European
Commission

METIS 3

Study S1/S10
Short-term sector coupling model

Outlook on EU gas adequacy

LEGAL NOTICE

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Abbreviations and definitions

Abbreviation	Definition
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
EC	European Commission
EU	European Union
EV	Electric Vehicle
FEC	Final Energy Consumption
FLNG	Floating Liquified Natural Gas
FSRU	Floating Storage and Regasification Unit
GIE	Gas Infrastructure Europe
HDD	Heating Degree Days
HP	Heat Pump
JRC	Joint Research Centre
LNG	Liquified Natural Gas
MD	Moldavia
MS	Member State
OCGT	Open Cycle Gas Turbine
O&M	Operation and Maintenance
PHS	Pumped Hydro Storage
PV	Photovoltaics
RES	Renewable Energy Sources
TAP	Trans Adriatic Pipeline
TYNDP	Ten Year Network Development Plan
UA	Ukraine
UK	United-Kingdom

METIS CONFIGURATION

The configuration of the METIS model used for this study is summarised in the table below.

METIS Configuration	
Version	METIS v3.0 Beta (non-published)
Modules	Energy system integration module
Scenario	Short term forecast based on ENTSO-E, Eurostat, ENTSO-G and GIE
Time resolution	Hourly (8760 consecutive time-steps per year)
Spatial granularity	Member State

EXECUTIVE SUMMARY

In 2022, Europe faced extreme price volatility caused mainly by the collapse of Russian gas imports (representing ~40% of the imports of the EU before 2022). Electricity price were further affected by the lower nuclear availability in France and low hydropower reservoir levels across Europe.

This energy crisis significantly impacted the gas flows and imports in Europe with more reliance on LNG, reverse flows (from West to East) and price spikes.

These events are expected to have a lasting impact, hence there is a need to understand how the European energy system can adapt in the short to medium term. This study uses the METIS platform to evaluate several potential short-term evolutions of the European power and gas sectors and assess the impact of different policies.

A first result concerns the gas supply-demand adequacy. The study shows that a combination of various risk factors including cold spell, non-compliance with gas demand reduction measures & new gas demand (combination referred to as the stress scenario) would call for sourcing additional supply (around 6 bcm) to meet the demand in winter 2024. The gas demand reduction measures implemented since 2022 strongly reduce the risks of gas supply-demand inadequacies.

Secondly, it is shown that the renewables capacities planned for 2024 limit the gas consumption by 18 bcm, representing 20% of the gas consumption for electricity production. Around 24 bcm additional gas would be required to meet the demand in 2024 if further renewables capacity expansion is restricted under the stress scenario.

Again under the stress scenario, around 11 bcm of additional gas would be required if the availability of French nuclear remains at 2022 levels while restoring to historical average would lead to surplus of around 1 bcm.

In terms of LNG infrastructure, delay or cancellation of planned LNG terminals & FSRUs for 2024 is found to have a minimal impact on the power generation mix at EU level, with less than 1% of gas-to-coal switches. These delays or cancellation also have a negligible impact on the gas imports. The existing terminal capacities remain sufficient for LNG imports, even under a stress scenario. Since many extensions or new LNG terminals have been planned in the wake of the energy crisis, a lower utilisation of LNG terminals might be observed towards the end of the decade.

Even if the LNG infrastructure seems not to be a limiting factor, the LNG supply might be more problematic. Minimum availability of LNG supply for EU in the international market (because of exogenous factors such as high recovery of Chinese demand, maintenance or strikes in liquefaction terminals) can lead to gas inadequacy under most scenarios. On the contrary, if the LNG supply available for the EU is high (e.g. because of low increase in Chinese demand, additional short lead time LNG capacities…), there is no adequacy issue in any of the scenarios.

Intermediate gas storage filling targets have recently been implemented for each Member State, with minimum levels imposed in February, May, July and September in addition to the existing target for November. The results of this study show negligible impacts of the intermediate targets on the generation mix or the gas supply-demand adequacy.

1 INTRODUCTION

In 2022, Europe faced extreme energy price volatility caused by the collapse of Russian gas imports subsequent to the invasion of Ukraine (Gil Tetre, et al., 2023). Prior to 2022, gas imports from Russia represented more than 40% of the imports of the European Union. However, these imports experienced more than threefold decline over the course of the year as shown in Figure 1.

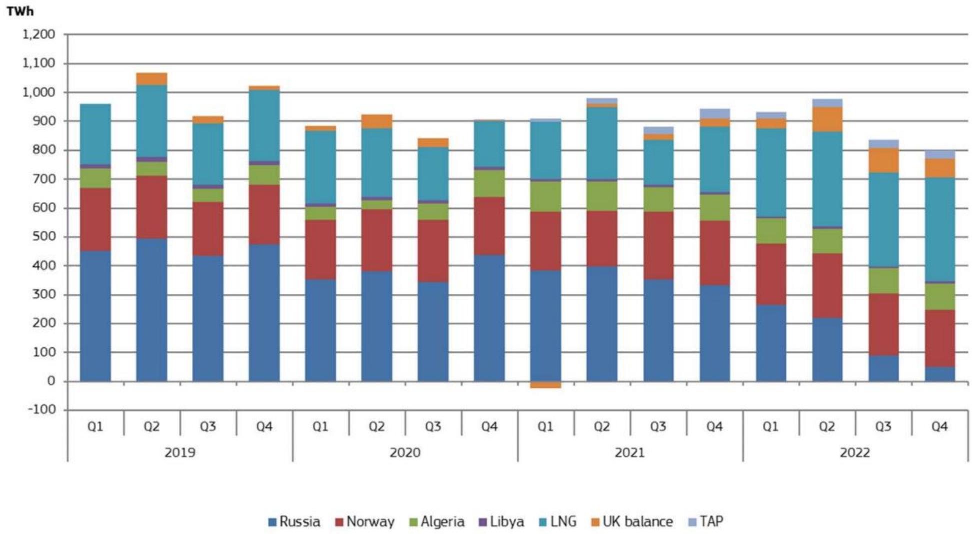


Figure 1: Evolution of the gas imports for the EU27 (European Commission (DG Energy), 2022)

This sudden drop of gas supply in a context of post pandemic growing energy demand triggered major security of supply concerns in both gas and power sectors. Other factors exacerbated these risks, such as historically lower nuclear availability in France and very lower water levels over all Europe.

This energy crisis significantly impacted the gas flows and the gas imports in Europe. The LNG imports doubled between 2021 and 2022, producing reverse flows going from the LNG terminals in the Western part of the Union to the East. These changes are expected to be exacerbated in the coming years, with a total phase out of Russian gas imports via pipelines and a higher LNG import potential due to new liquefaction and regasification LNG terminals. Furthermore, the EU27 domestic gas production is decreasing, especially with the recent closing of the Groningen gas fields in the Netherlands.

The European Member States reacted to this crisis by both implementing several short-term measures and by developing a longer-term plan, the REPowerEU Plan, organizing a structural phase out from Russian gas supply by, among others, increasing the targets of renewable energy sources (RES) in power generation. All the measures allowed to limit the impact of the energy crisis and avoid severe gas shortages in Europe.

Among the short-term policies implemented, the Member States agreed on setting voluntary gas demand reduction targets of 15% (European Council, 2022). Gas demand reduction measures were implemented in the Member States and the targets were met at EU level in 2022 and later extended to subsequent years. In parallel, gas storage filling requirements were implemented to ensure that sufficient gas is available at the beginning of the winter to supply the peak demand of the coldest months.

The impact of the crisis was somewhat alleviated by the mild weather observed in Europe during the year 2022. Weather is a key component, strongly impacting the energy system and deserves a particular attention in short-term projections.

The changes induced by the crisis in terms of gas supply and demand are expected to have a lasting impact, hence there is a need to understand how the energy system can adapt in the short to medium term.

Several studies assessed the evolution of the gas supply-demand adequacy in the EU for the years following the energy crisis. Among others, the IEA ((IEA, 2022) and (IEA, 2023)) evaluated the gas adequacy in 2023 and potential supply-demand gaps under different scenarios. Other studies such as IEEFA (IEEFA, 2023) focussed on specific topics such as the LNG terminal capacity and their utilisation rate in the short to medium term.

The present study aims at investigating the short-term evolution of the EU power and gas sectors under different scenarios. It models both sectors under a single METIS framework, allowing to better understand the interdependencies between both sectors.

Specifically, the study investigates the following objectives using a short-term sector coupling model developed in METIS:

- To assess the impact of various factors that create uncertainty in the gas demand including weather conditions, the effectiveness of energy gas demand reduction measures as well as the need to meet the gas demand of Ukraine and Moldova.

- To assess the drivers of gas demand in the power sector such as the share of renewables and availability of the nuclear fleet.

- To assess the impact of the gas supply structure for Europe due to changes in the LNG supply, LNG terminal expansion and gas storage filling targets.

The remaining part of the report is structured in six sections. The second Section summarizes the methodology and input assumptions and defines the scenarios. The findings of the study under the base case are then described in detail in the third Section where the short-term projections of the power and gas sector are presented. The fourth section focuses on the gas adequacy assessment under the different scenarios. Several sensitivity analyses are conducted and discussed in Section five. Finally, the main conclusions of the study and outlooks are presented in the last section.

2 METHODOLOGY AND ASSUMPTIONS

2.1 MODELLING SHORT-TERM SECTOR COUPLING IN METIS

The METIS model is a multi-energy model covering in high granularity (in time and technological detail) the entire European energy system, representing each Member State and relevant neighbouring countries. Each country is represented as a node and all assets of a given country are aggregated by technology type (e.g., wind onshore, lignite power plants, gas storage, electrolysers, etc.).

METIS includes a database with modelling assumptions, datasets and comes with a set of pre-configured scenarios. These scenarios usually rely on the inputs and results from the European Commission's projections of the energy system, for instance with respect to the capacity mix or annual demand of the different energy vectors. Additionally, new scenarios can also be generated via the capacity expansion features of METIS.

In this study, short-term forecast scenarios are defined for the years 2022, 2023 and 2024 using as input the projections from ENTSO-E, ENTSO-G and GIE (see section 2.2 for the overview of the input data). Using these scenarios, METIS allows to perform the hourly dispatch simulations (over the duration of an entire year, i.e., 8760 consecutive time-steps per year). The result consists of the hourly utilisation for the different energy vectors of all generation, storage, sector coupling and cross-border capacities, as well as demand side response assets for electricity.

METIS is also able of jointly optimise the investments in a large number of technologies together with the hourly dispatch. This feature is not used in the present study which focusses of the short term reaction of the given energy infrastructure. .
The figure below provides an overview of the workflow. The assumptions related to the key input and output data are presented in more detail in the subsequent section.

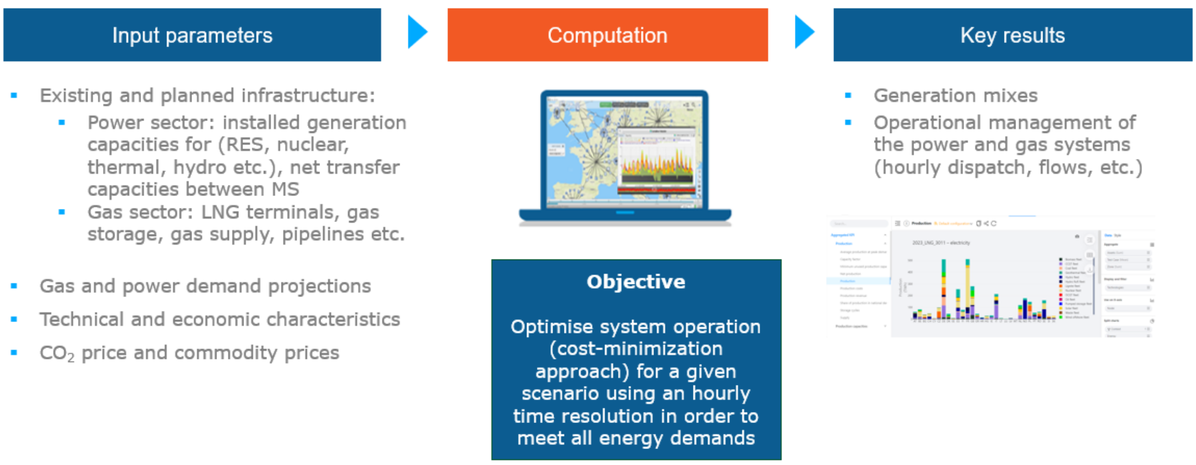


Table 1 shows a list of the main parameters and highlights which ones are fixed exogenously and which results from the optimization.

	Category	Data type	Unit	
Power sector	Electricity Demand	**Demand profiles**	MW	Fixed
	Transmission lines	**Transmission capacity**	MW	Fixed
		Flows	MW	Optimized
	Generators	**Installed Capacity**	MW	Fixed
		Generation	MW	Optimized
	Commodity prices	**Oil, coal, lignite, biomass, CO_2, gas (costs at sources)**	€/MWh	Fixed
		Electricity, gas (price in the EU)	€/MWh	Optimized
Gas sector	Gas storage	**Capacity (storage, injection, withdrawal)**	MW / GWh	Fixed
		Hourly injection/withdrawal	MW	Optimized
	LNG terminal	**Capacity (storage, injection, withdrawal)**	MW / GWh	Fixed
		Hourly production	MW	Optimized
	Gas pipelines	**Capacity**	MW	Fixed
		Flows	MW	Optimized
	Gas production	**EU27 domestic production profiles**	MW	Fixed
		Production from outside the EU	MW	Optimized
	Gas consumption	**Consumption profile**	MW	Fixed

Table 1: List of parameters fixed exogenously or optimized endogenously

The input values of the fixed parameters are gathered in METIS 'contexts'. These 'contexts' refer to a set of inputs files (typically in *.csv* format) and optimization parameters, generally covering one year and one scenario.

The general characteristics of the contexts built in this study are the following:

- **Time horizon:** 2022 (for calibration), 2023 & 2024
- **Geographical scope:** EU27 + Switzerland, Norway and United-Kingdom
- **Temporal granularity:** Hourly (8760 steps per context)
- **Geographical granularity:** One node per Member State
- **Optimization scope:** No investments, only optimization of the dispatch

2.2 Input data

This section summarizes the input data and the sources used to build the coupled METIS context representing the power and gas sectors.

The modelling of the year 2022 is primarily done for calibration purposes, so that the model replicates as close as possible the historical values observed during that year.

2.2.1 Power sector data

The power sector input data is based on the *JRC Power context 2023* (that uses the ENTSO-E Transparency Platform as main source). This context is updated based on other sources from ENTSO-E (TYNDP[1], ERAA[2], Seasonal Outlooks[3], Transparency Platform[4]) and on Eurostat.

Category	Data Type	Unit	2022	2023	2024
Electricity Demand	**Demand profiles**	MW	ENTSO-E TP	JRC Power context 2023	ENTSO-E ERAA 2022
Transmission	**Transmission capacity**	MW	ENTSO-E Seasonal Outlooks ENTSO-E TP	JRC Power context 2023	ENTSO-E ERAA 2022 ENTSO-E TYNDP 2022
Generators	**Installed Capacity**	GW	ENTSO-E Seasonal Outlooks ENTSO-E TP Eurostat	JRC Power context 2023 (based on ENTSO-E) ENTSO-E Seasonal Outlooks ENTSO-E TP	ENTSO-E ERAA 2022
	Technical characteristics		JRC Power context 2023	JRC Power context 2023	JRC Power context 2023
Renewables generation	**Renewable profiles**	%	ENTSO-E PECD *Weather year*		
			2011	2014	2014
	Hydropower inflows and storage levels		JRC Power context 2023		
Commodity	**Commodity prices**	€/MWh	Gas, coal, CO_2: DG ENER Oil, lignite: JRC Power context 2023 Biomass: European Biogas Association		

Table 2: Inputs and sources for the power sector

2.2.2 GAS SECTOR DATA

The gas sector input data is based mostly on Eurostat, complemented by other sources such as GIE[5] and ENTSO-G (TYNDP)[6].

Asset	Property	Unit	2022	2023	2024
Gas storage	Injection and withdrawal capacity	GW	ENTSO-G TYNDP 2022, GIE Gas storage database		
	Storage capacity	TWh	GIE Gas storage database		
	Entry & exit fees	€/MWh	ENTSO-G TYNDP 2020		
LNG Terminal	Injection and withdrawal capacity	GW	ENTSO-G TYNDP 2020 (Annex C1)		
	Storage capacity	TWh	GIE LNG database		
	Tariffs	€/MWh	ENTSO-G TYNDP 2020 (Annex D)		
LNG Liquefaction train	Tariffs	€/MWh	ENTSO-G TYNDP 2020 (Annex D)		
Pipeline	Capacity	GW	TYNDP 2022		

[1] https://tyndp.entsoe.eu/
[2] https://www.entsoe.eu/outlooks/eraa/
[3] https://www.entsoe.eu/outlooks/seasonal/
[4] https://transparency.entsoe.eu/
[5] https://www.gie.eu/transparency/databases/
[6] https://www.entsog.eu/tyndp

Asset	Property	Unit	2022	2023	2024
	Entry & exit fees	€/MWh	TYNDP 2020		
Gas production	Domestic natural gas production profiles	GW	Eurostat		
	Gas import potential by sources	TWh	*(IEA, 2022)*		
	Gas supply cost curves	€/MWh	Natural Supply cost curves (based on ENTSO-G TYNDP 2020). Calibrated based on commodity prices made available by DG ENER		
Biogas production	Capacity	GW	Eurostat		
Gas consumption	Yearly consumption	TWh	Eurostat		
	Consumption profiles	GW	PRIMES		
	Heating Degree Days		Eurostat		
	Share of thermo-sensitive & non-thermosensitive	%	JRC IDEES		

Table 3: Inputs and sources for the gas sector

The gas supply available for the EU is based on (IEA, 2022) complemented by other sources such as Eurostat and (Enerdata, 2023). This gas supply represents the quantity of gas that is available for the EU on global markets (i.e. considering the new liquefaction terminals, the demand from other countries such as China, the domestic gas production…). It has to be differentiated with the gas importing capacity, which is linked to the infrastructure (LNG terminals, pipelines).

The gas supply available for the EU in 2023 is summarized in Figure 2 and detailed in Table 4. The values derived for 2023 are also used for 2024. The uncertainty on the levels of gas supply in 2024 on the gas adequacy is explored in more details as part of the sensitivity analysis.

Important assumptions that can be noted are:

- No more reliance on imports from Russia via pipelines is considered from 2023 onwards[7].
- LNG imports potential for Europe is higher than in 2022 due to new liquefaction terminals in exporting countries and new LNG infrastructure in Europe.
- Reduction of domestic gas production in the EU, mainly because of the closing of Groningen gas fields in the Netherlands.

[7] In practice some imports from Russia have still been observed in 2023 and might be pursued in 2024. However to ensure European energy security without relying on Russian gas imports, a conservative assumption of no more gas imports from Russia is used. A sensitivity analysis assesses the impact on the energy system of having more gas supply available for the EU (e.g. from Russia).

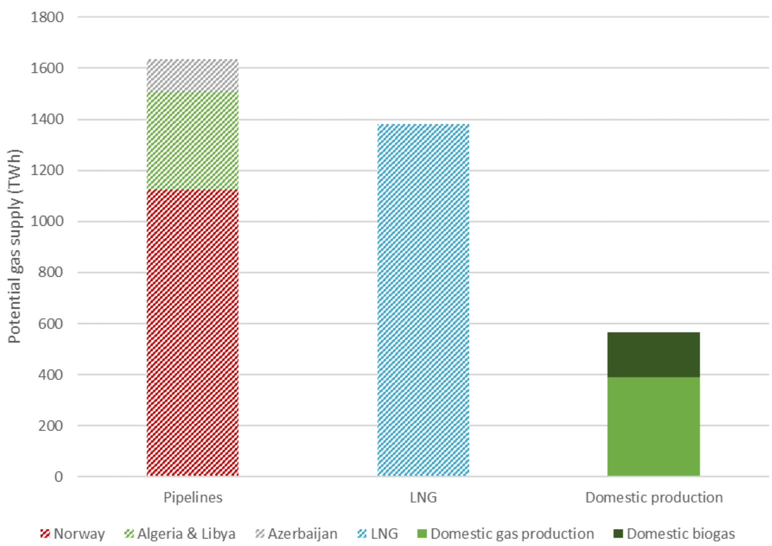


Figure 2: Forecast maximum gas supply available for the EU

Table 4 details the sources used to assess the gas supply. Since the United-Kingdom and Norway are explicitly represented in the METIS model, their domestic production is thus modelled in a similar way as in the EU Member States.

Figure 2 focuses on the gas supply available for the EU. The domestic gas consumption of Norway has thus been subtracted from its domestic gas production. UK has not been represented as a gas supply source for the EU, since its domestic gas consumption exceeds its domestic gas production.

Source	Category	Potential (TWh)	Reference
Azerbaijan	Import potential pipeline	94	(IEA, 2023)
North Africa (Algeria & Libya)		387	(IEA, 2023)
Norway	Domestic production non-EU	1178	(Enerdata, 2023), assuming 5% is also included in the LNG category (EPRS, 2023)
UK		388	(Statista, 2023)
LNG	Import potential LNG	1455	(IEA, 2023)
Biogas production	Domestic production EU	174	Eurostat 2022
Natural gas production EU		392	Eurostat 2022 (minus production from Groningen field)

Table 4: Forecast maximum gas supply available for the EU

2.3 SCENARIO AND SENSITIVITIES DEFINITION

This study investigates various scenarios and sensitivities that capture different risk factors and uncertainties which can have the gas supply adequacy and the outcome of the power and gas sectors.

Accordingly, four scenarios are defined representing different gas demand levels depending on the factors considered including weather conditions, gas demand reduction measures and new demand. These scenarios intend to provide insight into the adequacy of a given gas supply level. These scenarios are:

1. **Base case scenario**

2. **No gas reduction scenario:** representing the impact of not respecting the gas demand reduction measures.

3. **Cold case scenario:** representing the impact of facing a colder year than in the Base case scenario

4. **Stress case scenario:** representing a worst-case scenario (highest gas demand), with non-respect of the gas demand reduction measures, cold weather and additional demands (support to Ukraine and Moldova)

The specificities of these scenarios are thus stacked in a cumulative way as presented in Figure 3. This allows to evaluate the stress case scenario, which is a worst-case scenario in terms of gas demand, where several events increasing the gas consumption happen simultaneously.

Further building on the stress case scenario, additional sensitivities are performed to understand the impact of various risk factors that could worsen the stress case scenario in 2024. These factors focus on the **supply side** of the power and gas sectors.

Specifically, the impact of the following factors on the EU energy system and the gas adequacy level are assessed individually and in combination:

- Level of RES expansion
- Changes in French nuclear availability
- Delay/cancelation of LNG terminals
- Availability of LNG supply for EU in the international market
- Introduction of intermediate gas storage filling target

Figure 3 summarizes the scenarios and sensitivities that are assessed throughout this report.

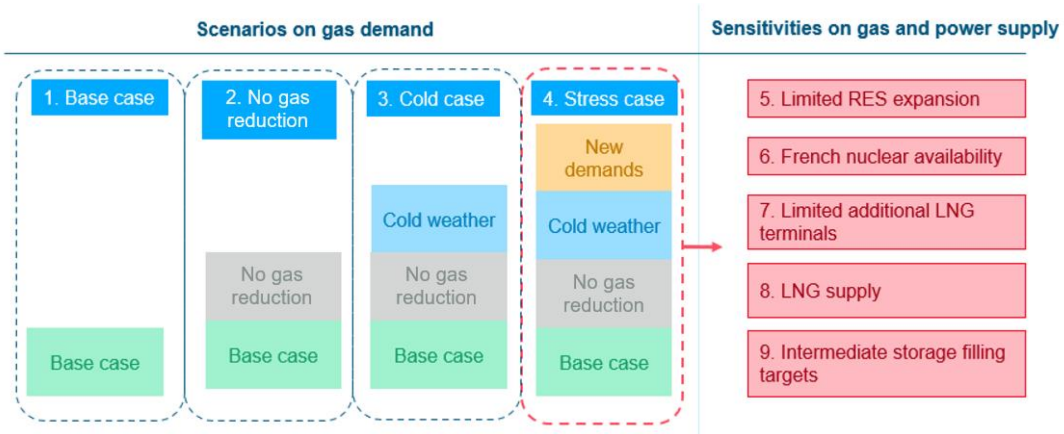


Figure 3: Summary of the scenarios and sensitivities

3 Base case scenario outlook of power and gas sectors

This section presents the results of the short-term modelling exercise for the power sector and the gas sector under the base case scenario.

3.1 Power sector

3.1.1 Electricity generation mix

The electricity generation mix is expected to evolve in the short term driven by two factors, the new installed capacities and the evolution of the merit order linked to changes in fuel & CO_2 costs.

The first factor, the installed **power generation capacities** are presented in Figure 4 for the years 2022-2024. The most important change over this time horizon is the strong development of solar and wind capacities which increase by 47% and 25% respectively between 2022 and 2024. On the other side, coal & lignite capacities decrease by 34% during the same time period.

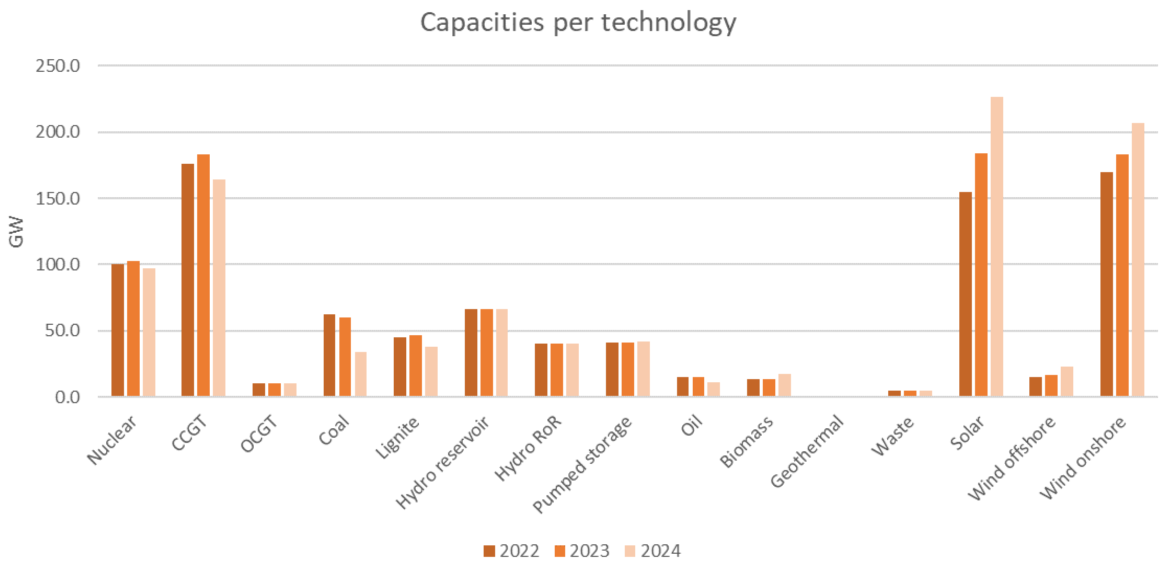


Figure 4: Evolution of the EU27 capacity per technology (GW) – Base case scenario

The second factor, the evolution of the **short run marginal costs**[8] of thermal technologies is displayed in Figure 5. A wide range of costs is shown for each generation technology. This is a consequence of the difference in efficiency characteristics across Member States. The costs of fuels and of CO_2 are also varying over the year, implying different production costs for a same unit.

It can be observed that coal and natural gas power plants become cheaper in 2023 & 2024 compared to 2022, due to a reduction in their fuel costs after the energy crisis and the price peaks of 2022. On the other side, lignite power plants become more expensive because of the increase in CO_2 price.

[8] The short run marginal costs are mainly determined by prices of fossil fuels, prices for emission allowances, power station's thermal efficiency and by other variable operating and maintenance costs. Short run marginal costs are the basis for power price formation and eventual plant dispatch.

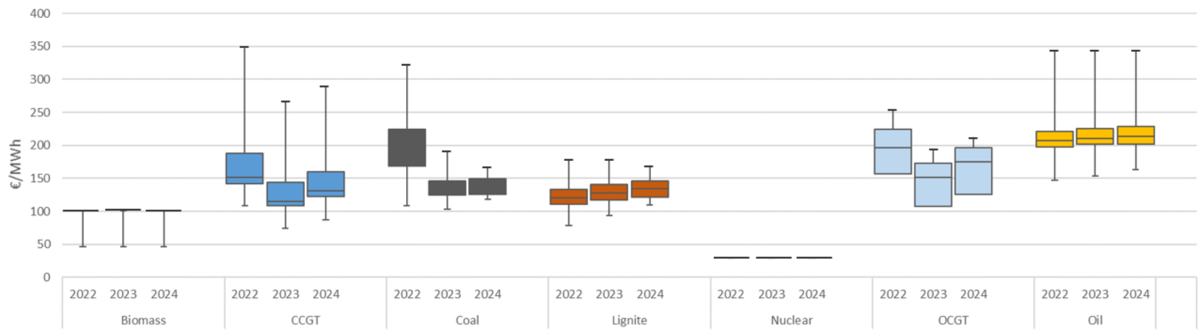


Figure 5: Comparison of the short run marginal costs between thermal technologies

The evolutions in terms of installed capacities and short run marginal costs of thermal power plants lead to the **electricity generation mix** presented in Figure 6.

The general trend in these results is that the acceleration in RES deployment limits the dispatch of thermal capacities. Solar and wind production increase rapidly and can supply the increasing demand and to reduce the dependence on fossil fuels-based generation.

On the thermal side, from 2022 to 2023 the coal-based production increases because of the fuel price reduction (see Figure 5). On the contrary, lignite-based production is reduced because of the competition with gas and coal power plants. Nuclear production increases due to the improved availability of French nuclear, after the historically low availability levels of 2022.

From 2023 to 2024, the gas & coal-based production are reduced and partially replaced by RES generation. Nuclear production is also reduced, resulting from the nuclear phase out in Germany.

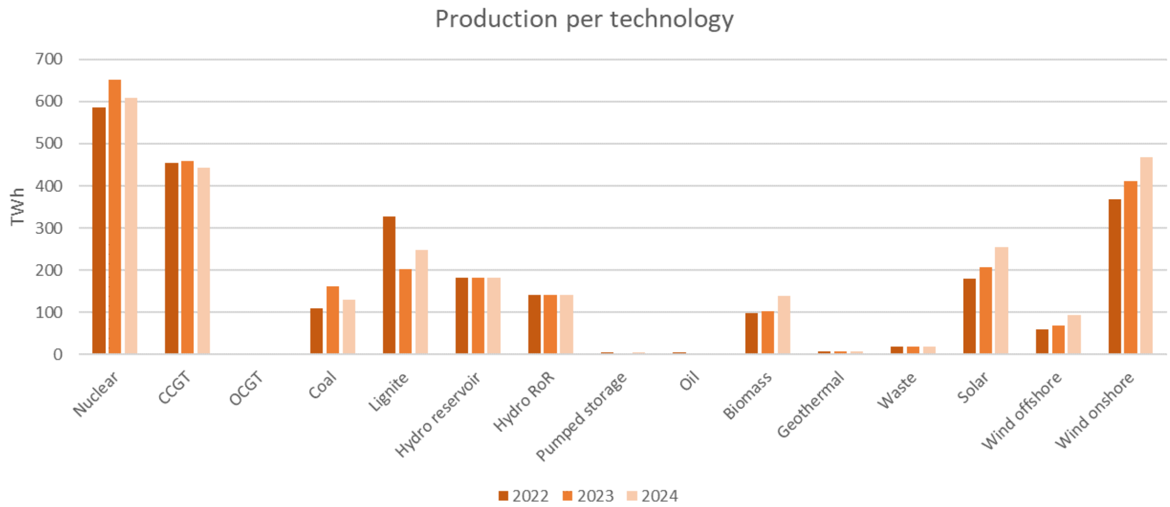


Figure 6: Evolution of the EU27 production per technology (TWh) – Base case scenario

These results can be aggregated by main fuel types and put in perspective with historical generation levels per technology from ENTSO-E, as shown in Figure 7. The main longer-term trend is again that the acceleration in renewables production limits the need of thermal generation.

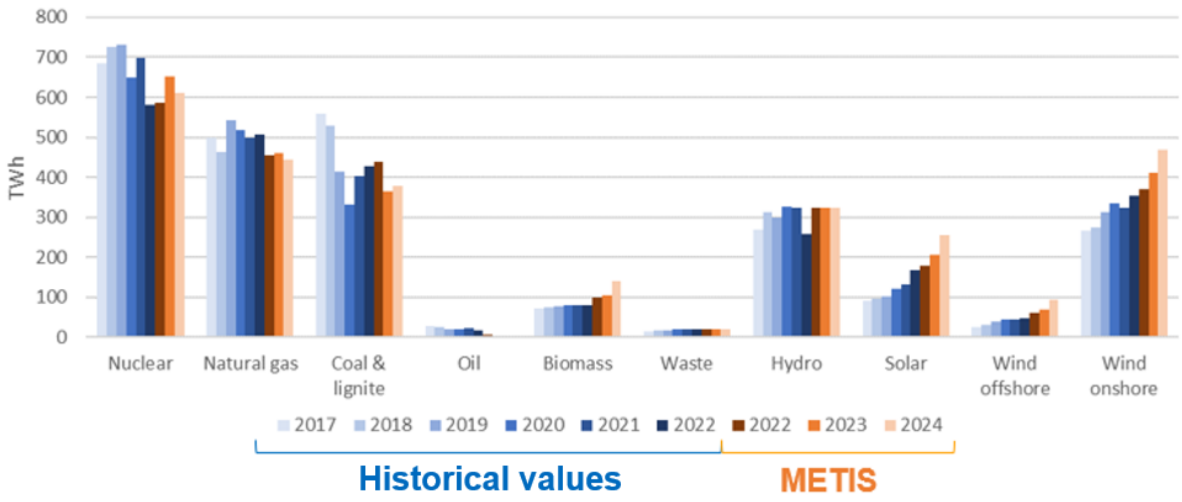


Figure 7: Evolution of the production per technology in the years 2017-2024 (TWh) – Base case scenario

Another conclusion is that no major gas-to-coal switch was observed as a consequence of the energy crisis and of the high gas prices. This is because coal prices also increased strongly in 2022, and that coal units are decommissioned in subsequent years (2023 & 2024). However, even if the coal & lignite production did not increase significantly, several governments decided to postpone some plants shutdown or their coal phase out plans.

Nuclear production in 2022 is lower than historically, mostly due to historically high unavailability in France and the decommissioning in Germany. The production goes back to higher levels in 2023 and 2024 with the increase of the French nuclear availability. Since the nuclear availability in France has a strong impact on the entire European energy system, some sensitivities study the impact of different potential levels in 2024 in chapter 5.

3.1.2 Net electricity balances

These evolutions in terms of generation mix impact the Member State’s net balances, and in consequence the flows on the interconnections between them.

Figure 8 puts in perspective the net balances in the 3 years modelled in METIS with the historical values from Eurostat.

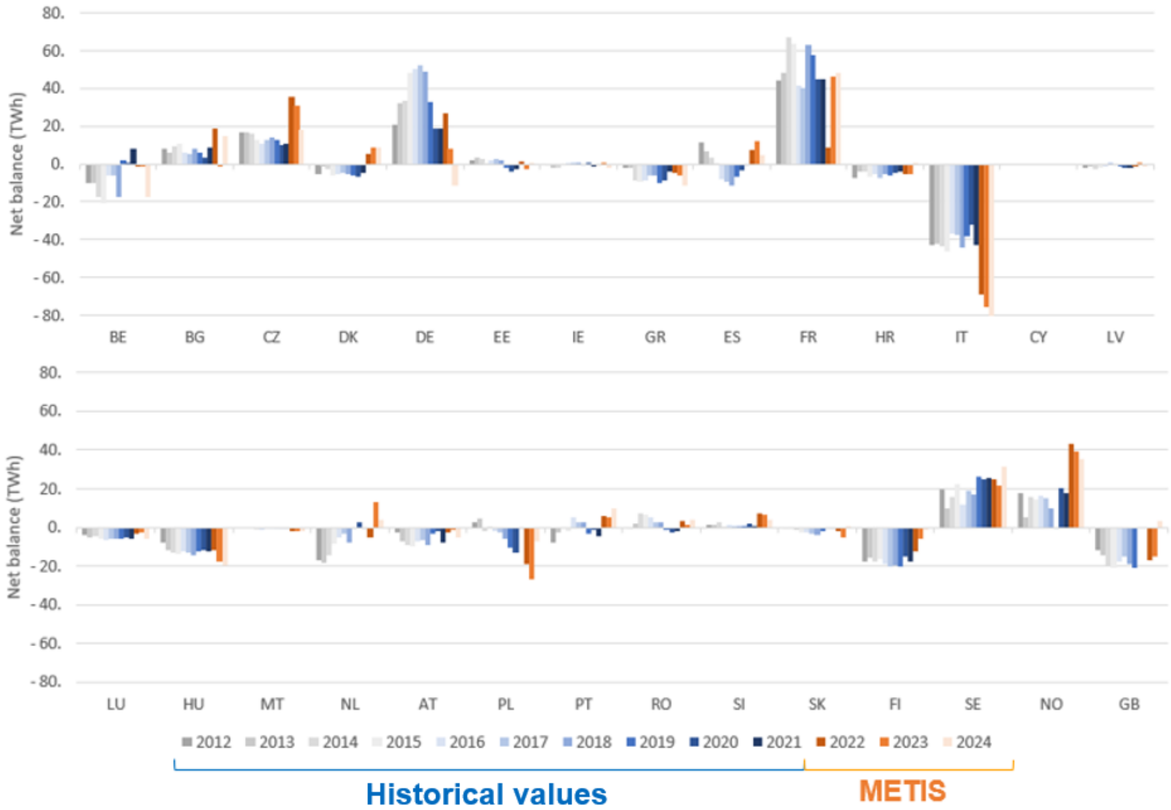


Figure 8: Evolution of the Member State's net balances in the years 2012-2024 – Base case scenario

In the coming years, some Member States will **export** more, such as Spain which will see an acceleration of the RES capacities development and the addition of new gas fired capacities. Another example is the Netherlands where large wind capacities will be commissioned.

On the other side, Poland and Italy will **import** more because of the shutdown of some of their coal power plants.

3.2 Gas sector

The evolution of the gas sector under the base case scenario can be observed in terms of gas consumption and gas supply, as well as the LNG terminal utilisation and the gas storage profile.

3.2.1 Gas consumption and gas supply

The gas consumption and supply patterns strongly evolved as a consequence of the energy crisis. The gas demand declined following the gas demand reduction measures and the development of RES, while the gas supply shifted towards more LNG.

First, as shown in Figure 9, the high gas prices and the gas demand reduction measures caused a decrease of about 17% of the gas consumption in the EU in 2022. In the base case scenario, this demand reduction is assumed to be pursued in 2023 and 2024. Figure 9 shows how the inland consumption is divided between a Final Energy Consumption (FEC) component and a gas demand for electricity production component. The former is an input of the model while the latter is a result of the simulation and of the level of production from the gas thermal power plants.

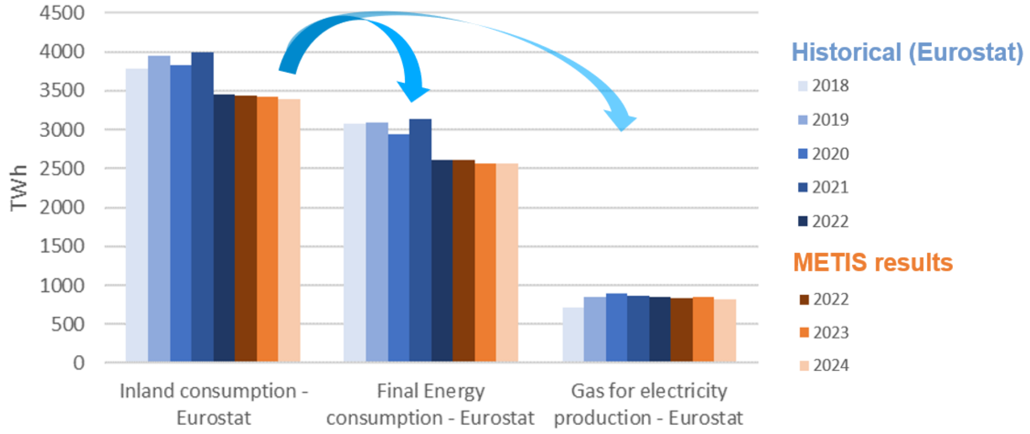


Figure 9: Evolution of the gas consumption – Comparison with historical values from METIS – Base case scenario

Secondly, the LNG imports increase strongly after 2022 and they partially replace the reduction of gas imports via pipelines that followed the invasion of Ukraine by Russia (see Figure 10). Overall, the gas imports slightly decrease compared to historical values. This is mainly explained by the reduction of inland demand presented in Figure 9.

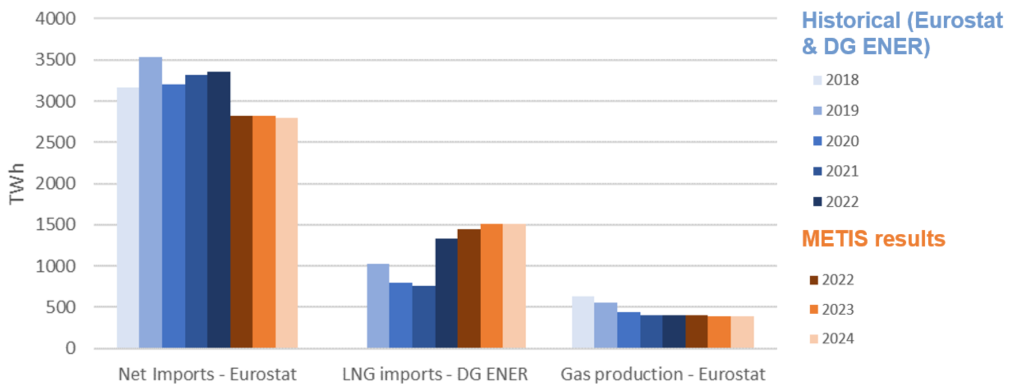


Figure 10: Evolution of the gas supply – Comparison with historical values from METIS – Base case scenario

3.2.2 LNG TERMINALS UTILIZATION

As presented here above, the LNG demand strongly increased in 2022 and is expected to slightly increase in the coming years. To be able to import this additional quantities of LNG, several new LNG terminals (or expansions of existing ones) have been planned for the coming years. The evolution of the LNG import capacity of the European Union is shown in Figure 11.

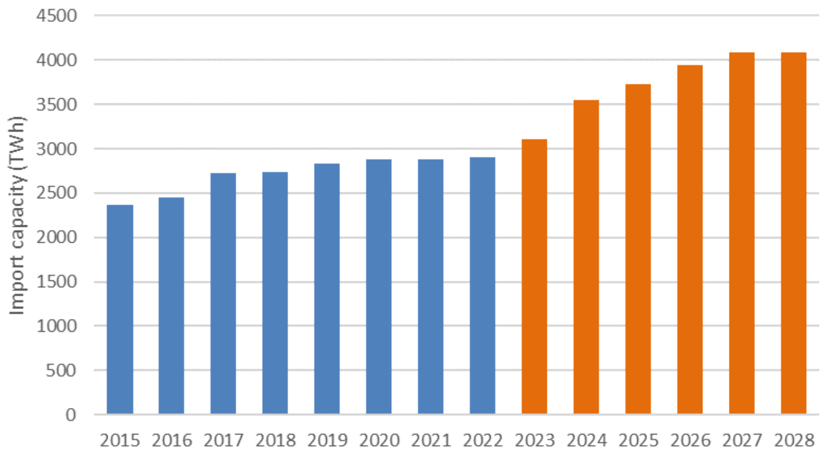


Figure 11: Evolution of the EU27 LNG import capacity (GIE, 2022)

These additional capacities are largely sufficient to ensure LNG imports. Figure 12 compares the imports per Member States resulting from the METIS simulations with the importing capacity of the Member States as forecasted by GIE (GIE, 2022). It shows that on average, the terminals are not limiting factors over the time horizon studied.

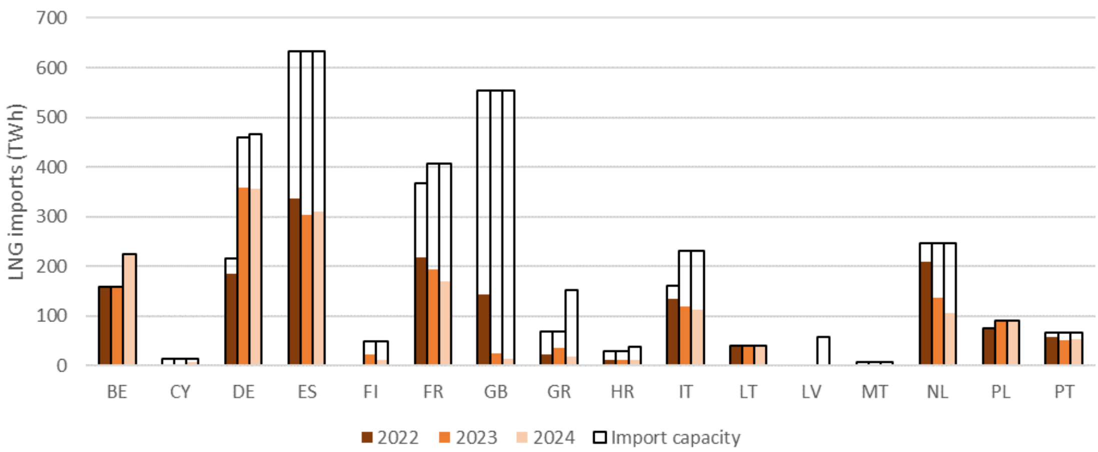


Figure 12: Comparison between the LNG imports and the import capacities per MS – Base case scenario

As shown in Figure 13, at EU27 level the utilisation rate remains below 70% and is even decreasing, meaning that the terminal capacities increase faster than the quantity of LNG imported.

It can be observed that utilization rates vary strongly between Member States. For example, LNG terminals are highly utilized in Belgium, Poland, Portugal and Lithuania while there is a potential oversizing of terminals[9] in Spain, Italy, France and Germany. The repartition between terminals is partly linked to the differences in terminal tariffs coming

[9] Even if this study shows a potential overcapacity at MS and yearly level, additional capacities might be needed to relieve local issues or to cover peak periods. This kind of dynamics are a limitation of the current version of the METIS model where the LNG imports have a flat profile (gas storage provides the bulk of the flexibility) and internal congestions are not represented.

from (ENTSOG, 2020). This topic is studied more in depth in sensitivity 3, which assesses the relevance of the terminals that will be commissioned in 2024.

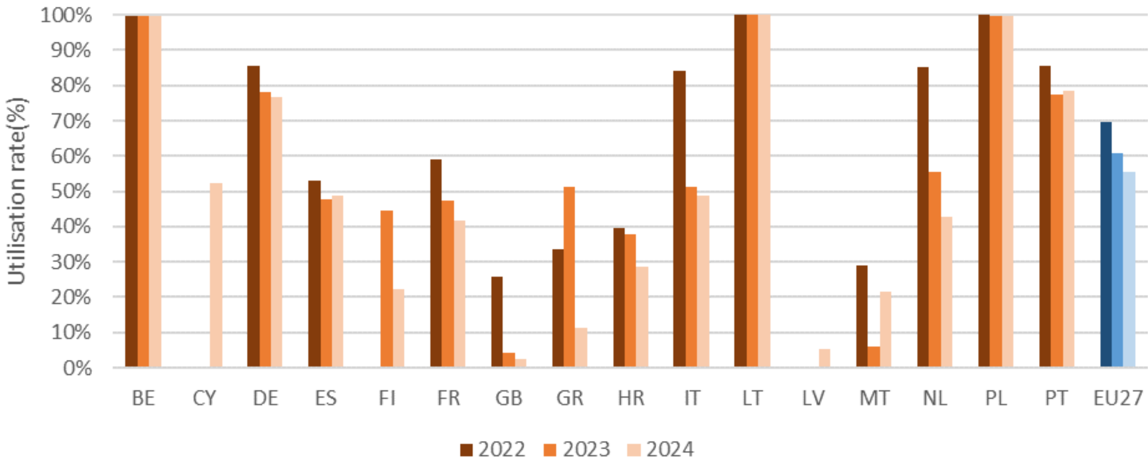


Figure 13: Average utilisation rates of the LNG terminals per Member State – Base case scenario

3.2.3 GAS STORAGE

After facing very low levels of gas storage in 2021 (European Commission (DG ENER), 2022), and in order to increase the resilience of gas supply, the European Commission and the Member States decided to impose minimum gas storage filling requirements (European Council, 2022). The minimum levels required are: 80% on the 1st of November 2022 and 90% on the 1st of November of following years.

These minimum storage requirements are considered by the METIS model. The impact of these requirements on the gas storage utilization strongly varies from one MS to another. Some MS would just respect the minimum storage requirements (e.g. Sweden, Germany), while others would keep their storage almost full all year long (e.g. the Netherlands, France, Spain), as shown on Figure 14.

At EU27 level, as shown in Figure 15, the gas storage profile is regular from one year to another and the minimum storage requirement is always respected and exceeded.

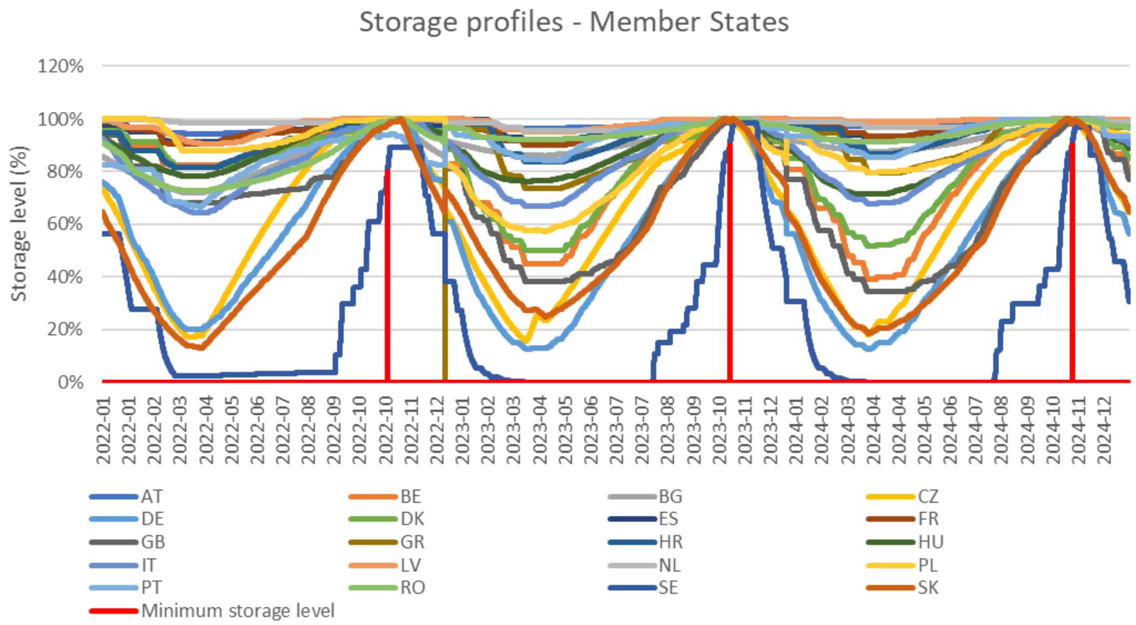


Figure 14: Gas storage profiles per Member State and minimum storage requirements – Base case scenario

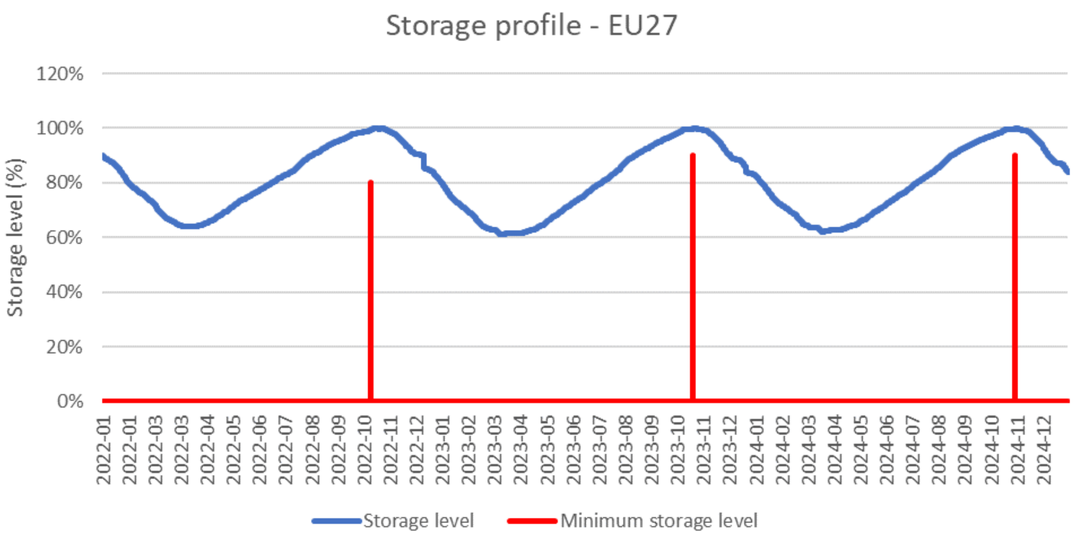


Figure 15: Gas storage profile at EU27 level and minimum storage requirements – Base case scenario

4 EU GAS ADEQUACY ASSESSMENT RESULTS

This section presents the gas adequacy assessment results under different gas demand scenarios for a given gas supply level provided in IEA's 2023 gas outlook (IEA, 2022). See section 2.3 for the definition of the scenarios.

4.1 BASE CASE SCENARIO RESULTS

The base case scenario assumes a relatively warm year in which the gas demand reduction measures are respected, and no new gas demand is foreseen. Under these conditions, the gas demand (final gas consumption and gas for power generation) would be lower than the available supply, leaving a margin of 250 TWh (26 bcm) of gas (see Figure 16).

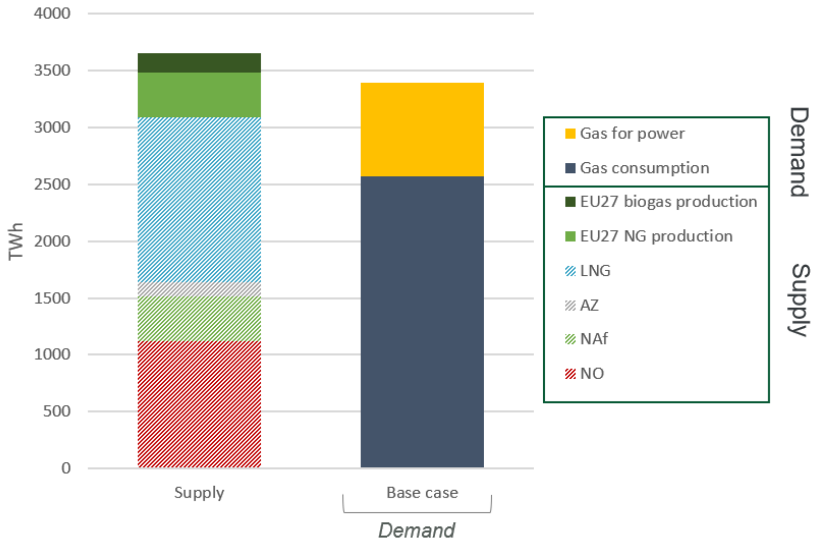


Figure 16: Gas supply-demand balance in 2024 in the base case

4.2 NO GAS DEMAND REDUCTION MEASURES RESULTS

Following the energy crisis and the disruption of the gas supply routes, the EC defined voluntary **gas demand reduction targets** aiming to ensure gas supply-demand adequacy. The EU Member States agreed to reduce their natural gas consumption by 15%[10].

Figure 17 presents the gas consumption reduction in August 2022-March 2023. It can be observed that these targets were respected at EU level even if some Member States failed to reach them.

[10] The reference being the average consumption per Member State between 1 April 2017 and 31 March 2022.

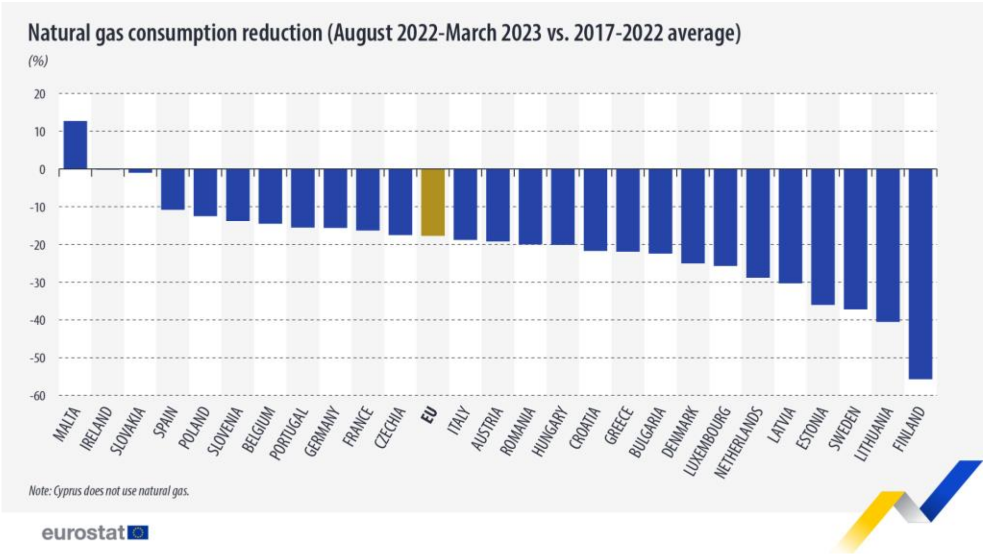


Figure 17: Natural gas consumption reduction per Member State (Eurostat, 2023)

These targets were first defined for April 2022-March 2023, and later extended to April 2023-March 2024.

In the base case, these reduction targets are enforced and considered as respected. To assess the impact of these consumption reduction targets, the 'no gas reduction scenario' is defined where these demand reductions targets are not respected.

The impact is shown in Figure 18. The gas demand in the no gas reduction scenario increases of 131 TWh (13 bcm) compared to the base case. It can be observed that the gas supply remains sufficient to meet the demand without gas demand reduction measures, leaving a margin of 127 TWh (13 bcm).

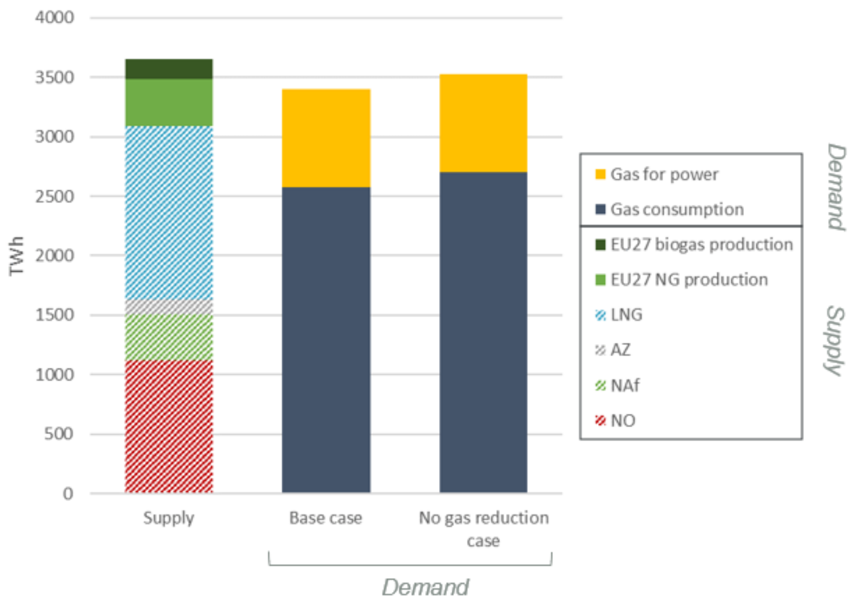


Figure 18: Gas supply-demand balance in 2024 in the no gas reduction scenario

4.3 Cold case scenario results

The Cold case scenario studies the impact of a cold weather year for the year 2024.The **weather condition**, and especially the cold periods, impacts both the power and the gas systems in terms of the gas & electricity demand, as well as the renewable electricity production.

The coldest weather year provided in the Pan-European Climate Database (PECD) of ENTSO-E[11] is 1988. It is identified based on the average heating degree days (HDD) at EU level. The year 2014, chosen as weather year for the Base case scenario in 2023 & 2024 (based on the assumptions from the *JRC Power context 2023*), is one of the warmest years provided in the PECD. Using the years 1988 and 2014 thus allows to cover a broad range of potential weather conditions.

Weather year	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
HDD Average EU	3510	3678	3466	3314	3274	3430	3726	3525	3665	3290	3012	3033	3400	3210	3375	3147	3219
Weather year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
HDD Average EU	3533	3194	3263	3129	2961	3210	3063	3226	3216	3210	3085	2986	3036	3113	3497	2968	3238

Figure 19: Average Heating Degree Days for the different years provided in the PECD

The Cold case scenario builds on the scenario not respecting the gas demand reduction measures but adapts the following inputs to take into account the impact of the cold weather:

- The **power demand** and **renewable production** profiles from the PECD for the years 1988 are directly used in the METIS model.
- In the gas sector, the thermosensitive share of the **gas demand** is scaled using the HDD of 1988.

The results below present the impact of the cold weather on the power and gas sectors. The "Cold case" is compared with the "No gas reduction scenario" to evaluate the impact of the weather on the gas and power sectors.

Figure 20 shows the impact of the cold weather on the gas demand. It can be observed that there is an increase of 90 TWh (4%) of the final gas consumption due to colder weather (higher heating demand). On the other hand, there is a small reduction (of <1%) of the gas use for power generation. Indeed, the higher final gas consumption provokes an increase in the gas prices and thus a slight reduction of competitivity of gas-fired power generation.

The additional gas needs are met by larger gas imports, mostly LNG imports.

[11] The PECD is a database from ENTSO-E providing power demand profiles and renewable production profiles for different weather years (1982-2016).

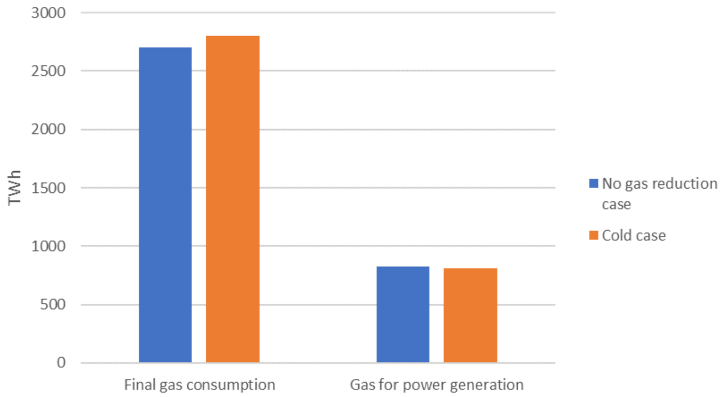


Figure 20: Comparison gas demand between the "No gas reduction case" and the "Cold case"

Contrary to the gas sector, the cold weather has a limited impact on electricity sector, as shown in Figure 21.

In the cold case scenario, there is a small increase in power demand of 32 TWh (~1%) due to colder weather. Figure 21 shows that this increase is mostly compensated by a higher production of wind energy which generally increases in colder years. Thermal generation is almost not affected except for the marginal decrease of gas-fired power generation as mentioned earlier.

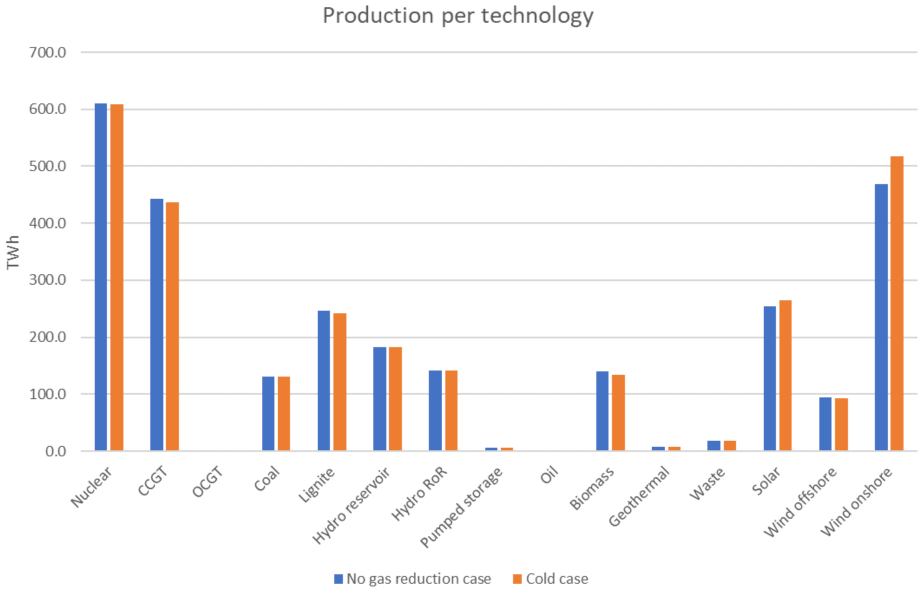


Figure 21: Comparison generation mix between the "No gas reduction scenario" and the "Cold case"

The gas adequacy assessment result shows that the gas demand increase by about 90 TWh compared to the no gas reduction case and of 220 TWh compared to the base case (see Figure 22).

As a result, the total gas demand in the Cold case scenario is still slightly lower than the projected gas supply (margin of 37 TWh) and no gas supply-demand gap is foreseen.

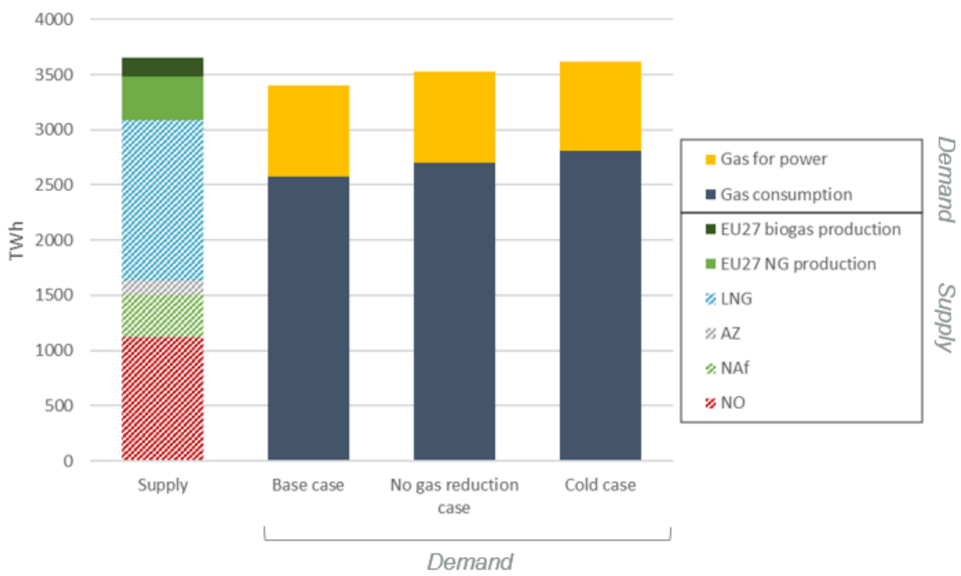


Figure 22: Gas supply-demand balance in 2024 in the Cold case scenario

4.4 STRESS CASE SCENARIO RESULTS

Besides the non-compliance with gas demand reduction measures and cold weather conditions, a third factor is the addition of new gas demand which would materialise if the EU would supply Ukraine and Moldova with gas. In case of total disruption of imports from Russia, these two countries could need up to 10 bcm per year of gas supply from the EU (IEA, 2023) in 2023 and 2024.

The stress case scenario builds on the cold case scenario but adds an additional gas demand of 10 bcm to represent the supply to Ukraine and Moldova. It can be seen as a worst-case scenario in terms of gas adequacy, with no respect of the gas demand reduction measures, cold weather and additional demands from Ukraine and Moldova.

Figure 23 and Figure 24 present the gas adequacy in the stress case and the other scenarios. As can be observed, under the stress case, the gas supply is not sufficient, and the gas supply-demand gap could reach 60 TWh (6 bcm) in 2024. This calls for sourcing additional gas supply from the international market to meet the gas demand in winter 2024.

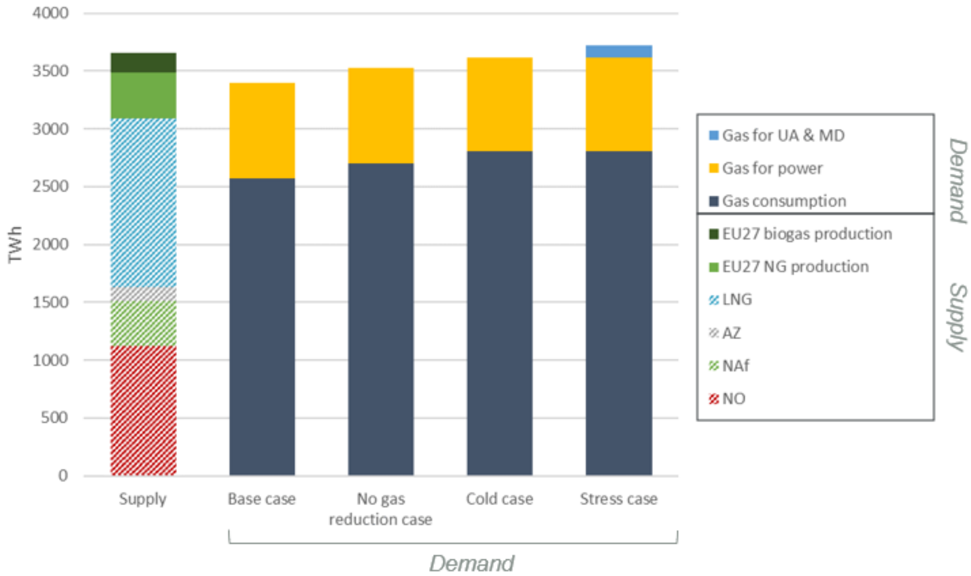


Figure 23: Gas supply-demand balance in 2024 for the different scenarios

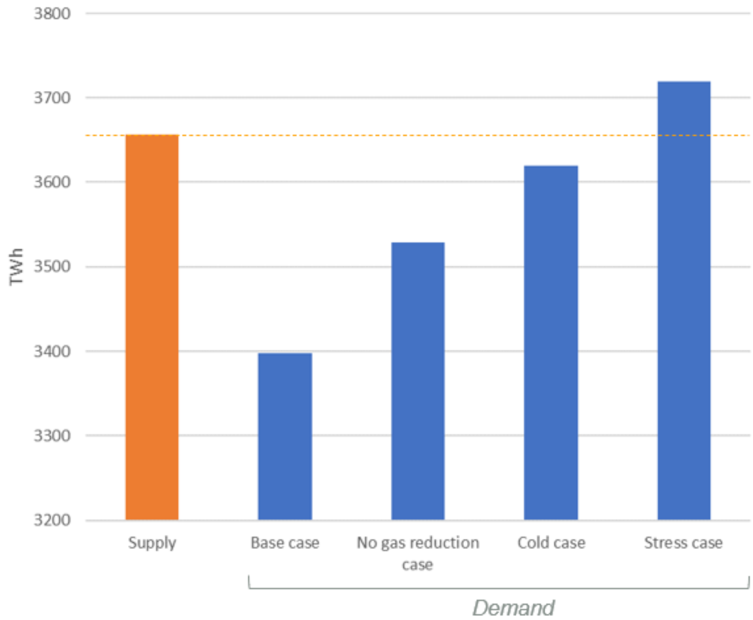


Figure 24: Gas supply-demand balance in 2023 (summary)

5 Sensitivity analyses

The previous sections show that additional gas supply would have to be secured for the winter 2024 under the stress scenario, in case of combination of multiple factors such as facing a colder weather than expected, non-respect of the gas demand reduction measures and the addition of new demands (e.g., for support to Ukraine and Moldova).

In this section, we further explore factors that could worsen the stress case in 2024, increasing the risk of gas inadequacy. The focus is on the factors that influence the gas demand in the power sector (e.g., share of RES, nuclear availability) and gas supply (e.g., LNG terminal capacity and LNG supply in the international market) as well as intermediate gas storage filling targets.

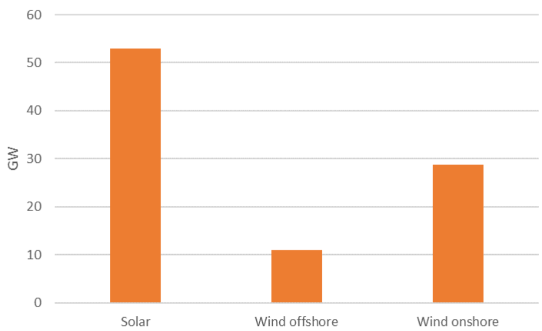
Specifically, these questions are addressed:

1. **Limited RES expansion:** What would be the impact of limiting further expansion of RES on the generation mix and gas adequacy?
2. **French nuclear availability:** What would be the impact of French nuclear availability on the generation mix and gas adequacy?
3. **Limited additional LNG terminals:** What would be the impact of delay/cancelation of LNG terminals and FSRUs on the generation mix and gas adequacy?
4. **LNG supply:** What would be the impact of minimal availability of LNG supply for EU in the international market?
5. **Intermediate gas storage filling targets:** What would be the impact of the intermediate gas storage filling targets?

In what follows the rationale for the sensitivities and their corresponding impact on both sectors and the adequacy of the gas supply are discussed.

5.1 Limited RES expansion

In 2024 more than 90 GW of PV and wind capacities are planned to be installed, generating about 225 TWh. This sensitivity assesses the impact of delaying or not developing these capacities. The "Limited RES expansion" scenario is thus equivalent to the stress case, with as only difference that the PV and wind capacities are still the ones of 2023 instead of 2024.



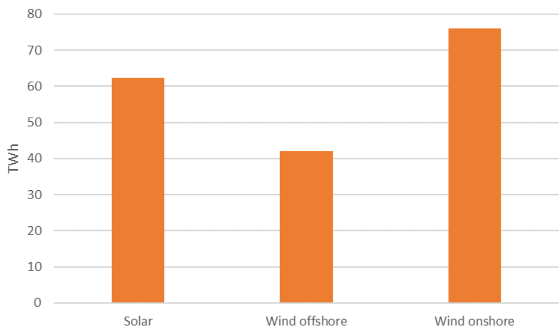


Figure 25: RES capacity (left) and RES generation (right) planned in 2024

The generation per technology in the "Limited RES expansion" sensitivity and the stress case are shown in Figure 26 presenting the absolute values in both cases and Figure 27 summarizing the changes in generation level due to the limited RES expansion.

These results show that in limiting the RES expansion in 2024 logically leads to higher thermal generation. The difference amounts to 23% for CCGTs, 15% for coal and 8% for lignite. This implies that the additional renewable generation planned for 2024 will strongly limit the use of thermal power plants (gas, coal and lignite).

Limiting the RES expansion could lead to additional costs of 50 billion € in 2024 taking into account the annualized RES costs (based on the assumption made for the 2020 Reference scenario (European Commission, 2020)) on one hand and the higher fuel costs due to the higher thermal generation on the other hand.

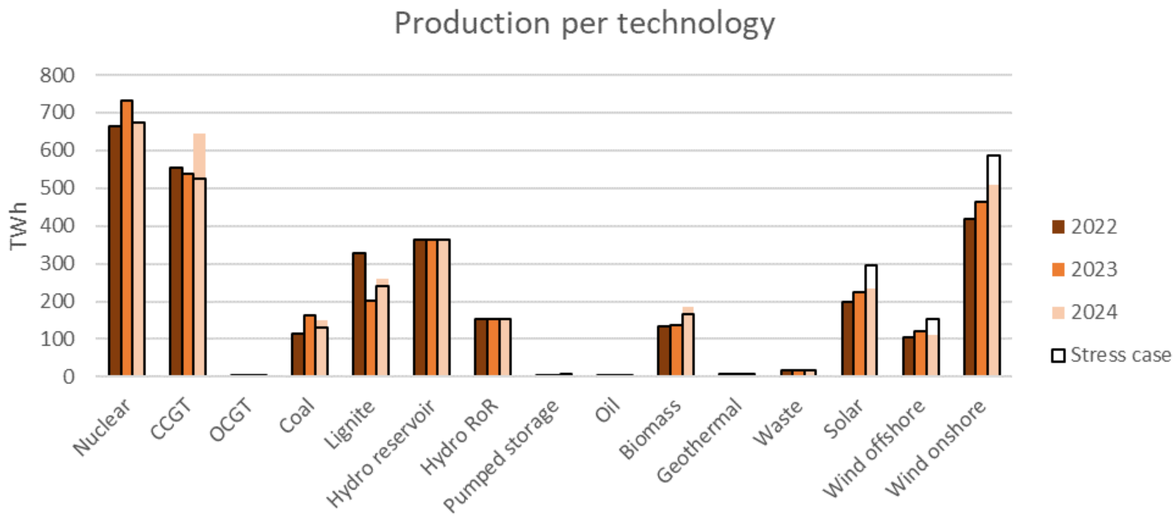


Figure 26: Comparison of generation per technology between the "Limited RES expansion" sensitivity and the stress case

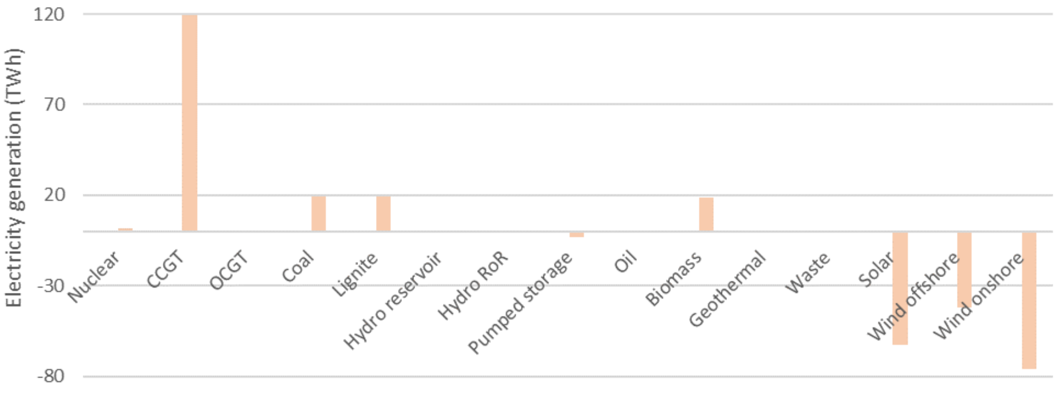


Figure 27: Difference of generation per technology between the "Limited RES expansion" sensitivity and the stress case in 2024

The lower renewables production also impacts the production per country, as shown on Figure 28. The Member States with the largest renewable production in the stress case

(DE, ES, GB, IT, NL…) are the most impacted ones, with thermal generation replacing renewables. This higher thermal generation mostly consists in CCGTs except in Germany, Poland and Bulgaria where the production based on coal & lignite also increases significantly.

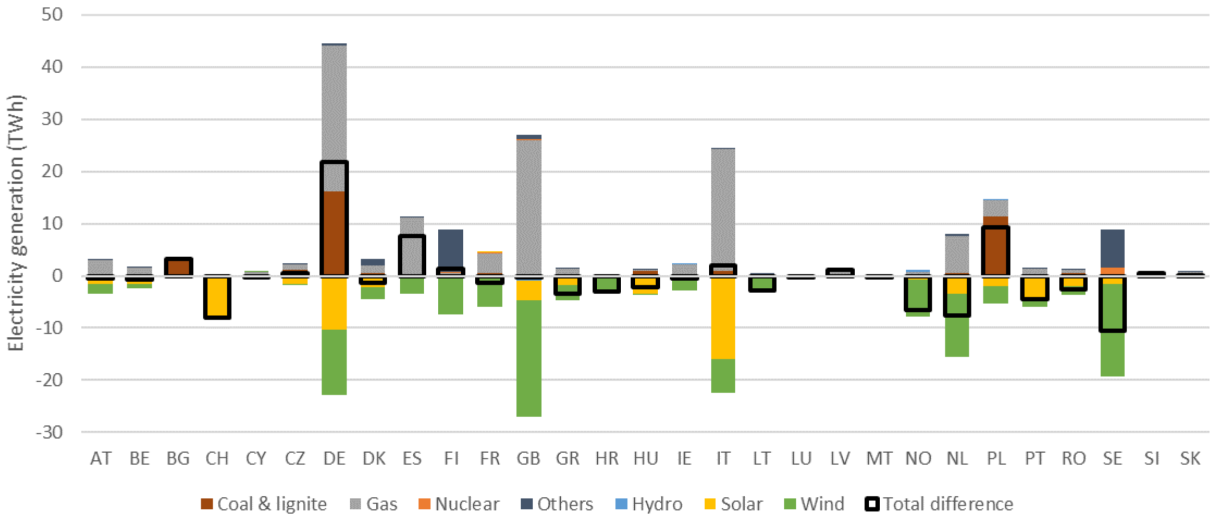


Figure 28: Difference between the electricity generation in the "Limited RES expansion" sensitivity and the stress case per technology and per country in 2024

The renewable capacities installed in 2024 significantly limit the need for thermal generation and thus gas consumption. As shown in Figure 29, they allow to reduce of 18 bcm (20%) the gas consumption for power generation compared to a case where they are not installed. The gas shortage could reach around 240 TWh (24 bcm) in the "Limited RES expansion" sensitivity compared to 6 bcm in the stress case scenario. The gas supply-demand adequacy is highlighted in Figure 30.

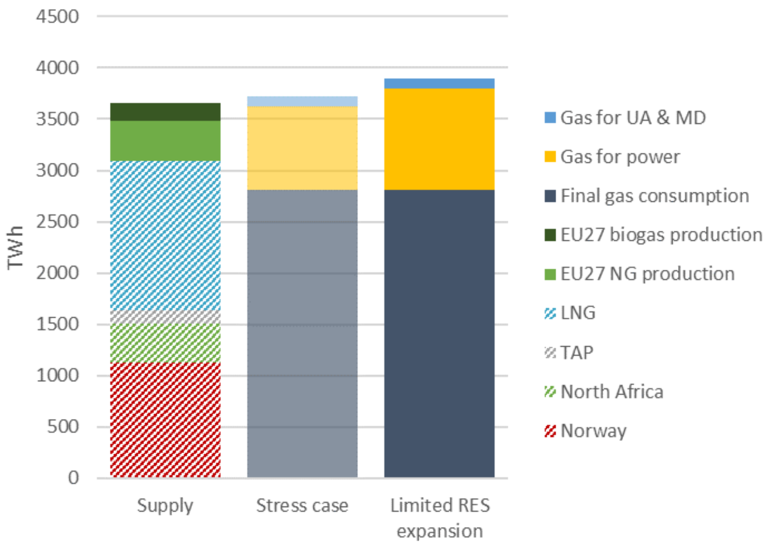


Figure 29: Comparison between the gas supply available for the EU, the gas consumption in the stress case and in the "No RES expansion" sensitivity

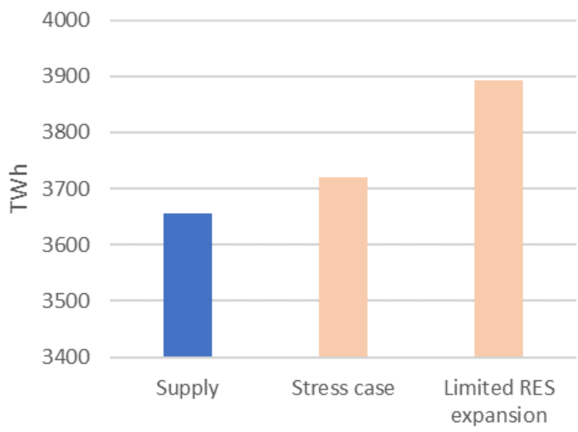


Figure 30: Zoom on the gas comparison between the gas supply and the gas consumption in the stress case and in the "No RES expansion" sensitivity

5.2 French nuclear availability

The French nuclear generation plays a central role in the European generation mix. It accounted for about 12% of the EU27 electricity production and half of the EU27 nuclear production. Therefore, its availability is key to evaluate the future gas-based power generation and the future gas needs.

The French nuclear availability was historically low in 2022, due to maintenance shutdowns and cooling water restrictions caused by low river levels. Figure 31 displays the daily evolution of the nuclear availability over the past years from (RTE, 2023). The year 2022 was record low, with a yearly availability of less than 54%, compared to an average of 68% during the period 2015-2021. The situation is improving in 2023 but uncertainty remains.

In the base case & stress case, the availability profiles used for the different years modelled are the following ones:

- **2022:** Historical RTE 2022 profile
- **2023:** Historical RTE 2023 profile up to Oct. and 2021 profile for Nov.-Dec.
- **2024:** Same profile than 2023

They are presented in Figure 32**.**

Two sensitivities are assessed for the year 2024:

1. "*Low nuclear availability":* The availability remains at the low 2022 levels in 2024 (see Figure 32)
2. "*High nuclear availability*": The availability is significantly higher in 2024, and goes back to its average values of the 2015-2019 period (see Figure 32)

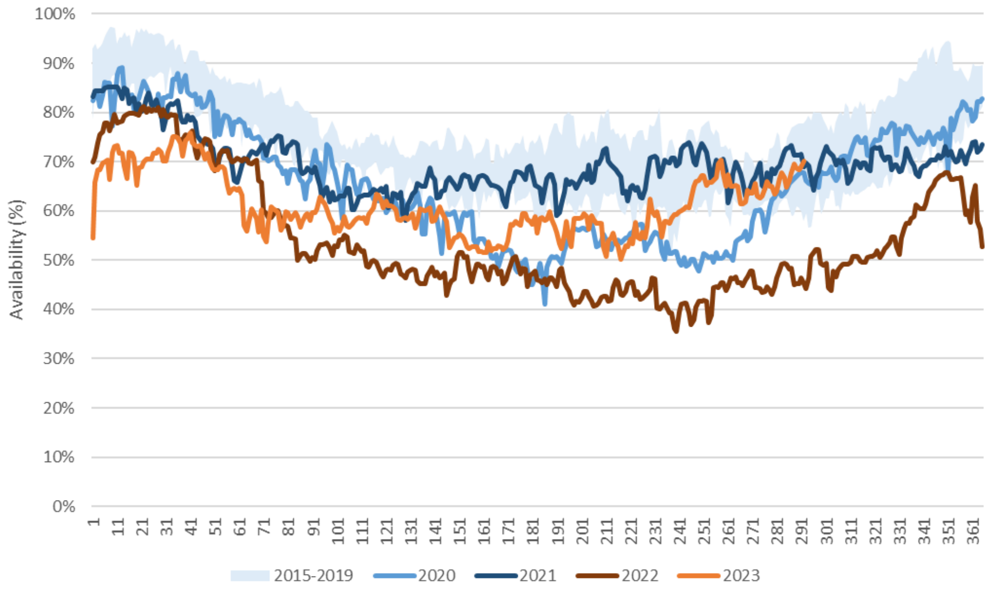


Figure 31: Historical nuclear availability in France (RTE, 2023)

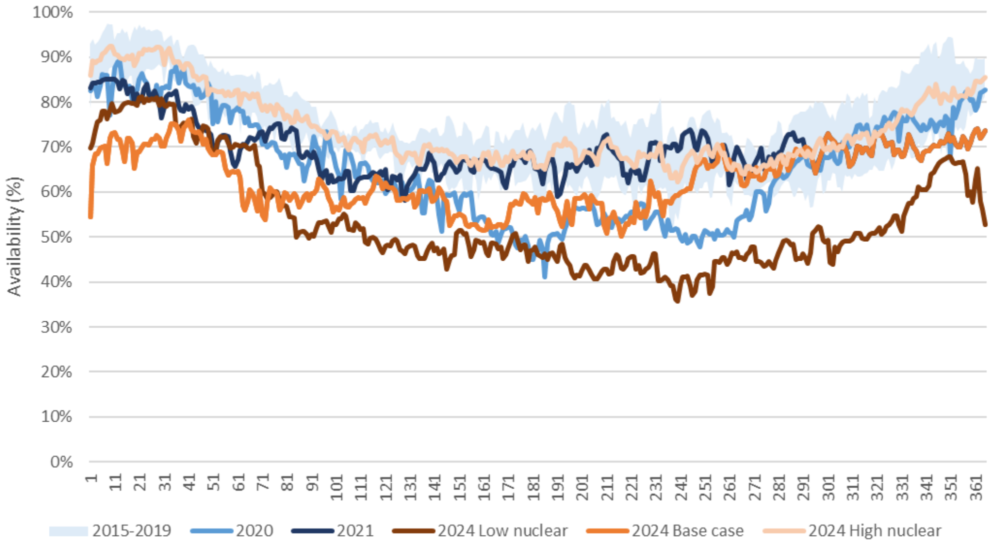


Figure 32: Nuclear availability profiles in the Base case scenario, and the low & high nuclear sensitivities

If the nuclear availability remains at 2022 levels, the nuclear production would be 50 TWh lower than in the stress case. In that case, the nuclear production in France would reach 290 TWh in 2024 compared to 340 TWh in the stress case.

On the contrary if the nuclear availability in France goes back to its average levels of the period 2015-2019, the nuclear production would be 60 TWh higher than in the stress case and reach 400 TWh.

The nuclear availability strongly impacts the thermal generation under both a "low nuclear" availability (2022 levels) and a "high nuclear" availability (historical levels of 2015-2019) cases. Figure 33 and Figure 34 show how the electricity generation per technology and Member State compare against the stress case.

The CCGTs act as a buffer, replacing or being replaced by the variations in nuclear generation. The largest impacts are in France and its neighbouring countries (such as Germany, Italy, Spain or the United-Kingdom).

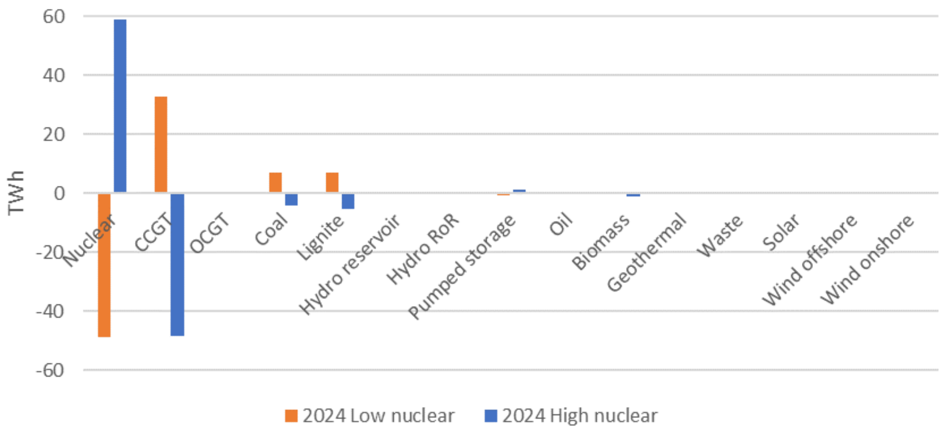


Figure 33: Electricity generation per technology (difference with the stress case)

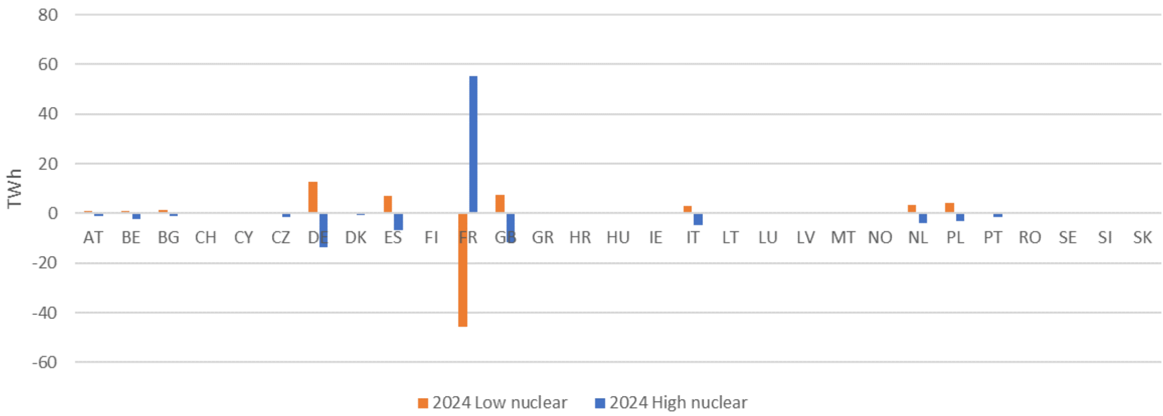


Figure 34: Electricity generation per Member State (difference with the stress case)

The gas supply-demand adequacy at EU level is thus strongly impacted by the availability of nuclear in France. A low nuclear availability would increase the gas demand by 50 TWh (5 bcm), leading to shortage of 11 bcm under the stress scenario. On the other hand, restoring to higher availability levels could reduce the gas consumption of 70 TWh (7 bcm), leading to margin of around 1 bcm.

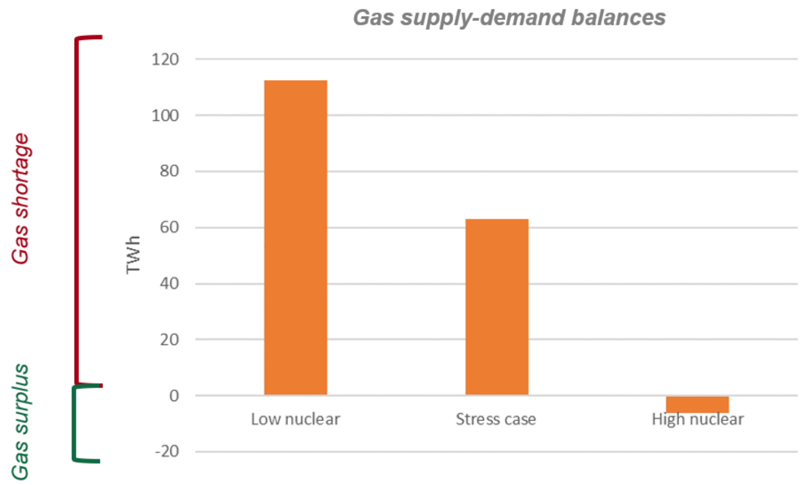


Figure 35: Gas supply demand balance in the stress case, and in the low & high nuclear availability scenarios

5.3 Limited additional LNG terminals

Following the energy crisis and the disappearing of gas imports from Russia via pipelines, many LNG terminals projects have been planned all over Europe. The total historical and planned LNG import capacity is shown in **Error! Reference source not found.**. Several additional LNG terminals are already planned to be commissioned in 2023-2024.

After the peak of 2022-2024 linked with the energy crisis, LNG demand is projected to decline due to the decreasing share of gas in the energy mix. The renewable development and the energy transition are expected to reduce the needs in fossil fuels and in gas imports.

The "Limited additional LNG terminals" sensitivity assesses the impact of having reduced LNG capacities. The terminal capacities planned for 2024 could indeed be delayed or cancelled and it is key to understand how the energy system might react in such case. The terminals planned in 2024 are mostly Floating Storage Regasification Units (FSRU) or extensions of existing terminals:

- FSRU Rostock (Germany)
- FSRU Stade (Germany)
- FSRU SNAM (Italy)
- FSRU Polish Baltic Sea Coast (Poland)
- Expansion of Zeebrugge (Belgium)
- Alexandroupolis LNG terminal (Greece)
- Expansion of LNG Croatia (Croatia)
- Skulte LNG terminal (Latvia)

This sensitivity assesses the impact on the system of having this set of terminals not available throughout the horizon of the study.

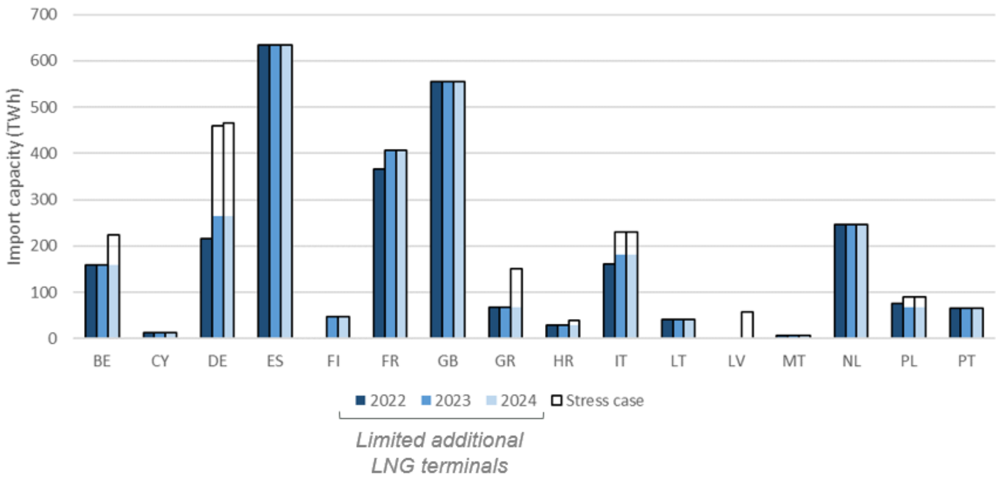


Figure 36: Comparison of the LNG terminals import capacity per Member State between the "Limited additional LNG terminals" and the stress case

The resulting electricity generation are compared with the stress case in Figure 37 and Figure 38, per technology and per Member State respectively.

Delay or cancellation of planned LNG terminals & FSRUs for 2024 is found to have a minimal impact on the power generation mix at EU level, with less than 1% of gas-to-coal switches.

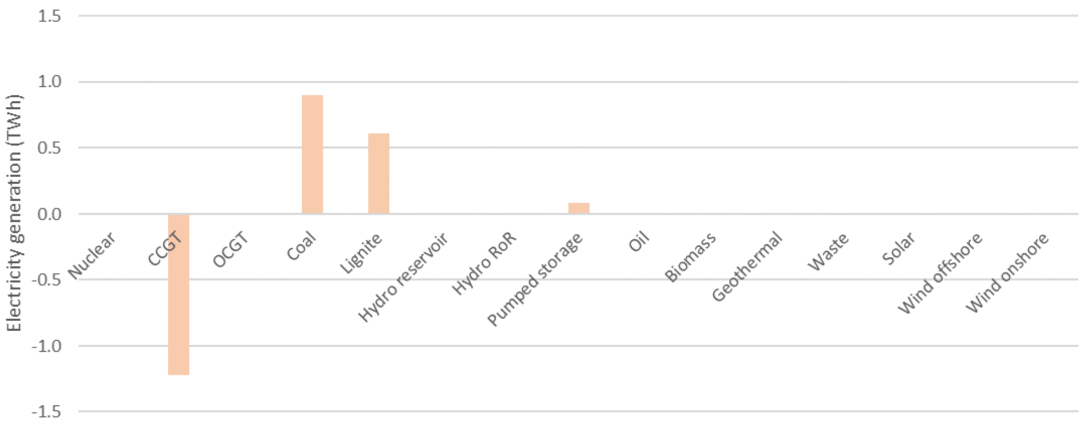


Figure 37: Electricity generation per technology (difference between the "Limited additional LNG terminals" and the stress case)

Figure 38: Electricity generation per Member State (difference between the "Limited additional LNG terminals" and the stress case)

As opposed to the electricity mix, the repartition of the LNG imports between the Member States is strongly impacted by the delay or cancelation of LNG terminals. Figure 39 compares the LNG imported per Member State between the "Limited additional LNG terminals" sensitivity and the stress case.

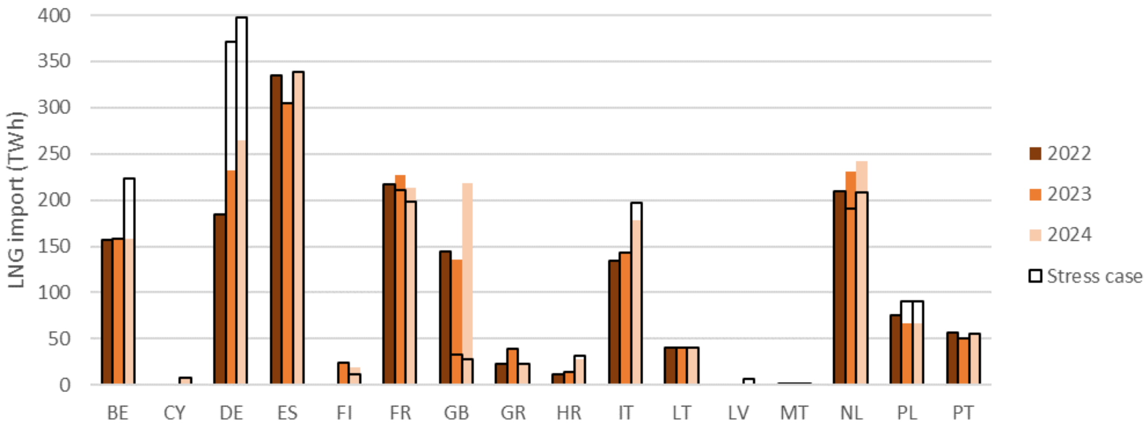


Figure 39: LNG imports per Member State (comparison between the "Limited additional LNG terminals" and the stress case)

Overall the existing capacities are used more intensively, as shown in Figure 40 and summarised in Figure 41, but the average utilisation rate remains at acceptable levels (below 70%).

Since 2023 and 2024 are expected to be among the most critical years because the LNG demand is foreseen to decrease in the second half of the decade, there will most likely be a lower utilisation of some LNG terminals in subsequent years.

At a Member State level, one of the biggest impacts is the reduction of imports in Germany. The lower import capacities force the existing terminals to be used more intensively. Also the imports in Poland and Belgium are lower due to the delay/cancelling of the FSRU *Polish Baltic Sea Coast* and of the expansion of the Zeebrugge terminal.

Part of the German, Belgian and Polish LNG imports are replaced by larger imports in the UK, the Netherlands and France.

Overall at European level, the LNG imports in TWh remain at the same level (reduction of <1%) even if the repartition between LNG terminals is different.

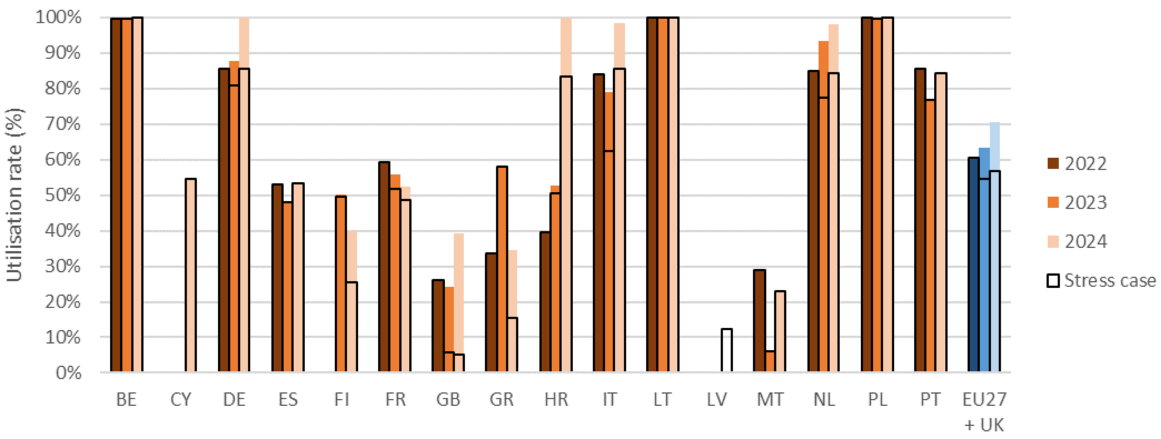


Figure 40: Average LNG terminal utilisation rate per Member State

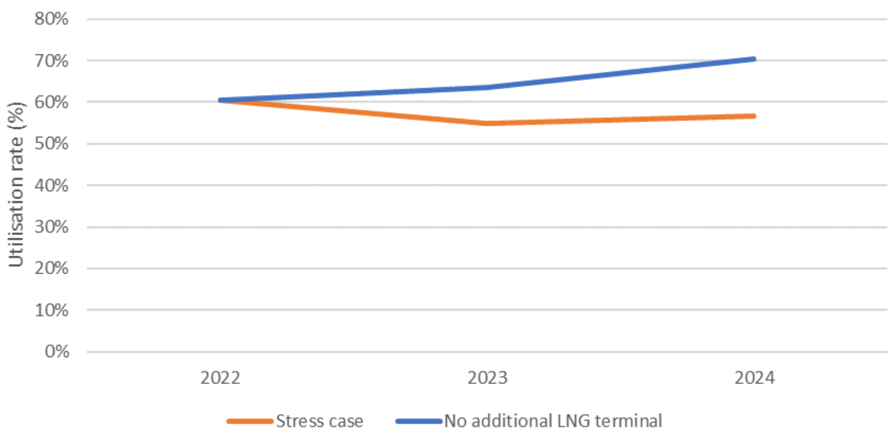


Figure 41 : Average LNG terminal utilisation rate (EU27 + UK)

Limitations of the analysis on LNG terminals

The results presented show that the existing LNG terminals are largely sufficient to import the necessary LNG quantities in 2023 and 2024 but some modelling limitations should still be highlighted. Since the internal congestions on the gas network are not represented:

- Some LNG terminals might still be needed/useful to relieve local issues and
- The choice of the importing LNG terminal strongly depends on the terminal tariffs' assumptions (ENTSOG, 2020)

5.4 LNG SUPPLY

The gas adequacy is assessed in the previous scenarios using the gas supply described in section 2.2.2, based on (IEA, 2022) and Eurostat. Several parameters are still uncertain, the most impacting ones being:

1 Global supply:

- 23 bcm additional LNG are available in 2023 on top of 2022 values (due to new liquefaction projects in the United States, Africa and Qatar) (IEA, 2022)

2 Short lead time LNG:

- Additional LNG could be developed in short lead-time, mostly through improving the use of existing LNG plants or using small scale Floating LNG (FLNG) liquefaction plants. The potential reaches 10 bcm (IEA, 2022).

3 Chinese LNG demand and LNG contracts:

- Chinese LNG demand fell by 20% in 2022 but is expected to come back to 108 bcm in 2023 (2021 level). This corresponds to an increase of 24 bcm, with an uncertainty of between +30 bcm and – 10bcm (IEA, 2023).
- China has long term contracts on 110 bcm (IEA, 2023), but only used 88 bcm in 2022 and has a right of right-of-first refusal on most of the upcoming additional LNG supply

4 Maintenance and strikes:

- Could lead to a reduction of supply of 10 bcm (IEA, 2022) (examples are maintenances in Norway and strikes in Australia)

Following the IEA, the **additional LNG available** for the EU is **7 bcm** in 2023, which is the value used in the previous scenarios & sensitivities.

To evaluate the impact of these uncertainties on the gas adequacy, the following sensitivities are defined[12] based on the parameters presented here above:

1 Stress case scenario:

- 7 bcm available for the EU on top of 2022 values

2 Low LNG supply:

- No more LNG supply available on top of 2022 values
- Maintenance and outages leading to a reduction of 10 bcm of LNG available for the EU

3 High LNG supply:

- No increase of Chinese LNG demand (potential reasons are mild weather, slow economic recovery, increase of pipelines imports…). All the 23 bcm additional global LNG supply is available for the EU.

[12] These sensitivities aim at assessing extreme situations that could impact the gas supply-demand balance. More accurate forecasts of the LNG available for the EU are out of the scope of this study.

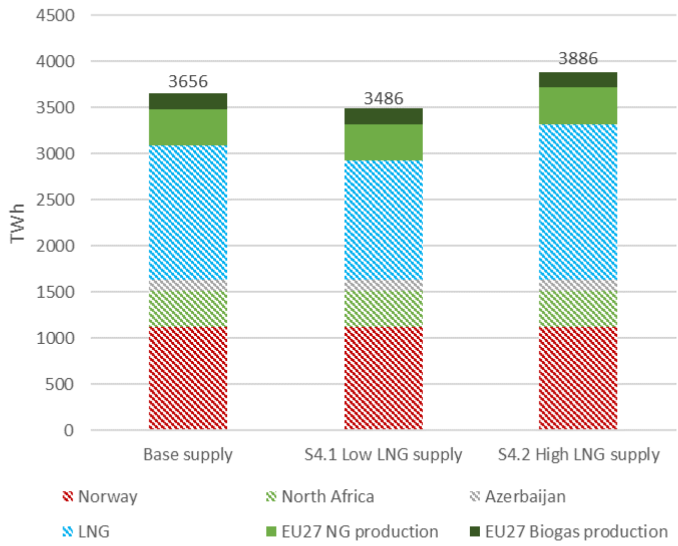


Figure 42: Gas supply for the EU27 in 2024 under different sensitivities

These different supply potentials are compared with the gas consumptions in the different scenarios and sensitivities in Figure 43.

There is an uncertainty of about 400 TWh on the LNG supply available for the EU due to various factors including the likelihood of commissioning of new liquefaction capacities, the growth of Asian gas demand, the maintenance shutdowns of terminals and labour strikes at liquefaction terminals.

If the LNG supply is minimal (170 TWh less than the base supply), the gas supply is insufficient in almost all the scenarios. Only the scenario with mild weather and gas demand reduction measures can close the gas supply-demand gap.

If the LNG supply is maximal (230 TWh more than the base supply), the gas supply is sufficient for all the scenarios.

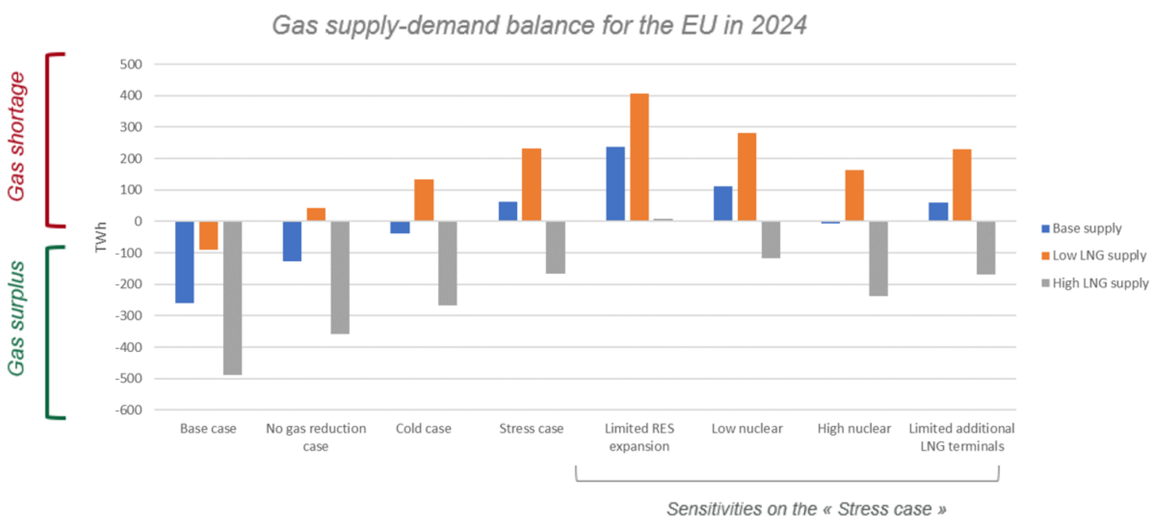


Figure 43: Gas supply-demand balance for the EU in 2024 for the different scenarios and sensitivities

5.5 INTERMEDIATE STORAGE FILLING TARGETS

Intermediate gas storage filling targets have been set in the EU for 2024 (European Commission, 2023), on top of the existing filling target of 90% on 1st of November. In this sensitivity, the additional targets have been added to the stress case to evaluate their impact. The resulting storage profiles are shown in Figure 44 and Figure 45, aggregated at EU level.

The generation mix and the gas imports in the model are not impacted by these targets. Since the congestions on the gas network are very low (no internal congestions) and that the constraints are not binding at European level (as shown on the figures here under), they do not impact the results at Member State's level.

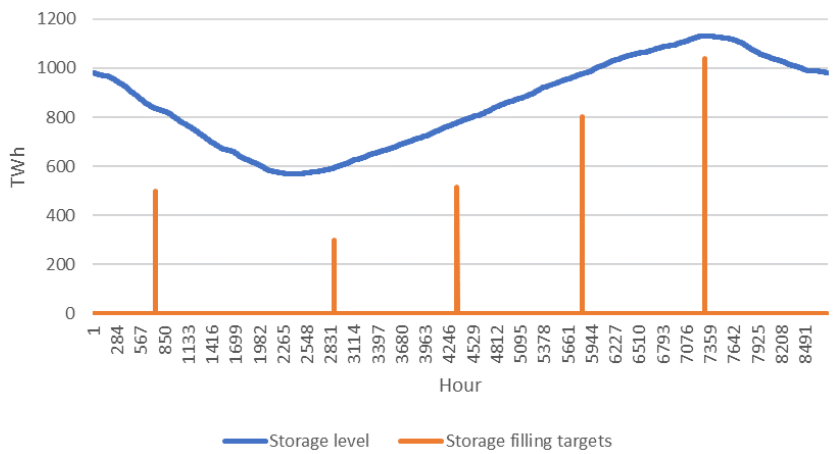


Figure 44: Gas storage level and filling targets (EU+UK) « Intermediate targets case »

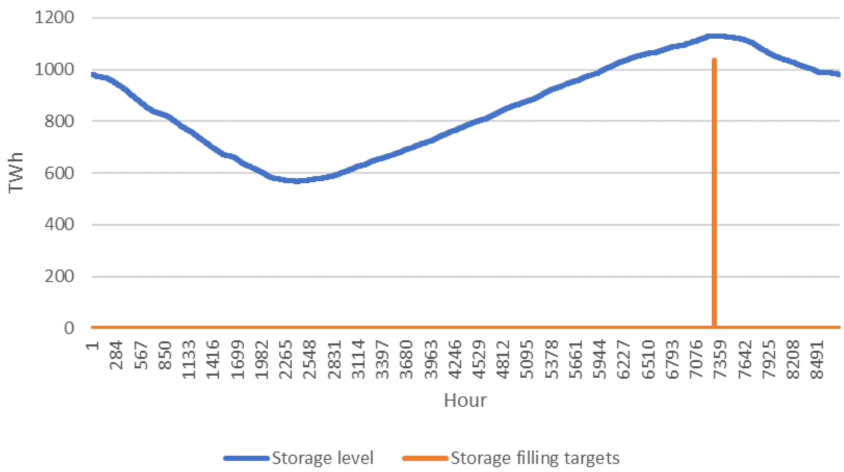


Figure 45: Gas storage level and filling targets (EU+UK) « Stress case scenario »

6 CONCLUSIONS AND OUTLOOK

This study uses the METIS platform to evaluate several potential short-term evolutions of the European power and gas sectors and assess the impact of different policies.

A first result concerns the gas supply-demand adequacy. The study shows that a combination of various risk factors including cold spell, non-compliance with gas demand reduction measures & new gas demand (combination referred to as the 'stress scenario') would call for sourcing additional supply (around 6 bcm) to meet the demand in winter 2024. The gas demand reduction measures implemented since 2022 strongly reduce the risks of gas supply-demand inadequacies.

In the power sector the years 2022-2024 will see an acceleration of the renewable deployment, allowing to limit the dependence on thermal generation. It is shown that the renewables capacities planned for 2024 could limit the gas consumption by 18 bcm, representing 20% of the gas consumption for electricity production. Around 24 bcm additional gas would be required to meet the demand in 2024 if further renewables capacity expansion is restricted under the stress scenario.

Moreover, under the stress scenario, around 11 bcm additional gas would be required if the availability of French nuclear remains at 2022 levels while restoring to historical average would lead to surplus of around 1 bcm.

In terms of gas supply, the LNG imports increase strongly and partially replace the reduction of imports via pipelines linked to the European ban on Russian gas. The LNG infrastructure is sufficient to import these additional LNG quantities. Delay or cancellation of planned LNG terminals & FSRUs for 2024 is even found to have a minimal impact on the power generation mix at EU level, with less than 1% of gas-to-coal switches. These delays or cancellation also have a negligible impact on the gas imports. The existing terminal capacities remain sufficient for LNG imports, even under a stress scenario. Since many extensions or new LNG terminals have been planned in the wake of the energy crisis, a lower utilisation of some terminals might be observed towards the end of the decade.

Even if the LNG infrastructure seems not to be a limiting factor, the LNG supply might be more problematic. Minimum availability of LNG supply for EU in the international market (because of exogenous factors such as high recovery of Chinese demand, maintenance or strikes in liquefaction terminals) can lead to gas inadequacy under most scenarios. On the contrary, if the LNG supply available for the EU is high (e.g., because of low increase in Chinese demand, additional short lead time LNG capacities…), there is no adequacy issue in none of the scenarios.

Concerning the gas storage requirements, the results show that the system can meet and even exceed them. Intermediate gas storage filling targets have recently been implemented for each Member State, with minimum levels imposed in February, May, July and September in addition to the existing target for November. The results of this study show negligible impacts of the intermediate targets on the generation mix or the gas supply-demand adequacy.

Further research is required to investigate the impact of the internal gas and power transmission constraints as this could potential adversely affect the gas supply adequacy.

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