 c€/kWh (PL, BA, HR, SK), or even less (RS, UA, HU). Without price signals consumers might not react with effective savings measures. During the summer of 2022 the regulated household prices were increased substantially in Moldova, in Bulgaria and in Hungary (though only for part of the households that consume above a pre-defined average volume).

[16] IEA (2021): What is behind the soaring energy prices and what happens next? Commentary. Paris. doi:https://www.iea.org/commentaries/what-is-behind-soaring-energy-prices-and-what-happens-next

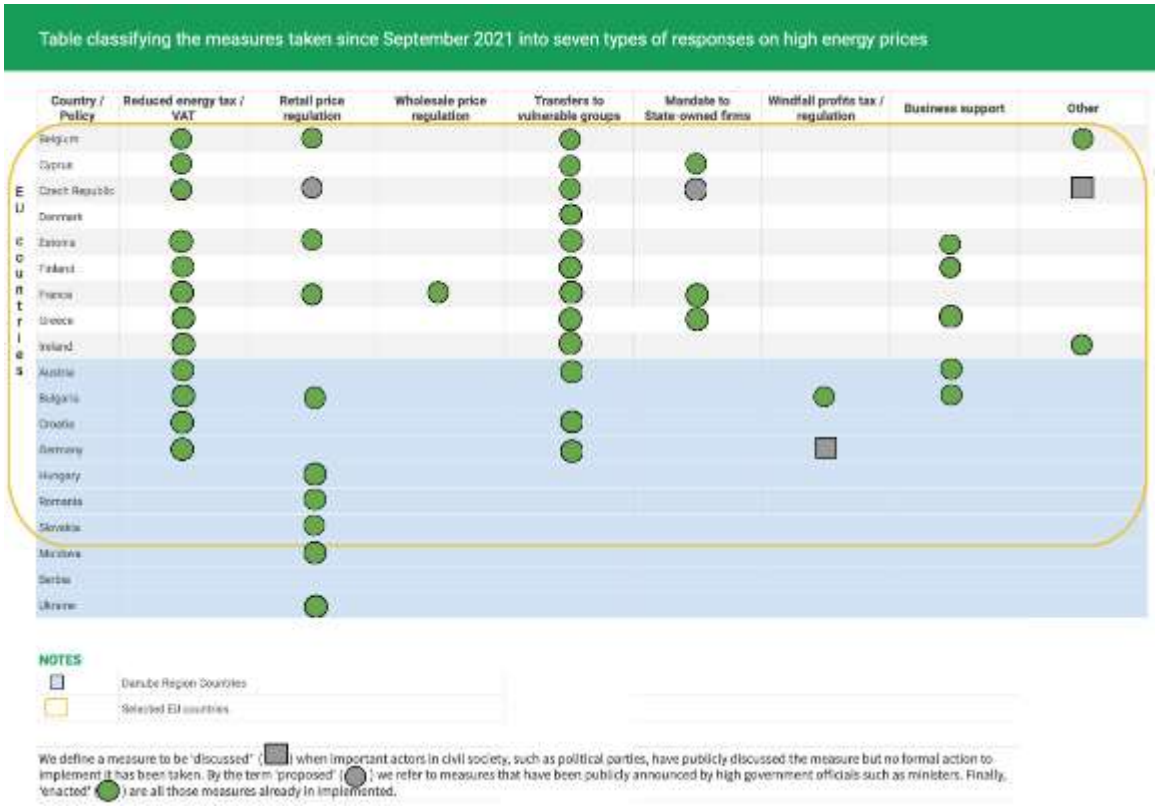
The European commission left it to the national governments to incentivise or regulate the gas consumption reduction. The actual demand reduction in the EU27 for the first half of 2022 was -10% according to Eurostat. This was achieved without any significant reduction of the gas consumption of the power sector. We know that in the summer most of the reduction came from the industry, but in Q1 2022 the building sector also contributed significantly in countries where price signal was strong. E.g. in Belgium in January and February of 2022, when the first wave of energy price increase hit in a -7% demand reduction was measured by one of the distribution system operators (DSOs) for the building sector.

There are programmes and initiatives to reduce gas consumption also referring directly in the public communication to the need to reduce Russian so that gas payments shall not finance Russian war on Ukraine. At the same time there are other regulatory measures that work in the opposite direction. We collected the policy measures that were taken in the Danube Region countries to mitigate the high gas prices for the vulnerable consumer groups between January 2021- August 2022, The categorization of the measures follows the methods used by the Bruegel Institute.[17] The table shows that the most widely used measures to protect the vulnerable consumer groups from the increasing energy prices are the reductions in the VAT and direct transfers.

The national level interventions (to reduce the financial burden for consumers) are more typical to EU countries compared to the Danube Region countries. Moreover, the measures applied in the EU countries are more diverse and complex including taxes regulation, subsidies to the low-income groups, and business support, meanwhile the majority of the Danube Region countries are implementing the retail price regulation (see Figure 24). The EU countries show high level of cooperation sharing their experiences in reducing the influence of the increasing energy prices with each other (see the Bruegel example). The enhancement of the international cooperation in the Danube Region following the example of EU could lead to elaboration of the effective long-term solutions to support the consumers and minimise the negative impact of the energy crisis but also the measures to prepare for emergency or to effectively reduce gas prices.

[17] Sgaravatti, G., S. Tagliapietra, G. Zachmann (2021) 'National policies to shield consumers from rising energy prices', Bruegel Datasets, first published 4 November 2021, available at https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices

FIGURE 24. MEASURES TAKEN BY EU27 AND DANUBE REGION COUNTRIES SINCE SEPTEMBER 2021 TO MITIGATE HIGH ENERGY PRICES



Source: Bruegel

The above described factors and mixed incentives will result in probably very different reactions from the households in their winter consumption in 2022/23, but on average we can expect an overall decrease of 2.5-7%.

3.3.2 LONG TERM GAS CONSUMPTION REDUCTION POTENTIAL OF THE HOUSEHOLDS

On the long term the investment into the building stock must start with a renovation wave. The building stock in the Danube Region, especially without Germany and Austria is in a much worst condition than in Western Europe. According to literature a deep renovation can save up to 50% of the energy need of a building, depending on its age and original condition. Further investment into electrification of the heating could theoretically phase out natural gas fully from the building sector. On the time horizon of this study – that is 2030 – we do not consider it realistic from implementation point of view nor economically rational to achieve this goal. But a well-planned and politically supported building heating strategy on gas consumption reduction is a very important corner stone. We assume that at least a 15% demand reduction can be achieved in the Danube Region in the long run, as envisaged by the European Commission in its Save gas for a safe winter communication.

4 CASE STUDIES ON ADRESSING THE GAS CRISIS IN THE DANUBE REGION

Danube Region countries do not have a uniform standpoint towards Russian gas phase out and the standpoints might change over time. A snapshot based on announcements of the countries between February to July 2022 is provided in Annex 1 of this report. During the data collection phase of this study in summer 2022 a questionnaire was compiled with the intention to carry out interviews with key stakeholders of the Danube Region on the tools and measures they intend to introduce to reduce their (Russian) gas dependencies. We found that the responsiveness to such inquiry was very limited, probably the questions were too early to pose, or the stakeholders were too busy to handle the short-term security of supply challenges. Therefore, we decided to provide desk research-based case studies on selected countries.

The following case studies show the Ukrainian situation that is special due to the extreme war situation. As Moldova has been identified in the first chapter of the study as being the most vulnerable, a case study has been dedicated to the measures and efforts of Moldova to prepare for the next winter. Two countries were selected on the other end of the spectrum: Austria and Germany are being well interconnected and having huge gas storage capacities. Still their measures taken to reduce gas dependency and to prepare for the next winter can serve as models for other Danube Region countries as well.

4.1 UKRAINE CASE STUDY

It's more than half a year since Russia's invasion of the territory of Ukraine started. The fighting will probably drag on for many months yet. Ukraine has put everything into strengthening its defensive efforts. Meanwhile, the economic and energy security should be stable to guarantee a strong back for the defence forces and ability to survive for the citizens of Ukraine.

The government of Ukraine is struggling to stabilise the campaign on the preparation for the 2022-2023 heating season. The CEO "Naftogaz of Ukraine" has shared the information about the shortage of natural gas in the storages of Ukraine that will lead to the decrease of the period of the 2022-2023 heating season in days and also the indoor temperature in the residential houses will not be higher then +17+18 degrees Celsius (for the insulated houses).

Since the beginning of the Russian invasion, oil and gas companies have been under constant shelling and have suffered damage due to destroyed infrastructure. The Regulator has prohibited the publication of energy information for security reasons, thus the process of initial data searching has become more challenging. The plans to repair the gas and heating infrastructure are approved and ready for implementation and the activities on the strengthening of the gas supply security are ongoing.

The works on enhancement of logistics and supply security for domestic coal have been started despite the announcements on implementing the European Green Deal for Ukrainian energy sector. To maintain the district heating system with the minimal needed temperature for its performance and given the shortage of gas Ukraine will use 1.83 million tons of coal which have already been accumulated in thermal power plants, combined heat and power plants and storage facilities. 12 billion cubic meters of gas have been pumped in relevant storage facilities (August 2022). The Ministry for Communities and Territories Development of Ukraine has noted that indicator of readiness of facilities for the heating season 2022-2023 as of 1 August 2022 is 60%.

The price of natural gas and district heating services is regulated by the state in Ukraine. Resuming from the Cabinet of Ministers of Ukraine decree No.812 dated 19 July 2022:

- the price for gas will be fixed for district heating companies and communal enterprises for the period from 1 August 2022 till 31 March 2023.
- the district heating companies which supply heat and hot water to residential buildings will pay price $201.65 per 1000 m3 (excluding transportation); communal enterprises will pay price $445.41 per 1000 m3 (excluding transportation); all other consumers will pay price $1041.53 per 1000 m3 (excluding transportation), the exchange rate used for calculations is 36.80 UAH per $1 as of 1 August 2022.

The gas and coal export ban has been implemented for the period of military activities in Ukraine according to the decision of the Cabinet of Ministers of Ukraine. The consumption of the industrial companies has decreased by 40% due to the war. Reduced consumption as well as the export ban have led to the oil and gas companies' inability to sell 100% of their gas. At the same time the Ukraine's daily natural gas production has decreased by 12% (as of 11 April 2022 compared to 23 February 2022).

The Minister of Energy of Ukraine has claimed the possibility of providing 50% of Ukraine's Underground Gas Storage capacities (15 bcm) for EU needs. The facilities are located in the western Ukraine away from military actions.

Many Ukrainian cities have been faced with the difficulties in restoring of the centralised heat supply where large thermal plants were destroyed. As a quick decision the modular boiler houses (15000 families) will be built with application of generators of electricity and water purifiers. Some cities like Lviv (Western Ukraine) have decided to use stoves with storages of wood and wooden pellets. The prices for wood and pellets have increased exponentially in Ukraine during the last year.

The Ministry of Energy of Ukraine has claimed that the decarbonisation plan for Ukraine will also become a part of the post-war recovery: Ukrainian energy mix will be represented with newly built RES capacities (growth from 1% in the base year to 5% in 2032) including hydropower; newly built RES for hydrogen production (8.6 toe in 2023); the full-fledged market of biofuel is also going to be created (growth from 5% in the base year to 10% in 2032).

The basis of the energy mix defined by Ukraine's National Recovery Plan is represented by nuclear power (36%), natural gas (26%) and oil (11%). These figures are planned to be reached in 2023. Number of nuclear power units to be built using AP1000 technology in Ukraine will be increased from 5 to 9 in 2032. The decision on nuclear power is questionable even more now as the active phase of war is still ongoing. The security for the energy supply is difficult to guarantee for the existing nuclear reactors and the process of securing the nuclear power facilities should be formalised and approved before construction of the new reactors. The Ministry of Energy of Ukraine has presented the nuclear and gas energy as a carbon-neutral without consideration of the emissions for the whole life cycle including delivery of the raw materials and utilisation.

The Ukraine’s National Recovery Plan presented by the National Recovery Council at the Lugano Ukraine Recovery Conference in July 2022 has included the European Green Deal terminology into the projects.

National programs	Critical projects	Funding needs, $bn
1. Defense and security	• Secure critical military supplies and needs	15-20[4]
2. EU integration	• Continue systematic effort on synchronization of Ukraine's legislation with Copenhagen criteria	<0.1
3. Re-build clean and safe environment	• Launch massive demining effort (up to 5% of UA territory in 2022) • Secure military waste utilization	1-2
4. Energy independence and Green Deal	• Power: prepare blocks for max. availability during winter, incl. mothballed gas blocks • Switch to biomass and biogas for district heating, where possible • Launch Energy Efficiency program (see Program #10) • Push work on interconnect extension (power, oil products) • Build-up gas reserves in storages (working capital)	~5-10

Source: National Programmes of the Ukraine's National Recovery Plan, July 2022

The critical projects are focusing on the natural gas in the power sector with the significantly smaller allocation of the biomass and biogas (mentioning "where possible" the National Recovery Council has indicated the lack of possibility to build up the new biogas/biomass capacities. There are up to 3 small existing projects using biogas/biomass in the power sector in the northern Ukraine).

In the energy efficiency sphere: the transition to the EU practices in the field of energy audit, energy management and eco-design has begun. The launch of the Energy Efficiency programme has been mentioned in the Ukraine's National Recovery Plan. The programme includes the following components:

- Energy efficiency improvement of buildings;
- Modernisation and optimisation of heating systems (district and individual);
- Modernisation and optimisation of heat distribution network;
- New housing in accordance with the best practices for urban planning;
- Capital repairs of housing stock;
- Piloting near-zero energy buildings and centralised cooling;
- Modernisation and electrification of urban transport;
- Improvement of infrastructure of coal mining "monocities".

4.2 MOLDOVA CASE STUDY

Moldova is highly exposed to the effects of the energy crisis because the role of natural gas is very important in all sectors and the sole supply source was Russia. To mitigate the impact of the crisis a Government Committee was set up to prepare for the 2022-2023 heating season. The Committee's plan includes measures to reduce gas consumption with and without supply curtailments, and specific preparation for 35%, 50% and 100% supply limitation scenarios.

According to state secretary Constantin Borosan[18] with all measures applied approximately 477 million m^3 can be saved or substituted in the 2022-23 heating season out of 1.2 bcm, and these measures do not contain the disconnection of all interruptible consumers and the involvement of alternative supply sources.

The planned measures are the following:

[18] Constantin Borosan (05.10.2022): Mitigating Crisis Effect Presentation on the 17th Gas Forum in Ljubljana, https://www.energy-community.org/dam/jcr:43676a09-b99c-4c53-8f1f-8d2a13f05a56/17GF_crisis_Moldova_1022.pdf
Constantin Borosan (04.10.2022) Winter Preparedness in Moldova, Presentation on teh 17th Gas Forum in Ljubljana https://www.energy-community.org/dam/jcr:61c830b2-2dac-4892-b7c3-ef2a35558a1c/17GF_Winter_Moldova_1022.pdf

- informing the citizens about how to reduce gas consumption,
- incentivizing to switch to firewood instead of gas,
- reduction of heating agent temperature in centralized heat supply systems,
- switching JSC “Termoelectrica” and heating plants of two sugar factories to alternative fuel (oil), this alone could save 264 million m^3 natural gas in the next heating season
- ensure maximum amount of operational balancing account limit at interconnection points.

A fund is created to help to cover energy bills and to subsidise replacement of obsolete appliances for those who are recorded in the register of energy vulnerability (managed by Labour and Social Protection Ministry). It is also under consideration to implement a mechanism through which the available amount of gas is distributed at different prices to buyers with different social backgrounds.

The law regulating the natural gas market was modified and now includes the provision of the creation and maintenance of security reserve of at least 10 days of winter consumption (55-60 million m^3). Additional amendments of the law provide responsibilities to the National Regulator to allow them to react immediately in emergency situations on the gas market.

To help supply diversification the national energy company will obtain all authorizations to start natural gas trading to reach new sources and supply routes, for example the company already entered the Romanian wholesale electricity and natural gas markets. The creation of security reserves and supply diversification is supported by a loan agreement of 300 million € between Moldova and the EBRD.

4.3 GERMANY CASE STUDY

Germany was selected as a good example of quick response to the gas emergency at the governmental level as well as complex support for the consumers implementing the subsidies and tax reduction for different vulnerable groups. The legal acts which were elaborated for the gas shortage conditions are supporting the energy market first and the governmental regulation would take control of the market in the critical situation only.

As a result of the coalition committee on the Package of the Federal Government to deal with the high energy costs (dated March 23, 2022) it was proposed to replace a large portion of natural gas by renewable gases including domestic green gases as an energy source, to build up the hydrogen economy including international supply partnerships. Germany has identified the target of increasing the import of climate-neutral hydrogen and its derivatives. The role of biomass is going to increase intensively starting from the support of methane production to feeding it into greed. Among the energy efficiency targets the most perspective are the following: promoting energy saving measures, increasing energy efficiency standards for new buildings, making every new heating system installed powered by 65% RES, heat pump campaign, federal programme on replacing heating systems more than 20 y.o.; comprehensive municipal heat planning system. The government is aiming to achieve at least 50% climate-neutral district heating by 2030.

New regulations applicable from September 2022 include efficiency measures in the residential heating sector and restrictions on lighting of shop windows, monuments and outside of public buildings. Office buildings should not heat areas like corridors, only cold water will come from water taps in these buildings, also maximum temperatures are defined for workplaces depending on physical activity (usually 19 degrees instead of 20). Private shops have to carefully close their doors and windows to avoid warm escaping. Contractual minimum temperatures in rented flats are no longer obligatory to uphold.

The Federal Ministry for Economic Affairs and Climate Action announced the early warning level of the Emergency Plan for Gas in March 2022, and the alert level has been announced in June 2022. The security of supply continues to be ensured despite the shortage of the volumes going to Germany through the Nord Stream 1. The Government asked the operators to fill their storage facilities up to 95% before November 1, 2022.

To increase the security of energy supply the Federal Government supports the procurement of LNG, pushes for the rapid approval of LNG terminals, supporting filling of gas storage facilities and all opportunities to increase the natural gas procurement in all countries except Russia for the near-term.

Urgent action is needed and despite the European Green Deal strategy the exception was made for coal. Germany is going to step back from the coal refusal, reducing gas consumption for electricity generation by keeping coal-fired power plants. This decision will act in the short-term because of the lack of immediate access to energy supply based on RES and green gases.

The proposed measures by the state have included the reduction of re-export of natural gas in case of shortage of it for German customers during the heating season 2022-2023. The countries which are receiving the natural gas from Germany (Poland, Czech Republic and Switzerland) should have the backup strategy if Germany's re-export would be decreased or stopped. Nevertheless, the EU countries have decided to coordinate their efforts on reduction of natural gas with each other and the risks are under control. In the industrial sector the process of auctions for the unused gas has been introduced to provide compensation for those actors that are willing to cut back gas usage. The industrial consumers and suppliers can attend the auctions to propose the unused volumes of gas and to cover the part of demand on the energy market. Freed-up gas through this procedure will be filled in the storages.

To ensure customer (low-income and middle-income household customers and customers providing essential social services) security the Federal Government will be providing support with subsidies for the energy resources.

The Federal Government has defined the steps of the energy crisis management and the roles of crisis managers. TSOs, Market Area Managers and the Federal Network Agency designate crisis managers with responsibility for acting at crisis level and communicate this information to the Federal Ministry for Economic Affairs and Energy. An interdisciplinary crisis team advises and supports the Federal Ministry for Economic Affairs and Energy ahead of and during a crisis. The position of Chair is filled by the Federal Ministry for Economic Affairs and Energy. The Federal Network Agency acts as the Deputy.

Three crisis levels were defined in the country with respective actions to be taken:

- **Early warning level** (already announced): European internal market rules continue to apply in full.
- **Alert level**: Gas undertakings continue to guarantee the supply of natural gas pursuant; **TSOs** – will submit timely situation reports in writing to the Federal Ministry for Economic Affairs and Energy at least once a day.
- **Emergency level**: the Federal Network Agency, as the federal load distributor, or the Länder as load distributors, undertake sovereign measures in accordance with the **Ordinance to Ensure the Supply of Gas in a Supply Crisis**; the aim is to ensure grid stability, paying particular attention to protected customers, vital needs, and the minimisation of consequential damage.

At the first two levels the responsible market players act on their own responsibility to overcome the supply bottlenecks with their own set of tools, particularly as defined in the Energy Industry Act.

4.4 AUSTRIA CASE STUDY

Austria has clear understanding that the industrial development is crucial for their economic growth and the processes on the energy market would influence the industry most. In parallel with tax reduction and climate bonus initiatives Austrian government introduced strong crisis support for the industrial production sites.

In February 2022 the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology presented the methodology "Climate-neutral industry: Paths toward clean, competitive manufacturing". The industrial sector of the country has the second largest GDP share in the economic structure and is the biggest consumer of energy resources. Therefore, the dominant role in increasing of energy efficiency and decarbonisation was given to industry. The decision to separate the industrial processes and enhance its energy efficiency and energy security one by one where possible had been made. The governmental strategies for industrial sector in Austria focus on increasing energy efficiency, promoting the electrification and decarbonization of processes, supporting climate-neutral and climate-friendly processes, and creating the conditions for a circular economy. These steps are also effective in the long term in reducing the role of natural gas within the industry.

The acceleration of industrial decarbonization is supported by several recently launched platforms and programs, such as the Net-Zero Industries Mission (NZI), which was launched jointly with Australia in 2022 to mobilise investments to drive forward the development of key technologies for the complete decarbonisation of industry, and the New Energy for Industry (NEFI) network, which aims to make energy-intensive industries carbon neutral in 2025.

In addition, in the short term, it is crucial for the industrial sector to ensure an alternative supply of gas in order to maintain operations. To ensure this, the Austrian vertically integrated gas supplier OMV has booked 40 TWh (45% of consumption) transport capacities from Norway (natural gas) and Italy (liquified natural gas) for October 2022-September 2023. The main goal was to minimise gas dependency from Russia and to diversify the energy sources.

In order to maintain the security of the energy supply in the short-term, from August 2022 the government had allowed the Austrian companies to use the gas storage capacity at Haidach that went unused by Russian company Gazprom. Thus, Austria has increased its potential to store natural gas, the overall commercially available storage capacity has increased to 95.5 TWh.

At the same time, the federal government has lifted all restrictions on power stations fired by fossil fuel in June 2022. Austria decided to immediately withdraw the restriction on production for coal-fired power stations. This decision is not in line with the decarbonisation goals of the country. However, the option was presented as a temporary one and the 2030 coal exit date is not in doubt at all. In addition to increasing the security of energy supply, Austria has also taken periodic measures to protect consumers, which are targeted at vulnerable consumers and the affected companies. In the newly introduced Energy Relief Packages due to the energy crisis, energy cost compensation is provided for households, as well as energy consulting and pilot projects for energy-poor households and small and medium size enterprises.

5 MODELLING OF GAS SUPPLY REDUCTION SCENARIOS

5.1 CALIBRATING THE REFERENCE CASE AND MODELLING THE SUPPLY CUT

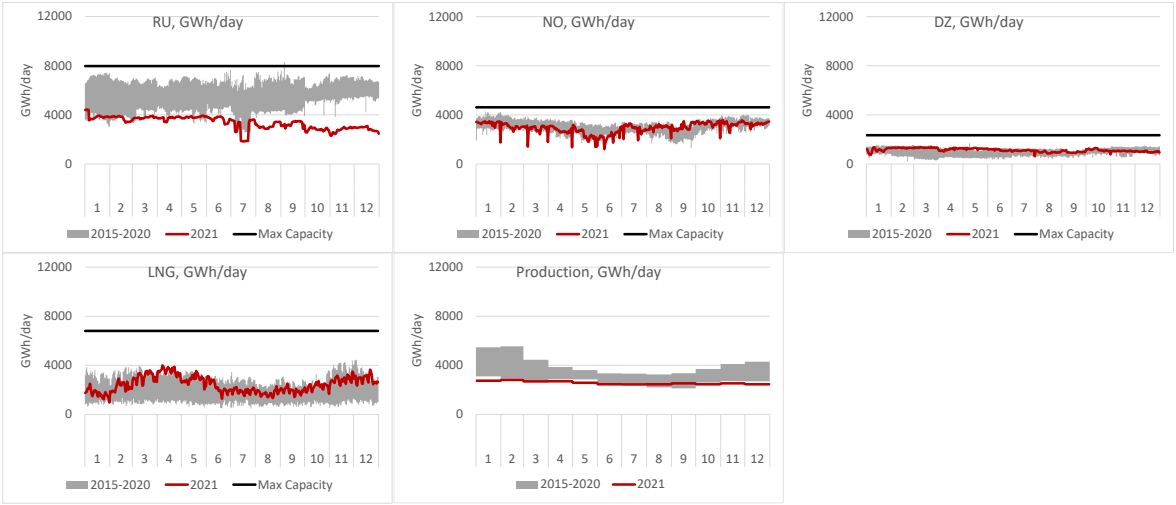
Supply side alternatives to Russian gas are assessed using the European Gas Market Model (EGMM). EGMM considers pipeline, LNG, storage and other infrastructural and contractual, regulatory constraints when modelling the interconnected European gas market. Geographical coverage of the model is the EU27, plus Energy Community (EnC) contracting parties, Switzerland, UK, Turkey and the Caucasus. The model simulates one gas year, made up of 12 consecutive months.

Model inputs need to be calibrated to represent the reality as close as possible, to allow for the current simulation and evaluation of proposed measures. We have chosen to calibrate our model to three main characteristics of the gas market:

- Represent the supply structure of 2021 in the EU27
- Simulate the demand level of 2021 in the EU27
- Result in price levels indicative of H2 2021

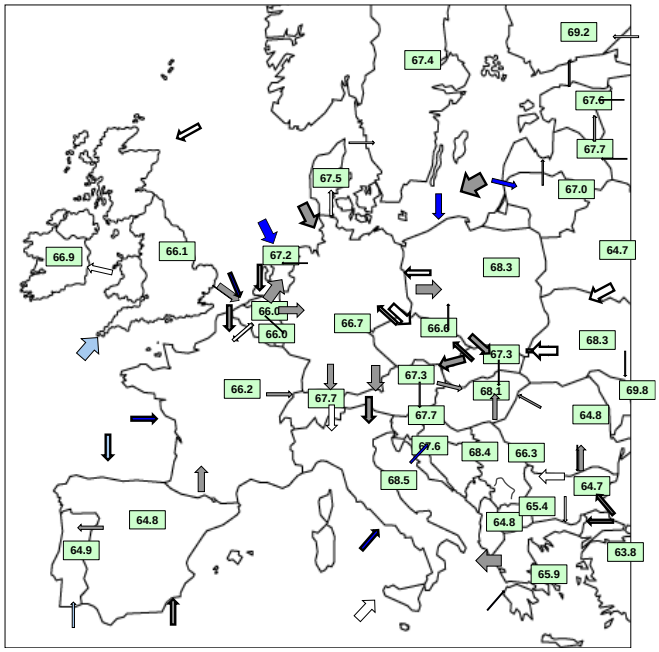
In the second half of 2021, Russian gas deliveries to the EU were considerably below the available capacities and the historical shipped volumes. Norwegian pipeline supplies and increased LNG volumes could not offset the loss of these. (Figure 25)

FIGURE 25. HISTORICAL FLOWS AND UTILISATION OF MAIN SUPPLIES TO EUROPE



The reference case is calibrated to represent the 2021 gas year, reflecting the demand and supply structure of the EU27 and price levels of 65-70 EUR/MWh indicative of H2 2021. We assumed tight LNG markets and high Asian gas demand as a reference case. The modelled prices in the reference scenario are shown in Figure 26.

FIGURE 26. 2021 MODELLED GAS MARKET REFERENCE CASE, €/MWH

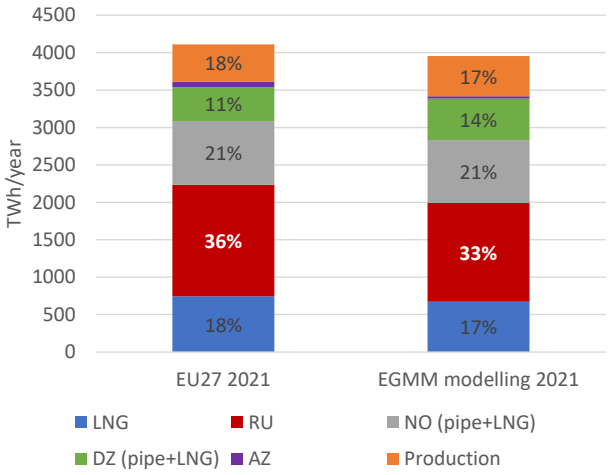


Note: Boxes show the average annual wholesale gas price. Arrows show gas flows, dark grey and blue arrows represent congestion on the infrastructure in at least one month

Source: EGMM

The modelled supply structure of the EU27 was compared to the supply structure reported by the European Commission in its Q4 Quarterly Report on the European gas market[19]. It is apparent that the model simulation fits the 2021 reference, hence the calibrated reference case can be used as a basis for comparison. (Figure 27)

FIGURE 27. ACTUAL AND MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES, TWH/YEAR



Source: REKK modelling and EU Quarterly report. NO and DZ sources include pipeline and LNG volumes.

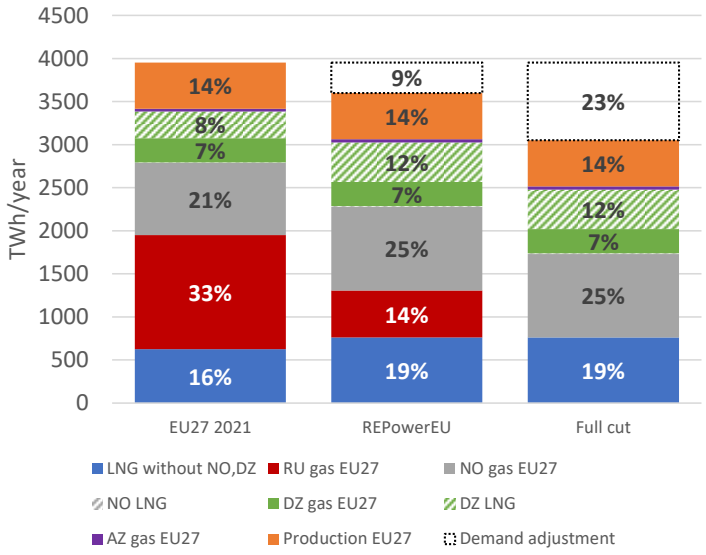
[19] Market Observatory for Energy DG Energy. (2021). Quarterly Report on European gas markets With focus on 2021, an extraordinary year on the European and global gas markets. Volume 14(Issue 4).

As a second step, two curtailment scenarios for the Russian gas are introduced. The curtailment is performed for the full modelled year, in all months:

- In the Repower Europe Communication[20] (REPowerEU) scenario, 55 bcm of Russian gas is allowed in the EU27, as suggested by the policy document.
- In the full cut scenario, no Russian gas is allowed to be delivered to the EU27.

Figure 28 shows the supply structure of the EU27 and the needed demand adjustment in the scenarios. The modelling finds an equilibrium solution in all cases, but with higher prices and lower demand compared to the no curtailment case.

FIGURE 28. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE CURTAILMENT SCENARIOS, TWH/YEAR



Source: EGMM

The results show that the LNG and Norwegian pipeline gas may substitute the missing Russian volumes to a certain extent on the supply side. However, significant reduction in annual demand is needed to keep up the supply-demand balance of the gas market. Implementing a 55 bcm/yr (as set in the REPowerEU) constraint on Russian gas would force Europe to curtail 355 TWh or 9% of current demand. A complete cessation would lead to a demand decrease of 900 TWh or 23% of current demand.

5.2 MODELLING THE SHORT-TERM EFFECT OF SUPPLY AND DEMAND SIDE MEASURES

As a next step, in case of REPowerEU and no deliveries from Russia scenarios, we modelled the effect of the following supply side measures the EU can apply in the short-term to mitigate the potential negative effects of decreased gas supply from Russia:

1. Infrastructure scenario 1 lists all possible pipeline and LNG investment which can be realised **by this winter**. This includes:

[20] European Commission. (2022a. March 08). REPowerEU: Joint European Action for more affordable, secure and sustainable energy. COM(2022) 108 final. Forrás: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1511

- the Polish-Lithuanian interconnector (GIPL) – commissioned 1 May 2022
- the Baltic Pipe, which will allow transporting of gas from Norway to the Danish and Polish market, - planned 1 Oct 2022
- IGB connecting Bulgaria and Greece – planned 1 July 2022
- The Croatian-Slovenian interconnector to resolve internal bottlenecks and enable the LNG flows into the interior parts of Europe – partly implemented since Jan 2019 ongoing extension

2. In Infrastructure scenario 2, additional infrastructure to be commissioned **within one year**
   - 3 LNG terminals in Germany: FSRU, floating storage and regasification unit which can be re-directed to other markets (e.g. South America) and creates no stranded assets on the long term – planned 2023
   - Reverse flow on UK-NL and FR-DE pipelines – not planned
   - Reverse flow on Trans-Balkan pipeline system from Bulgaria to Ukraine – partly implemented, additional capacity planned but no date yet
3. Production scenario envisages additional EU27 natural gas or renewable gas production, altogether +78 TWh/year
   - Partly re-opening the Groningen field in the Netherlands
   - Doubling the Danish offshore gas production (Tyra platform)
   - Up-scaling biogas and biomethane generation in Germany
4. Combination of infrastructure and production scenarios
   - Infrastructure 2 scenario is combined with the production scenario

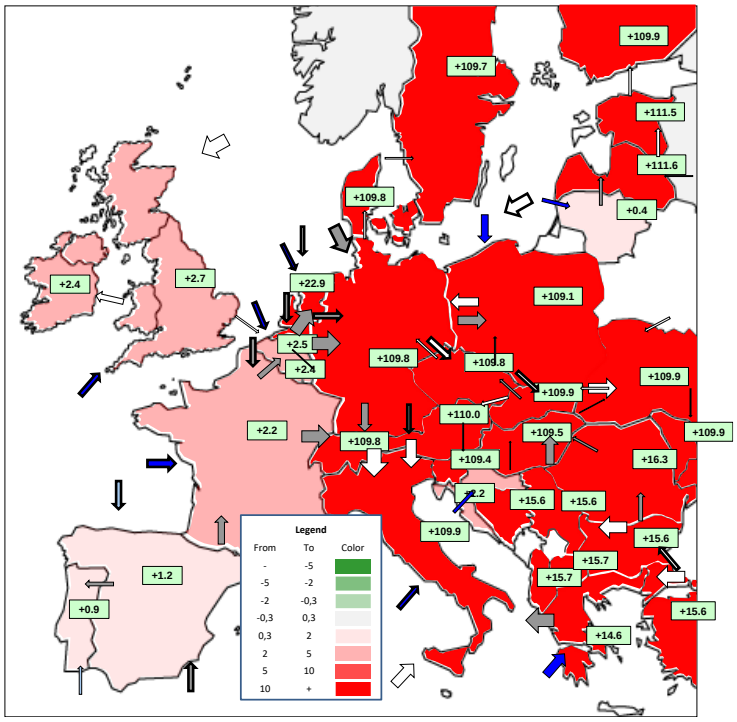
5.2.1 REPOWER EUROPE SCENARIO

5.2.1.1 WITHOUT ANY EUROPEAN RESPONSE OR MEASURES

Without any EU-side measures introduced, European gas markets would disintegrate to regional markets. Countries with access to LNG would have less severe price increase than the ones without. Western Europe including the Iberian Peninsula, France, Benelux and UK would experience no considerable change in price levels. The Central Eastern European (CEE) region including countries East to the Germany-Switzerland-Italy line would see a price increase of ~110 EUR/MWh on average. Prices in the Balkans are closer to Western Europe than CEE, owing to low demand, LNG from the south, and Azeri supplies via the Trans Adriatic Pipeline (TAP). (Figure 29)

LNG terminals capacity usage is limited by internal bottlenecks (e.g. UK, Iberian Peninsula, FR-DE). Consumers in the Danube Region would be paying +119% more for the natural gas consumed and using up 194 TWh less than in the 2021 reference case.

FIGURE 29. ANNUAL AVERAGE WHOLESALE GAS PRICE CHANGE IN THE REPOWEREU SCENARIO COMPARED TO 2021 MODELLED REFERENCE, €/MWH

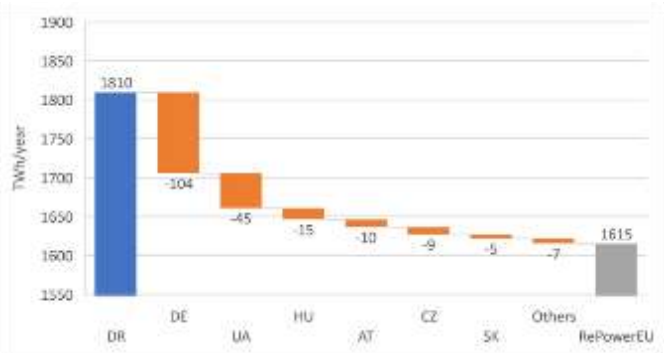


Note: The green boxes show the €/MWh price change in the REPowerEU scenario compared to reference. The blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

The largest demand adjustment is related to Germany (-104 TWh) and Ukraine (-45 TWh), followed by countries of the CEE Region. (Figure 30)

FIGURE 30. DEMAND ADJUSTMENT IN THE REPOWEREU SCENARIO PER COUNTRY, COMPARED TO REFERENCE, TWH/YEAR

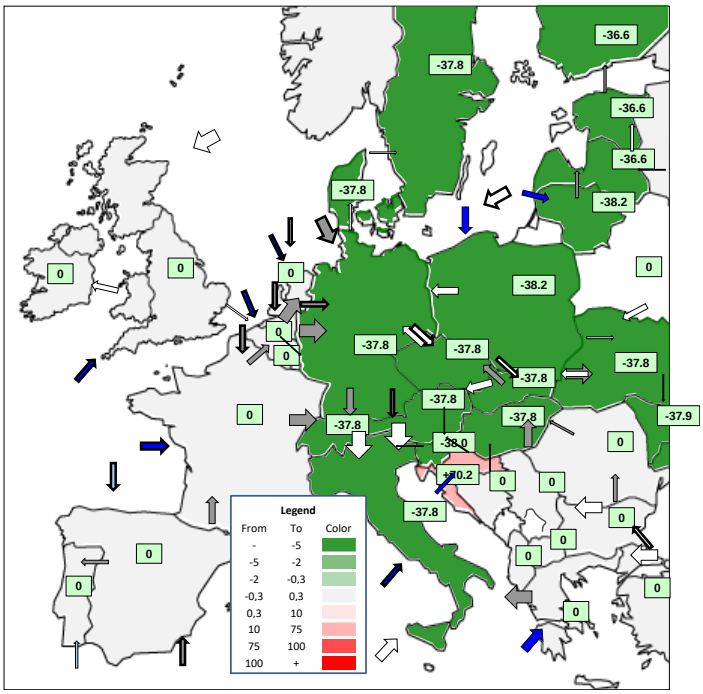


Source: EGMM

5.2.1.2 SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE 1 (BY 2022/23)

As a next step, we illustrate and compare the price effect of all measures in the REPowerEU scenario (55 bcm), and in the no Russian supply scenario. Not surprisingly, the measures have the most effective price effect in those countries that suffered more from the shortage of Russian gas. Hence, Balkan part of the Danube Region is much less impacted than countries in the CEE Region.

FIGURE 31. PRICE EFFECT OF SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE (INFRA 1) COMPARED TO REPOWEREU SCENARIO WITHOUT MEASURES, €/MWH

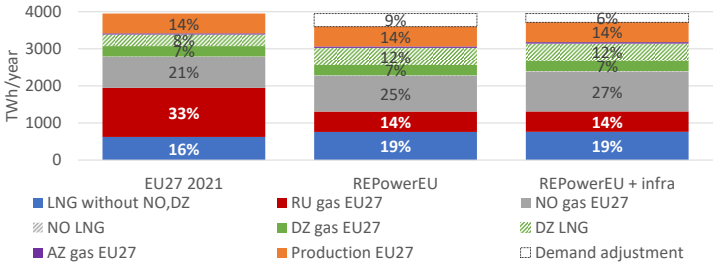


Note: The green boxes show the €/MWh price change attributable to the infrastructure (Infra 1) investments, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

Short-term adjustment of infrastructure has a significant price effect (-38 €/MWh) in CEE countries compared to the no measure scenario, but this price is still significantly higher (+75 €/MWh) than in the reference scenario. Countries in the Balkan are not affected by this scenario. (Figure 31)

FIGURE 32. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, REPOWEREU SCENARIO AND THE REPOWEREU SCENARIO WITH INFRASTURE 1 MEASURE, TWH/YEAR



Source: EGMM

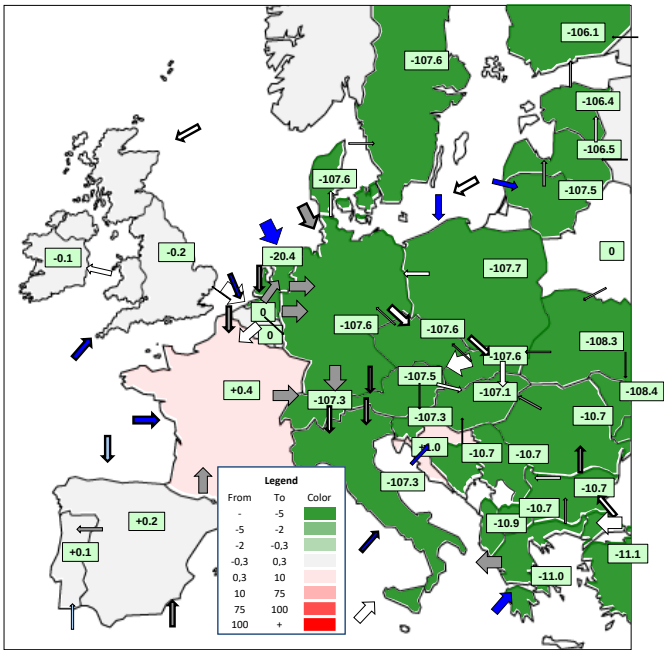
Due to the new infrastructure, the share of Russian gas further decreases compared to the REPowerEU scenario, compensated by an increase of Norwegian sources (due to Baltic Pipe) and LNG. (Figure 32)

5.2.1.3 SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE 2 (BY THE GAS YEAR 2023/24)

Infrastructure scenario 2 has a similar, but more significant effect due to the new LNG terminals and reverse flows: prices in Germany and CEE countries decrease with 108 €/MWh to the price level of reference scenario, while in the Balkan countries price decrease is much more modest (~11 €/MWh).

Figure 33 also shows that price convergence due to new infrastructure may increase prices for some countries.

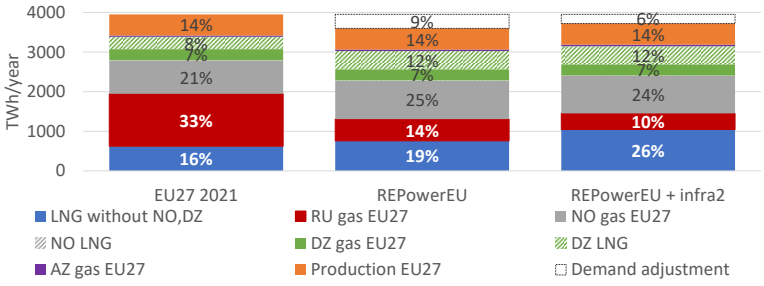
FIGURE 33. PRICE EFFECT OF SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE (INFRA 2) COMPARED TO REPOWEREU SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to the infrastructure (Infra 2) investments, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 34. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, REPOWEREU SCENARIO AND THE REPOWEREU SCENARIO WITH INFRASTURE 2 MEASURE, TWH/YEAR



Source: EGMM

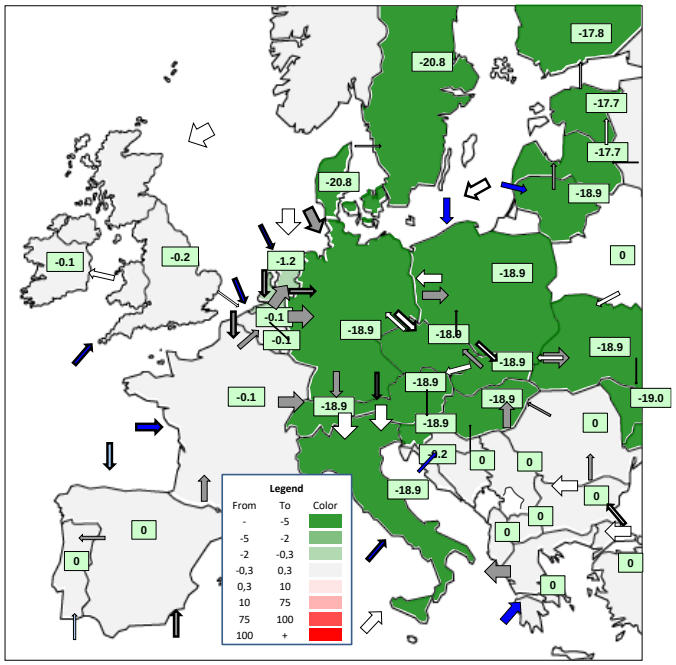
Due to new LNG terminals in Germany LNG deliveries to Europe increase significantly resulting in further decreasing Russian deliveries and lower demand compared to the REPowerEU scenario. (Figure 34)

5.2.1.4 ADDITIONAL EUROPEAN PRODUCTION

Additional European production available in short term has a modest price effect: -19€/MWh in Western Danube Region countries, while prices in the Balkan do not change apparently. (Figure 35)

In the supply structure the domestic production – be that natural gas or RES gases – would substitute Russian gas hence would reduce Russian gas dependency and allow for slightly higher consumption of gas. (Figure 36)

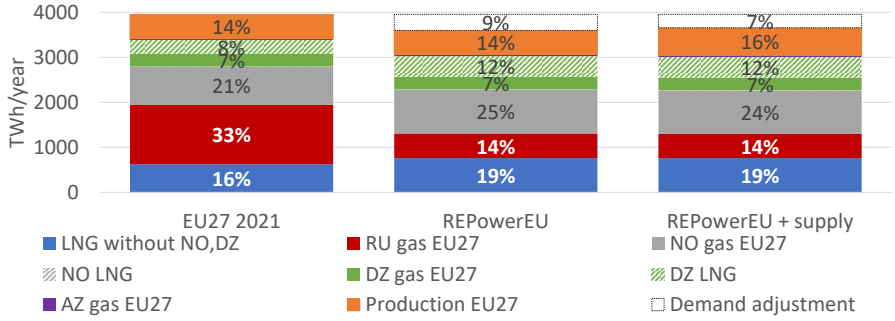
FIGURE 35. PRICE EFFECT OF ADDITIONAL EUROPEAN PRODUCTION (PRODUCTION) COMPARED TO REPOWEREU SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to additional production, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 36. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, REPOWEREU SCENARIO AND THE REPOWEREU SCENARIO WITH ADDITIONAL PRODUCTION MEASURE, TWH/YEAR



Source: EGMM

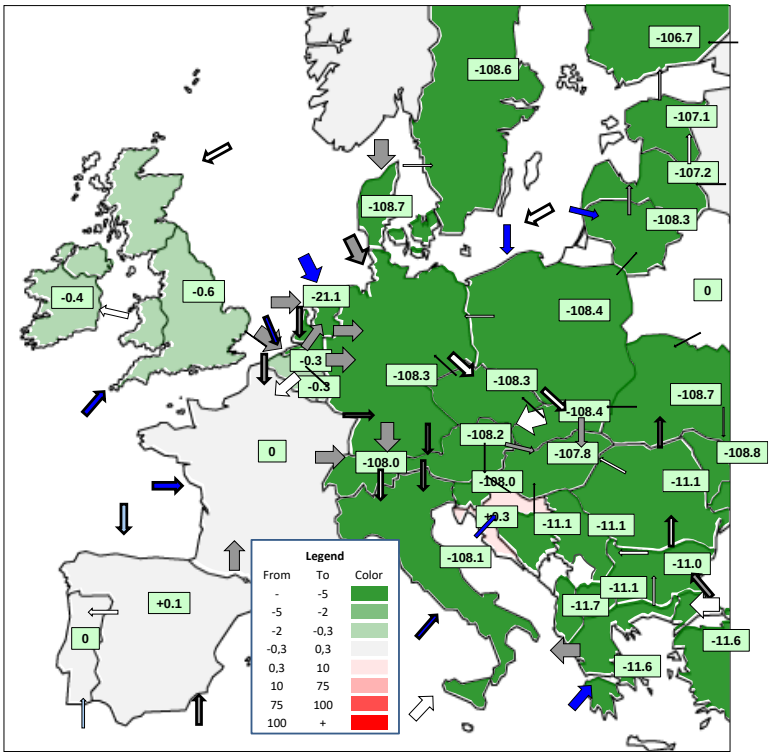
5.2.1.5 COMBINED SUPPLY MEASURES

Price effect of combined measures is very similar to the effect of scenario Infrastructure 2 meaning that additional production does not really have significant additional effect. (Figure 37 and Figure 38)

Based on the supply side measure modelling of the REPowerEU scenario we can conclude, that the infrastructure investments already decided before 2021 - mainly PCI projects from the 4th list with substantial EU funding sources from the Connecting Europe Facility - help to mitigate the effect of reduced Russian gas supplies to a large extent. However, the additional infrastructure decided in 2022 – mainly the German LNG terminals) are very much needed to help LNG reaching the Danube Region. Compared to the LNG sources that are available on the global market the volume and the impact of

additional EU natural gas production and increased production of RES gases is negligible but has important role to play in terms of reducing import dependency.

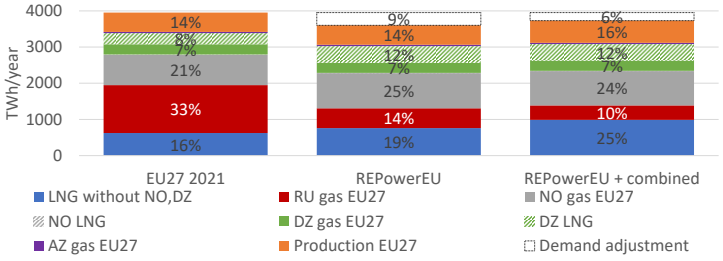
FIGURE 37. PRICE EFFECT OF COMBINED MEASURES (INFRA 2+PRODUCTION) COMPARED TO REPOWEREU SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to the combined supply measures, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 38. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, REPOWEREU SCENARIO AND THE REPOWEREU SCENARIO WITH COMBINED MEASURES, TWH/YEAR



Source: EGMM

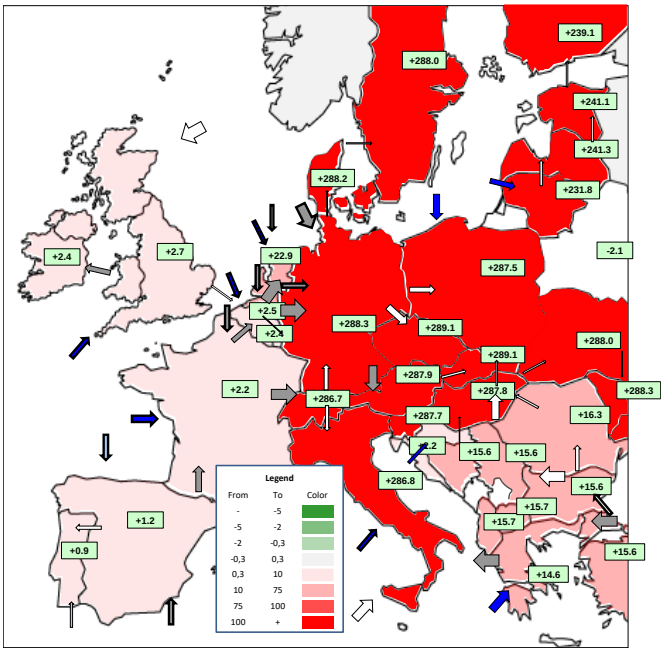
5.2.2 FULL RUSSIAN CUT SCENARIO

5.2.2.1 WITHOUT ANY MEASURES

Without any EU-side measures introduced, European gas markets would disintegrate to regional markets. Countries with access to LNG would have less severe price increase than the ones without. Western Europe including the Iberian Peninsula, France, Benelux and UK would experience no considerable change in price levels. The CEE region including countries East to the Germany-Switzerland-Italy line would see a price increase of ~290 EUR/MWh on average. Prices in the Balkans are closer to Western

Europe than CEE, owing to low demand, LNG from the south, and Azeri supplies via the Trans Adriatic Pipeline (TAP). (Figure 39)LNG terminals capacity usage is limited by internal bottlenecks (e.g. UK, Iberian Peninsula, FR-DE). Danube Region consumers would be paying +234% more for the natural gas consumed, and using up 500 TWh less than in the 2021 reference case.

FIGURE 39. ANNUAL AVERAGE WHOLESALE GAS PRICE CHANGE IN THE FULL RUSSIAN CUT SCENARIO COMPARED TO 2021 MODELLED REFERENCE, €/MWH

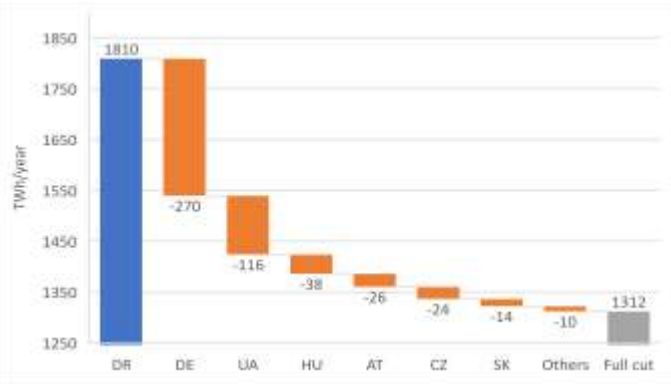


Note: The green boxes show the €/MWh price increase in case of full cut scenario compared to the reference, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

The demand adjustment is related to Germany (-270 TWh), Ukraine (-116 TWh) and the CEE region (~100 TWh overall). (Figure 40)

FIGURE 40. DEMAND ADJUSTMENT IN THE FULL RUSSIAN CUT SCENARIO PER COUNTRY, COMPARED TO REFERENCE, TWH/YEAR

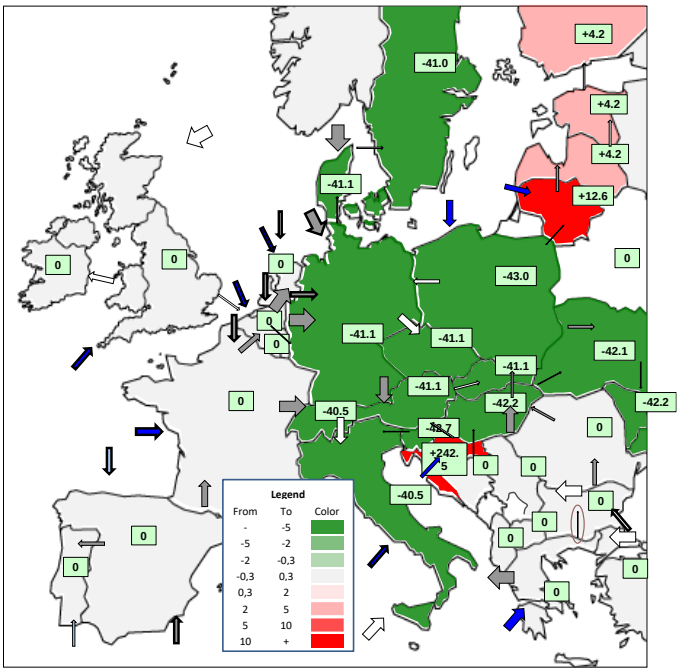


Source: EGMM

5.2.2.2 SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE 1 (BY THIS WINTER)

Due to infrastructure 1 scenario we can see 40 EUR/MWh price decrease in CEE compared to full cut scenario. However, these prices are still much higher (~250 €/MWh) than we experienced in the reference scenario. On the other hand, prices on Balkans are not affected. (Figure 41 and Figure 42)

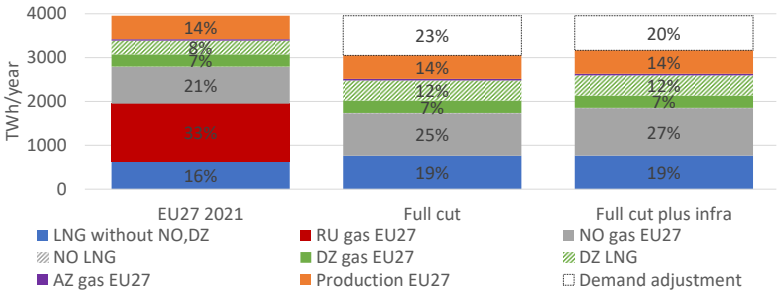
FIGURE 41. PRICE EFFECT OF SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE (INFRA 1) COMPARED TO FULL CUT SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to the infrastructure (Infra 1) investments, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 42. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, FULL CUT SCENARIO AND THE FULL CUT SCENARIO WITH INFRASTURE 1 MEASURE, TWH/YEAR

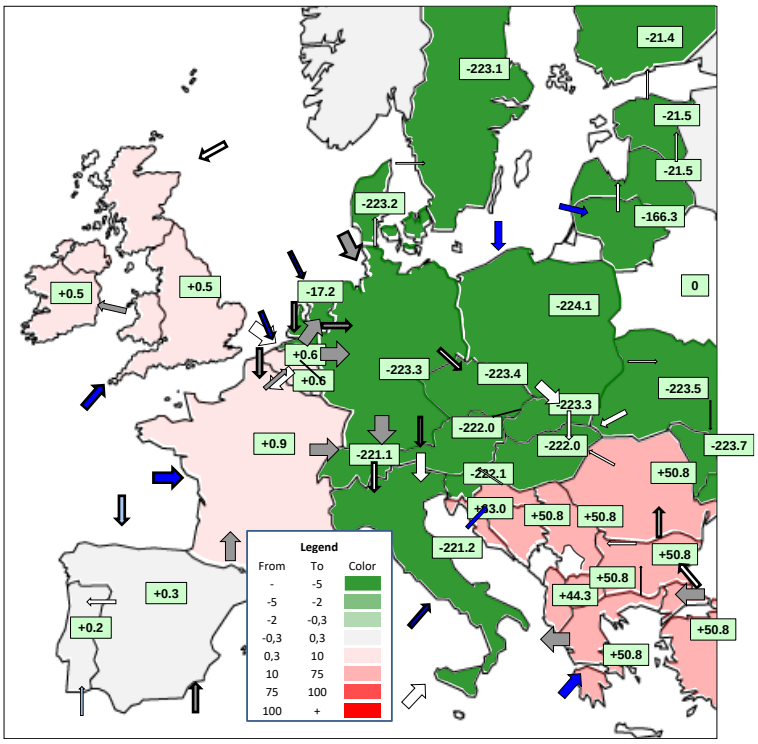


Source: EGMM

5.2.2.3 SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE 2 (WITHIN ONE YEAR)

Prices in Germany and CEE countries decrease by around 220 €/MWh, but this price level is still significantly (with 65 €/MWh) higher than in the 2021 reference scenario. while in the Balkan countries price decrease is much more modest (~11 €/MWh). Parallelly, price convergence due to reverse flow on the Trans-Balkan results in price increase in Balkan countries. (Figure 43)

FIGURE 43. PRICE EFFECT OF SHORT-TERM ADJUSTMENT OF INFRASTRUCTURE (INFRA 2) COMPARED TO FULL CUT SCENARIO WITHOUT MEASURES, €/MWH

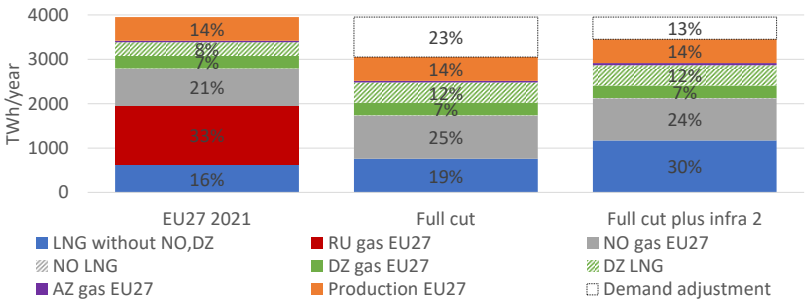


Note: The green boxes show the €/MWh price change attributable to the infrastructure (Infra 2) investments, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

Due to new LNG terminals in Germany LNG deliveries to Europe increase significantly leading to a significantly lower demand adjustment – 13% instead of 23 % in the without measures full cut scenario. (Figure 44)

FIGURE 44. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, FULL CUT SCENARIO AND THE FULL CUT SCENARIO WITH INFRASTURE 2 MEASURE, TWH/YEAR

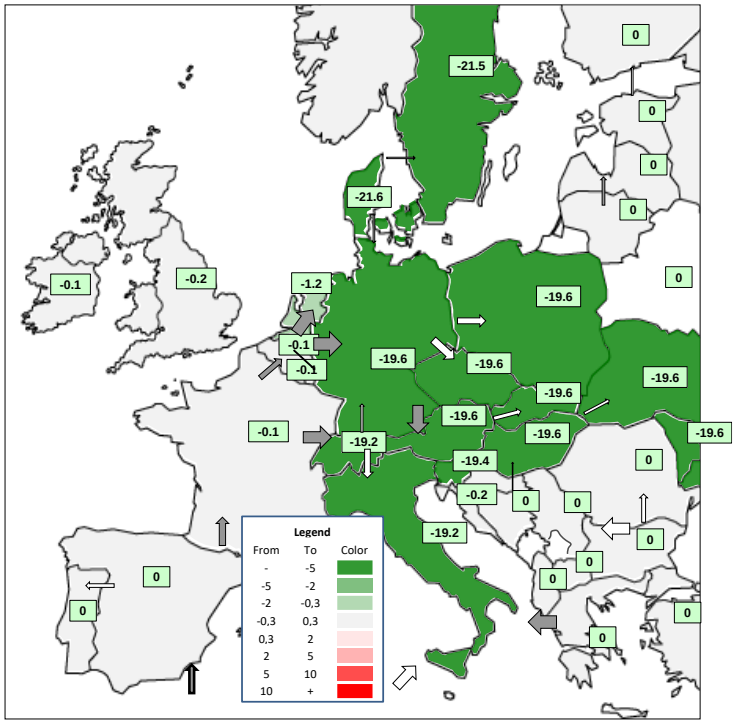


Source: EGMM

5.2.2.4 ADDITIONAL EUROPEAN PRODUCTION

Additional European production available in short term has a modest price effect also in the case if there are no Russian deliveries to Europe: -19.5 €/MWh in Western Danube Region countries, while prices in the Balkan do not change apparently. (Figure 45) The impact of the increased production on the supply mix is limited. (Figure 46)

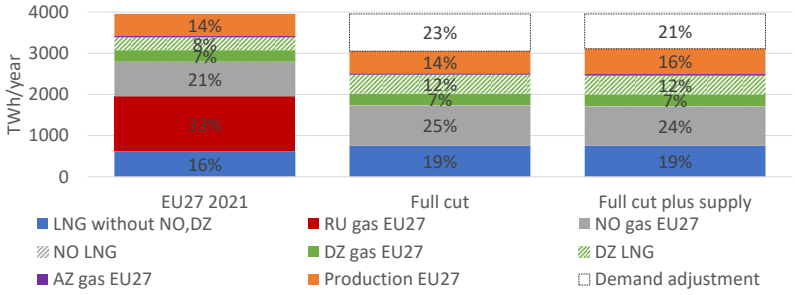
FIGURE 45. PRICE EFFECT OF ADDITIONAL EUROPEAN PRODUCTION (PRODUCTION) COMPARED TO FULL CUT SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to the additional production, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 46. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, FULL CUT SCENARIO AND THE FULL CUT SCENARIO WITH ADDITIONAL PRODUCTION MEASURE, TWH/YEAR



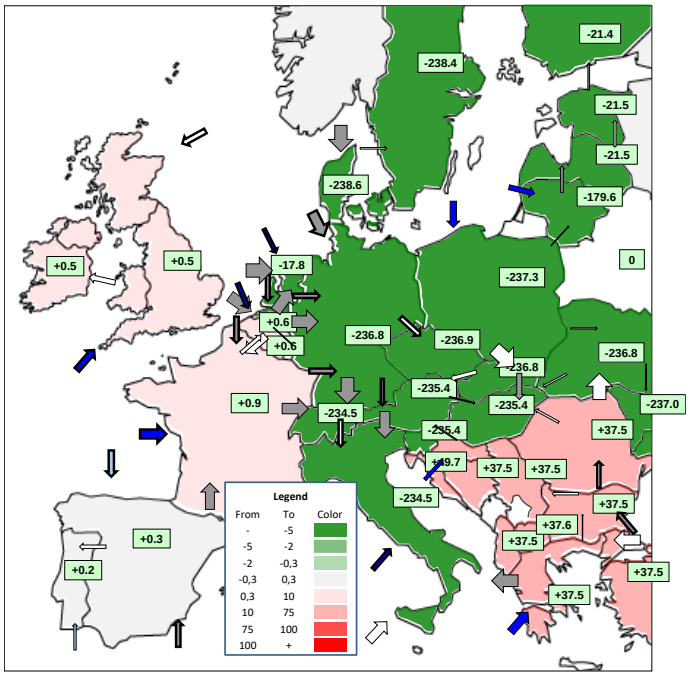
Source: EGMM

5.2.2.5 COMBINED SUPPLY MEASURES

Price effect of combined measures is very similar to the effect of scenario Infrastructure 2 meaning that additional production does not really have significant additional effect.

Based on the supply side measure modelling of the Full cut scenario we can conclude, that the infrastructure investments already decided before 2021 - mainly PCI projects from the 4th list with substantial EU funding sources from the Connecting Europe Facility - help to mitigate the effect of reduced Russian gas supplies to a large extent. However, the additional infrastructure decided in 2022 – mainly the German LNG terminals) are very much needed to help LNG reaching the Danube Region. Compared to the LNG sources that are available on the global market the volume and the impact of additional EU natural gas production and increased production of RES gases is negligible.(Figure 47 and Figure 48)

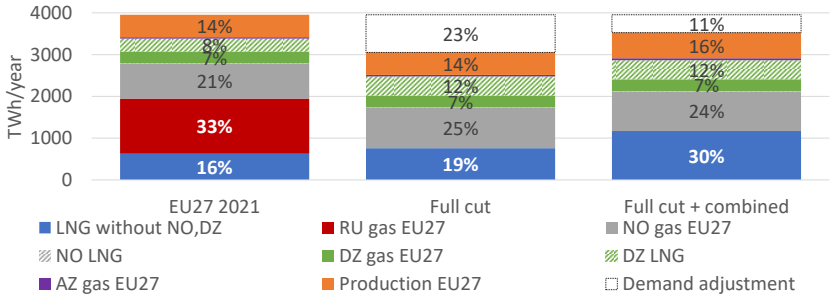
FIGURE 47. PRICE EFFECT OF COMBINED MEASURES (INFRA 2+PRODUCTION) COMPARED TO FULL CUT SCENARIO WITHOUT MEASURES, €/MWH



Note: The green boxes show the €/MWh price change attributable to the combined measures, the blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

FIGURE 48. MODELLED NATURAL GAS SUPPLY STRUCTURE AND CONSUMPTION OF THE EU27 BY MAIN SOURCES IN THE 2021 REFERENCE, FULL CUT SCENARIO AND THE FULL CUT SCENARIO WITH COMBINED MEASURES, TWH/YEAR



Source: EGMM

5.2.3 COMPARISON OF ALL MEASURES

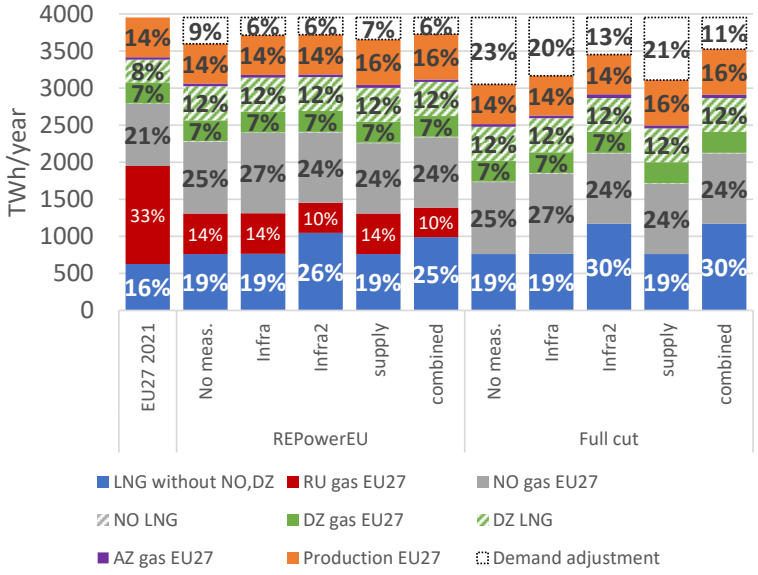
In case of REPowerEU assumptions, when Russian gas is still in the supply mix up to about 55 bcm/yr the supply measure scenarios can further reduce the quantity of Russian gas, while other sources (Norway, LNG) are increased to at least partly substitute it. There is a much more severe problem, when Russian gas drops out from the supply mix fully. In this case the missing volumes can only partly be substituted by other sources.

Figure 49 shows that in most scenarios demand reduction is also needed to get in balance:

- Demand adjustment is 23% in a full cut scenario.
- Realisation of 2022 projects may ease demand adjustment to 20% in the full cut scenario (mainly Baltic Pipe).

- Realisation of additional infrastructure (LNG terminals in DE) further decreases demand adjustment to 13%.
- Increasing production in Europe has limited effect, but comparable to 2022 projects.

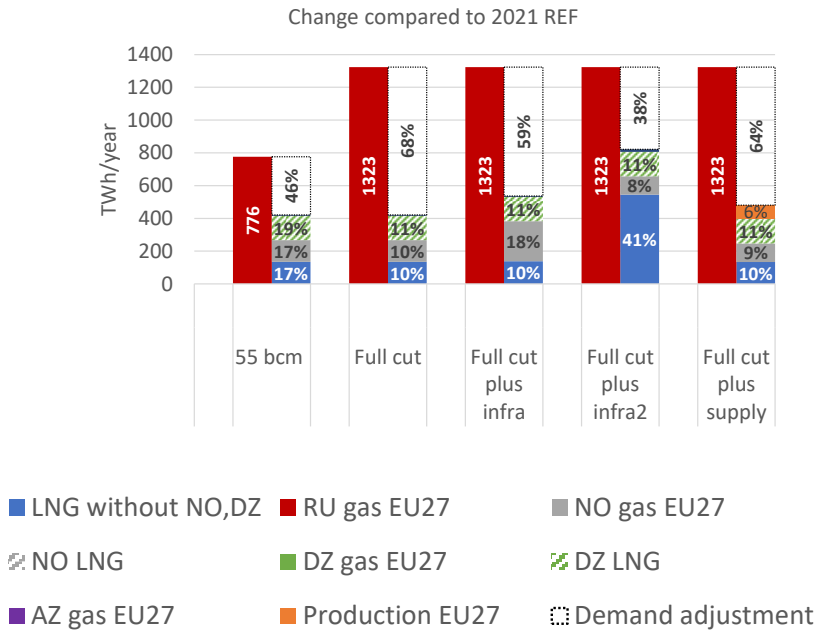
FIGURE 49. COMPARISON OF SUPPLY STRUCTURE SCENARIOS, % AND TWH/YR



Source: EGMM

Figure 50 shows the results of the modelling in comparison to the missing Russian volumes. The demand adjustment percentage is present in all cases, meaning that especially in the full Russian cut scenarios the supply side mitigation measures, building more infrastructure and increasing domestic gas production up to the technical limits cannot fully substitute the missing Russian gas volumes.

FIGURE 50. CHANGE IN SUPPLY STRUCTURE AND MITIGATION OPTIONS FOR MISSING RUSSIAN GAS SUPPLY, % AND TWH/YEAR

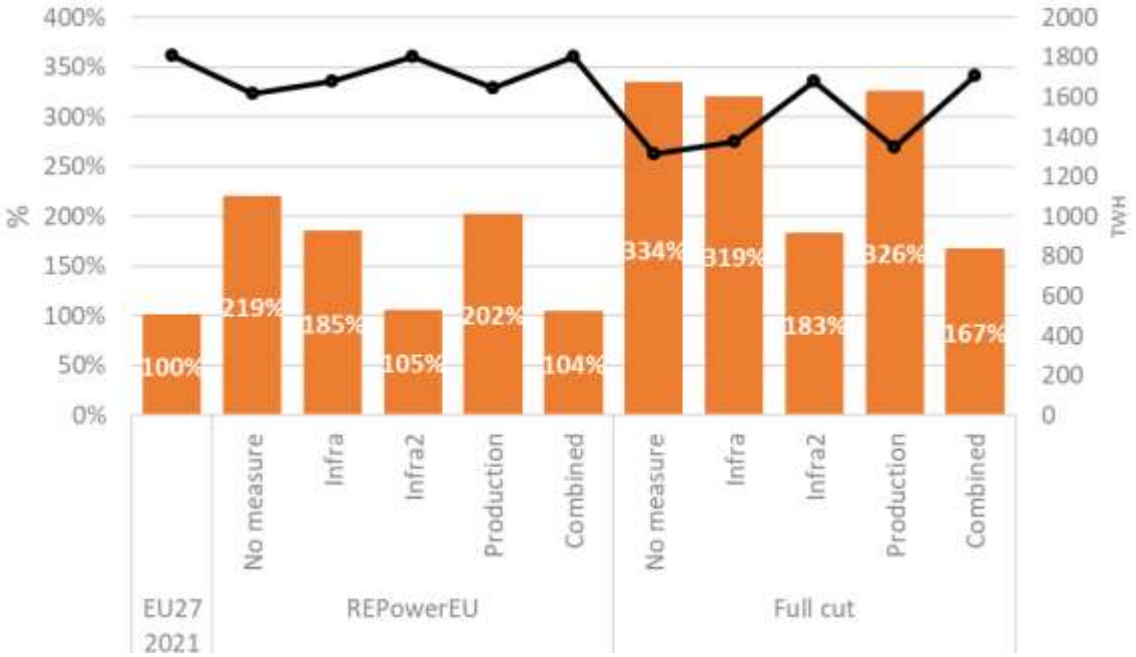


Source: EGMM

Figure 51 illustrates how the potential measures affect the overall gas bill of the Danube Region countries in case of both the constrained Russian supply and zero Russian deliveries (2021 Reference Danube Region gas bill is considered as 100%). Overall, the region pays less for gas if there are Russian sales in all scenarios.

The available additional domestic production and short-term new infrastructure (Infrastructure 1 scenario) can only slightly decrease the Danube Region gas bill in both the REPowerEU and full cut cases. The commissioning of all the assumed new infrastructure (Infrastructure 2 scenario) has a more significant effect since it allows additional sources to enter the European market and also release important capacity constraints (e.g. France-Germany reverse flow) which help LNG to reach more markets. The combined scenario can result in almost the same, significant reduction of the Danube Region gas bill. Applying these measures together can cut down the region's gas bill to its reference level where Russian gas is not constrained in case of the REPowerEU scenario, but remains higher in case of the full cut scenario.

FIGURE 51. COMPARISON OF DANUBE REGION GAS BILL AND CONSUMPTION, % AND TWH



Source: EGMM

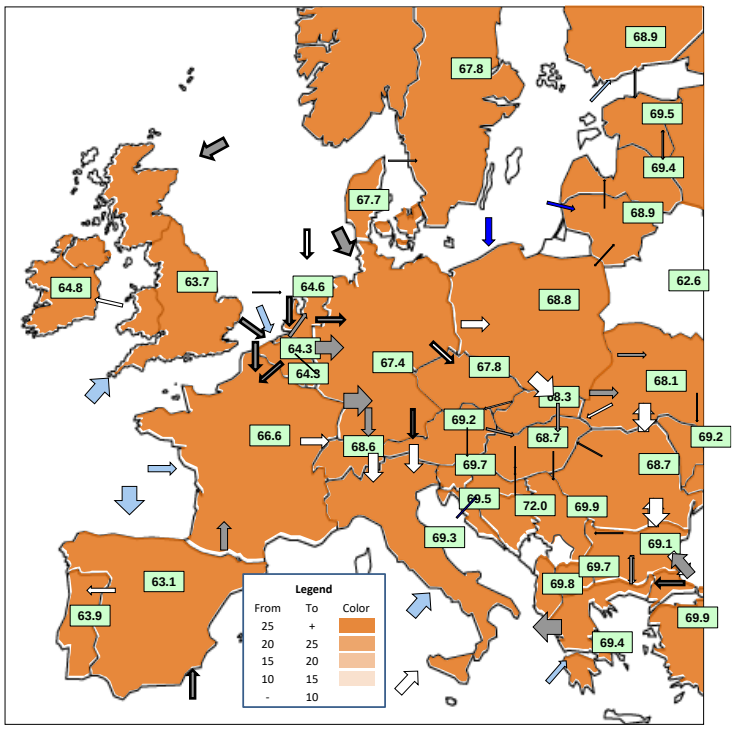
We can conclude that the Danube Region is more vulnerable to Russian supply cut than the EU overall. Central and Eastern European countries (including Germany) would face the highest prices due to the internal bottlenecks that prevent LNG from moving west to east and reaching these markets. Without any additional supply side measures the overall gas bill in the Danube Region would increase by 119% in case of REPowerEU and by 234% in case of full cut scenario. Infrastructure 2 and combined measures can compensate the effect of decreased Russian deliveries in REPowerEU scenario not only in EU, but also in the Danube Region countries. In case of the full cut of Russian supplies however not even the combined measures are enough to mitigate these negative effects.

5.3 LONG TERM OUTLOOK

In order to access the long-term effect of gas demand reduction on gas markets of Danube Region countries we started from the market setup of full Russian cut in 2022, but we added all the additional supply sources and new infrastructure elements that we analysed in section X and assumed that Europe may reach already in the short run. As a potential additional source to the Danube Region, we also assumed that the contracted gas from Azerbaijan is doubled to 20 bcm. Concerning the potential LNG sources we calculate the market outcomes besides different LNG prices in Japan, assuming both high Asian gas demand, hence tight LNG market is Europe and wide LNG supply in Europe. On the demand side we assumed the demand reduction aim published in the REPowerEU strategy, hence we assumed that the demand decreases by 20 percent in all EU and Danube Region countries. Hence, we supposed that Energy Community contracting parties will also implement this rule and will decrease their demand with the same proportion.

Figure 52 below illustrate the yearly average wholesale gas prices in the modelled countries assuming two different Japanese prices (75 and 150 EUR/MWh). We found that contrary to the market situation in 2022-23 when in case of a full Russian cut European gas markets would disintegrate to regional markets, by 2030 the big price differences between regions disappear. This can be explained by the significant demand reduction and supply measures assumed that Europe would introduce in short term. We found that a 75 EUR/MWh Japanese price would result in 67-69 EUR/MW price in the Danube Region countries. Prices are a bit higher in the Balkan countries probably due to the higher demand and prices in the neighbouring Turkey (where we did not assume a demand decrease). Although with limited congestion on some pipeline from West to East the price difference between these regions is minimal. It is also worth noting that due to significant demand decrease LNG terminals are not fully used despite of zero deliveries from Russia.

FIGURE 52. WHOLESALE ANNUAL PRICES, EUR/MWH, 2030, JAPANESE PRICE IS 75 EUR/MWH

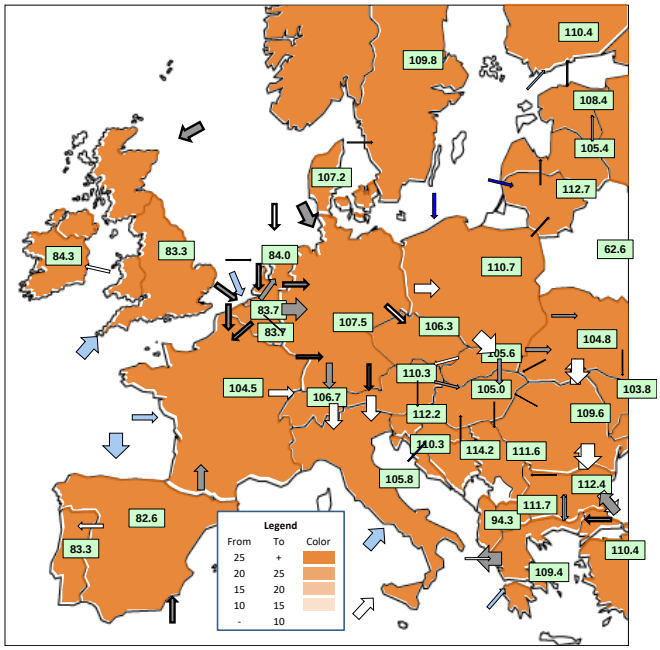


Note: The green boxes show the yearly average wholesale prices (€/MWh) in 2030 assuming 75€/MWh Japanese price. The blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

Figure 53 show that in case of very high Japanese prices the price difference between Western European countries increases: while for example the price in the Netherlands is 84 EUR/MWh in some Danube region countries it is more than 110 EUR/MWh.

FIGURE 53. WHOLESALE ANNUAL PRICES, EUR/MWH, 2030, JAPANESE PRICE IS 150 EUR/MWH

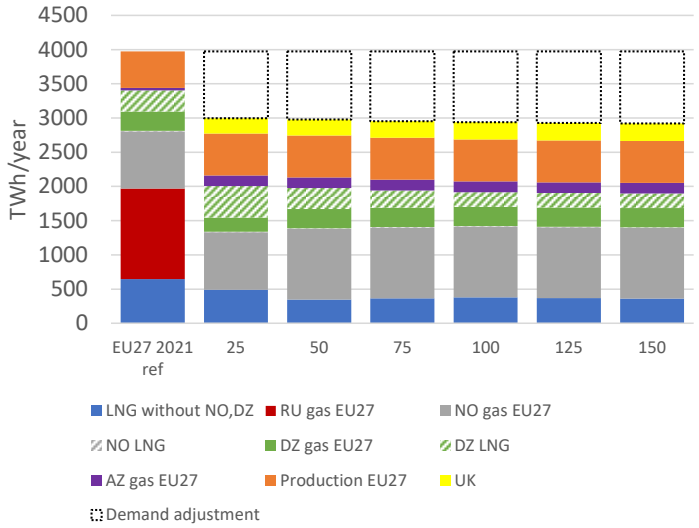


Note: The green boxes show the yearly average wholesale prices (€/MWh) in 2030 assuming 150 €/MWh Japanese price. The blue arrows stand for the LNG flows, the white arrows stand for the modelled gas flows, and the dark blue and grey indicate congestion in at least one month.

Source: EGMM

Figure 54 illustrates the supply structure of EU27 assuming different price levels in Japan. Beyond the demand reduction Europe carried out based on the REPowerEU strategy, Russian gas may be substituted by LNG and pipeline gas from Norway. In case of lower Japanese prices, the LNG supply is higher in Europe which leads to higher share of the LNG, while in case of higher Japanese prices the LNG supply in Europe is tight resulting in higher share of Norwegian gas in the European supply mix.

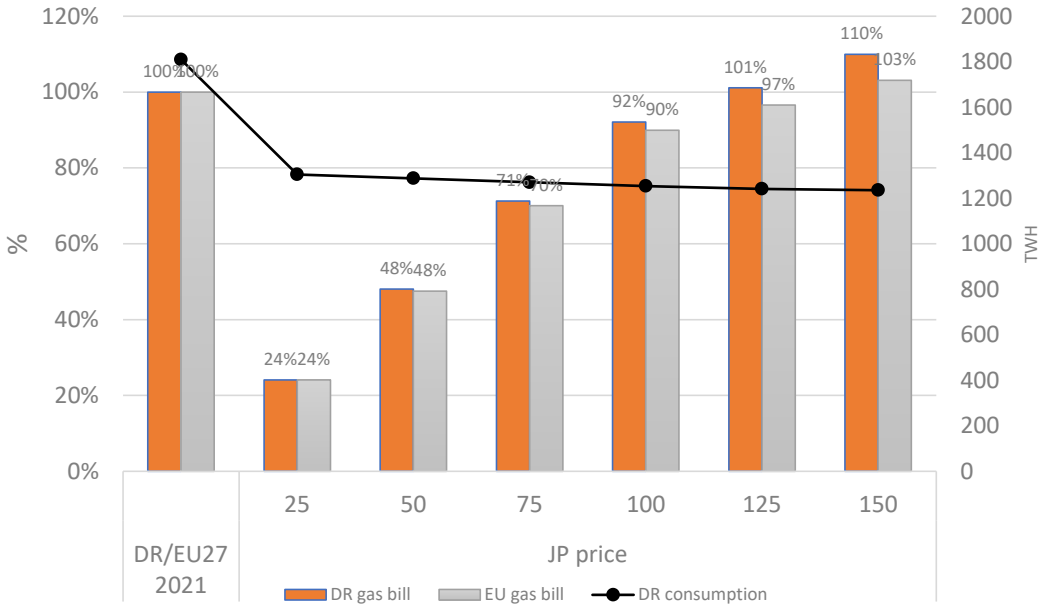
FIGURE 54. EU27 SUPPLY STRUCTURE, 2030 WITH VARIOUS LNG MARKET SCENARIOS (JP=25-150)



Source: EGMM

Figure 55 below shows how the total gas bill of the Danube Region and EU countries changes with the Japanese price. Logically, higher prices in Japan absorb the higher share of global LNG supply and leads to tight LNG supply in Europe and consequently prices in the European markets are higher. It can be also seen that higher prices lead to only marginally lower consumption levels overall resulting in higher gas bills.

FIGURE 55. EU27 AND DANUBE REGION GAS BILL AND CONSUMPTION IN DANUBE REGION.



Source: EGMM

Overall, the total gas bill in the Danube Region countries moves together with the EU gas bill. However, in a market environment where Japanese prices are extremely high (as it was the situation in Q2.Q3 2022) there is a risk for Danube Region countries to suffer from higher price increase and total gas bill than the EU on average. The vicinity of the large Turkish market would be risky for Balkan countries: if they do not reduce their demand significantly Turkey can cause a supply deficit in the region resulting is higher prices.

6 POLICY RECOMMENDATIONS FOR THE DANUBE REGION PA2 STEERING GROUP

The Danube Region is more vulnerable to a Russian supply cut than the EU overall. Therefore, the issue of gas dependency and how it can be reduced is among the most pressing problems that is to be addressed in 2022. It is also reflected in the fact that the "Diversification of gas supply in the EUSDR "has been selected as "Flagship Project".

Individual countries have different vulnerabilities and strategic goals that might be contradicting to each other. Therefore, it is very important to keep on monitoring, discussing and coordinating the national measures also within the Danube Region framework with the aim to avoid unintended consequences or negative impacts.

Regular updates of the dependency indicators calculated in this study can provide important insight into how the shift of vulnerabilities changes the relative and absolute dependency position of the countries.

Updated modelling of the geopolitical developments and the impact of those on the EU, the Danube Region and on individual countries can support defining common goals and positions that can also be communicated on EU level and contribute to the common goal of strengthening the European gas market resilience to supply shocks.

Supply options – mainly the LNG infrastructure already under construction – if implemented will help the EU and also to the Danube Region countries to mitigate the energy crisis, both in terms of high prices and to avoid supply disruptions.

Demand reduction is key to achieving a gas bill reduction especially in the case of full Russian supply cut. Due to the price increase, industrial and household sector reacted and curbed their demand already in H1 2022. The power sector did not react to the high prices with reduced gas consumption in 2022, because of the lack of other capacities in the system. Power sector's gas saving potential depends on French nuclear and hydro availability also in the upcoming winter 2022/23. The residential sector was so far partially shielded by the regulated prices. To unlock the further potential in demand reduction a price signal is needed. We encourage the Danube Region countries to prioritize demand reduction measures that target gas savings and avoid direct subsidization of gas prices to household consumers. Most vulnerable households might be a temporary exemption.

Demand response combined with alternative sources can compensate the full cut of Russian supplies even in the Danube Region for the 2022/23 winter. The storage obligation of the EU (to fill storages up to a min 80% by October 2022 was overdone by November 2022 (95%), and this can also help the non-EU member state Danube Region countries to survive the winter. The storage obligation increased the resilience of the EU to Russian supply cuts, but at the same time created an artificial demand surge in the summer that very much impacted the wholesale gas prices. A less steep filling up of storages by next winter might help to prevent competition with Asian buyers for spot LNG cargoes in the summer.

Solidarity and interconnectedness of the Danube Region country is key to keep the energy supplies under control. We suggest to monitor the development of the solidarity mechanisms between Danube Region countries as well.

ANNEX 1: DR ACTIONS TO REPLACE RUSSIAN GAS

Danube Region countries do not have a uniform view on the future of Russian gas deliveries. We identified three main questions along which the countries may be categorised:

ATTITUDE TOWARDS PAYING IN RUBLES

In March 2022, President Putin required "unfriendly" European counterparties to start paying in Rubles for the gas deliveries. This action was to enhance the stability of the Russian currency. The European Commission declared that paying in Rubles would be a clear violation of the sanctions policy, however, in the end European traders were allowed to open a Euro account at Gazprombank, which then converted the Euro payments to Rubles. This way the deliveries could continue. Bulgaria and Poland choose not to follow this procedure, and deliveries to these countries stopped.

- *Paying in Rubles: no DR country*
- *Opened an account, paying in Euros and this is converted to Rubles*: This was the case for most major European importers, such as AT, DE, HU, SK and SI
- *Not paying in Rubles, no account opened:* Bulgaria refused to open an account and deliveries stopped. Russia did not consider Serbia and Bosnia and Herzegovina "unfriendly" countries and did not require payment in Rubles.

LOOKING FOR ALTERNATIVES FOR RUSSIAN GAS SUPPLIES

After the curtailment of supplies to Europe from 2021 and the war in Ukraine some Danube Region countries already viewed Russia as an unreliable partner and seek to end their dependency and trade relations with Russia regarding natural gas. These policies mainly include securing alternative supplies, ramping up biogas and hydrogen production or energy efficiency initiatives to curb consumption. These policies however need time to be converted into measures. As we see from the data collection in Table 7 the actions could not yet be identified during the data collection period of this study which happened from May till August 2022.

- *Looking for alternative supplier: Bulgaria seeks Azeri gas to be delivered via the new Interconnector between Greece and Bulgaria (IGB starts gas deliveries in August 2022), all countries with access to LNG (via own LNG terminal or booked capacities) contract additional volumes or negotiate new contracts (BG, HR, DE, CZ, SK, SI). Germany and Croatia expands LNG terminal capacities, Moldova tenders alternative gas and rents storage in Romania, Slovakia plans to reach LNG and Norwegian sources via the newly commissioned SK-PL interconnector*
- *Energy efficiency initiatives and demand side measures: AT has a ban on gas boilers from 2027*

PLANNING TO END RUSSIAN GAS DELIVERIES

Even without dedicated measures in place, the political will and statement of ending Russian gas imports in the future communicates the attitude of a country.

- *No Russian imports:* Ukraine stopped buying gas from Russia already in 2015. Gas deliveries to Bulgaria stopped in April, and were be replaced by US LNG via Greek ports.
- *Statement to end Russian imports:* Germany, Slovenia and Moldova stated that they plan to end Russian gas imports.
- *No plan to phase out Russian gas:* Bosnia and Herzegovina and Serbia were not declared "unfriendly" by Russia. Romania does not have a state-level import contract, but independent traders are conducting business with Gazprom – therefore no policy exists to phase out Russian gas.

TABLE 7. ATTITUDE OF DANUBE REGION COUNTRIES TOWARDS RUSSIAN GAS*

	Paying in Rubles / € account opened[21]	Looking for alternative supplies	Planning on ending RU deliveries?[22]
AT	Yes (€ acc.)	Yes (Gulf region)	No
BA	No	No	No
BG	No	Yes (US LNG)	Stopped 27 April
HR	Yes (€ acc.)?	Yes (Expand Krk LNG)	No
CZ	No	Yes (Nuclear), LNG via NL)	No
DE	Yes (€ acc.)	Yes (LNG)	Yes
HU	Yes (€ acc.)	No	No
MD	Yes	Yes (tendering for LTC, storage in RO)	Yes
ME	n.a.	n.a.	n.a.
RO	No	No?	No
RS	No	No (new 3-year RU LTC signed in May 2022), Storage deal with HU	No
SK	Yes (€ acc.)	Yes (LNG, NO pipe)	No
SI	Yes	Yes (LNG, Africa)	Yes
UA	-	Yes	Not buying RU gas from 2015

*Data collection for this table covers May to August 2022
Sources:
AT: https://www.reuters.com/business/energy/austria-says-russian-gas-still-flowing-it-scrambles-alternatives-2022-04-27/ https://www.euractiv.com/section/politics/short_news/austrian-industry-warns-russian-gas-embargo-would-be-catastrophic/
BA: https://www.reuters.com/article/bosnia-russia-gas-prices-idUSL5N2WC3K8 https://seenews.com/news/russian-gas-supply-to-bosnias-serb-republic-undisrupted-distributor-775775
BG: https://www.euractiv.com/section/energy-environment/news/bulgaria-to-replace-russian-gas-supply-with-cheaper-us-lng/

[21] Source: https://www.politico.eu/article/ruble-gas-paid-russia-eu/, https://rusbankrot.ru/en/society/which-countries-agreed-to-pay-for-russian-gas-in-rubles/

https://www.rferl.org/a/bulgaria-life-after-russian-gas/31860510.html
https://www.energymonitor.ai/tech/networks-grids/weekly-data-can-bulgaria-live-without-russian-gas
https://www.reuters.com/article/ukraine-crisis-bulgaria-idUSL5N2WQ7PE
HR: https://hr.n1info.com/english/news/daily-without-russian-gas-croatia-will-be-left-with-no-heating-in-winter/
https://vlada.gov.hr/news/croatia-is-willing-to-increase-lng-terminal-capacity-even-more-with-the-help-of-our-european-partners/35337
https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/032922-croatia-eyes-expansion-of-floating-lng-import-terminal-slovenia-supply-option
https://www.total-croatia-news.com/politics/62381-russia-will-suspend-gas-to-croatia
CZ: https://oopstop.com/the-czech-republic-refused-to-pay-for-russian-gas-in-rubles-2/
https://www.dw.com/en/russian-gas-imports-czech-republic-and-slovakia-scramble-for-alternatives/a-61943751
https://www.expats.cz/czech-news/article/will-russia-cut-off-czechia-s-gas-supply
DE: https://www.uniper.energy/news/uniper-to-build-germanys-first-lng-terminal---aim-is-to-diversify-natural-gas-supply-sources
https://www.dw.com/en/germany-could-be-off-russian-gas-by-winter-says-economic-think-tank/a-61413354
https://www.cleanenergywire.org/news/germany-can-do-without-russian-gas-2024-oil-and-coal-end-2022-econ-min
https://www.bmwi.de/Redaktion/DE/Downloads/Energie/0325_fortschrittsbericht_energiesicherheit.pdf?__blob=publicationFile&v=10
https://energypost.eu/what-can-replace-russian-gas-modelling-germanys-options-on-renewables-coal-nuclear-lng-lowering-thermostats/
MD: https://seenews.com/news/moldova-unable-to-halt-russian-gas-imports-seeking-alternatives-president-779746
https://balkaninsight.com/2022/04/20/moldova-makes-plans-to-escape-russian-energy-dependence/
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RS: https://www.aljazeera.com/news/2022/5/29/serbia-ignores-eu-sanctions-secures-gas-deal-with-putin
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SK: https://www.euractiv.com/section/politics/short_news/slovakia-yet-to-plan-solution-to-lower-dependency-on-russian-energy/
https://www.energyintel.com/00000181-1518-d67b-a3cd-f5dae3ce0000
SI: https://sloveniatimes.com/logar-for-ban-on-russian-gas-imports-as-slovenia-joins-energy-independence-initiative/
https://www.euractiv.com/section/politics/short_news/slovenia-to-consider-gas-supplies-from-qatar/
https://seenews.com/news/slovenia-in-talks-to-increase-african-gas-imports-via-italy-minister-776843


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Danube Strategy Flagships strengthen internal and external communication of the Strategy and the visibility of the topics, initiatives and prospects in the Danube Region. They illustrate the progress achieved in implementing the EUSDR and demonstrate exemplarily significant improvement in the Region that is induced by cooperation.
EUSDR National Coordinators and Priority Area Coordinators with the respective Steering Groups, in their capacity as representatives and key implementers of the EUSDR, as well as the Danube Strategy Point, are committed to contribute to and promote Danube Strategy Flagships in accordance with the Guidance Paper for identifying and listing Danube Strategy Flagships.
Date: 14 September 2022
DANUBE REGION strategy
EUSDR Priority Area(s): PA 2 Sustainable Energy