ENTSOG
UNION-WIDE

SECURITY OF SUPPLY

SIMULATION REPORT

JANUARY **2025**

Union-wide simulation of gas supply and infrastructure disruption scenarios (SoS simulation) 2024

Contents

Executive summary

Regulation (EU) 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010 ("the Regulation") entered into force on 1 November 2017. It was subsequently amended by Regulation (EU) 2024/1789 of the European Parliament and of the Council of 13 June 2024 on the internal markets for renewable gas, natural gas and hydrogen.

The Regulation assigns to ENTSOG the task to carry out a Union-wide simulation of gas supply and infrastructure disruption scenarios every four years, in cooperation with the Gas Coordination Group[1]. ENTSOG's previous Union-wide Security of Supply Simulation Reports were published in October 2017 and November 2021. Since then, the European gas transmission grid and market conditions have undergone significant changes. At the request of the Gas Coordination Group, ENTSOG conducted a revision of the simulations earlier than required by the Regulation, in 2024. Consequently, the methodology and assumptions for ENTSOG's Union-wide security of supply simulation report 2024 have been thoroughly reviewed by ENTSOG in collaboration with the Gas Coordination Group. In addition, the composition of risk groups, as defined in Annex I of Regulation, as well as the disruption scenarios, were reassessed by ENTSOG and the Gas Coordination Group for the assessment in this report.

All disruption scenarios in this edition of the simulation report assume a complete disruption of Russian pipeline supply during the winter season period. Therefore, the Eastern gas supply risk group (point 1 of Annex I in the Regulation) and related disruption scenarios involving supply from Russia have not been retained due to changes in their major supply infrastructure and significant overlap with the North Sea risk group. The increased role of gas supply in the form of LNG to Europe was addressed by the new "LNG" risk group which includes all Member States. The disruption scenarios related to L-gas, which was part of the North Sea risk group, were discontinued due to the conversion of gas markets from L-gas to H-gas.

As a result, the 12 supply and infrastructure disruption scenarios cover all the emergency supply corridors as well as the four Risk Groups of Member States: North Sea, North African, South-East and LNG supply.

The main findings of the Union-wide simulation of gas supply and infrastructure disruption scenarios (SoS simulation) 2024 are:

- The gas infrastructure, including projects commissioned since 2022 following the invasion of Ukraine and projects to be commissioned over the next year, increases energy security in the EU and significantly improves possible cooperation among Member States during extreme climatic conditions and individual supply route disruption scenarios.
- Even if the infrastructure enables an efficient European gas market, an unexpected combination of extreme climatic conditions and supply route disruption may nevertheless result in local constraints and limitations, requiring some demand side response measures (either policy-based or price-based). The analysis shows that satisfying demand in cold winter and maintaining a minimum 30% average Underground Gas Storage (UGS) stock level at the end of the winter season would require at least a 10% demand side response, depending on the balance between supply source availability and gas in storage.
- Gas storage facilities and LNG terminals are essential for ensuring seasonal and short-term flexibility. The evolution of storage levels is driven by market decisions and can significantly influence withdrawal capacities. Low UGS stock level leads to a decrease in withdrawal capacity,

[1] The Gas Coordination Group is a standing advisory group, coordinating security of supply measures, especially during crises

primarily due to reduced pressure in the storage. The simulation results show that short-term high demand events (typically expected to occur late in winter) can be managed through efficient withdrawals from UGS and LNG tanks assuming that above mentioned measures, e.g., 10% demand response reduction and adequate storage level at the beginning of the cold demand event (not lower than 35%) would be in place. Nevertheless, in some cases of peak day demand combined with an infrastructure disruption scenario, infrastructure limitations can prevent a few Member States from fully efficient cooperation.

- In all scenarios, efficient cooperation between EU Member States ensures that exports to non-EU countries can be maintained and supplied up to the available capacity.

Important: *The Security of Supply results should be interpreted as an assessment of the ability of the gas infrastructure to allow for an efficient cooperation of the EU Member States to cope with an unusual cold winter season under different scenarios. The EU-wide simulation is not a forecast of the expected gas supply situation.*

Table 1. Disruption scenarios Union-wide security of supply simulation 2024 results summary

Risk Group	#	Disruption scenario	Disruption location / duration	Demand response	Final UGS filling level
-	-	Reference case	-	**No**	**3%**
				10%	30%
North Sea	**1**	Disruption of the largest offshore infrastructure to continental EU (Europipe 2)	offshore / 6 months	**10%**	**22%**
				13%	30%
	2	Disruption of the largest onshore infrastructure from Norway (Emden station)	onshore / 2 weeks	**10%**	**29%**
				10%	30%
	3	Disruption of the largest infrastructure to Denmark (Nybro area)	onshore / 2 weeks	**10%**	**30%**
				-	-
	4	Disruption of the largest offshore infrastructure to the UK (Langeled)	offshore / 6 months	**10%**	**27%**
				11%	30%
	5	Disruption of Forties pipeline system	offshore / 6 months	**10%**	**26%**
				11%	30%
North African	**6**	Disruption of the largest offshore infrastructure to Italy (Transmed)	offshore / 6 months	**10%**	**18%**
				14%	30%
	7	Disruption of the largest offshore infrastructure to Spain (Medgaz)	offshore / 6 months	**10%**	**28%**
				11%	30%
	8	Disruption of all imports from Algeria, including LNG	offshore / 6 months	**10%**	**10%**
				17%	30%
	9	Disruption of all imports from Libya	offshore / 6 months	**10%**	**29%**
				-	-
South-East	**10**	Disruption of all imports from Turkey to Greece (TANAP + Kipi import point)	offshore / 6 months	**10%**	**26%**
				12%	30%
	11	Disruption of the largest onshore infrastructure to Greece (TANAP)	onshore / 2 weeks	**10%**	**30%**
				-	-
LNG	**12**	S-1 LNG. Limited availability of LNG supply	6 months	**10%**	**16%**
				15%	30%

1. Introduction

Regulation (EU) 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010 ("the Regulation") entered into force on 1 November 2017. It was subsequently amended by Regulation (EU) 2024/1789 of the European Parliament and of the Council of 13 June 2024 on the internal markets for renewable gas, natural gas and hydrogen.

In Article 7, titled "Risk Assessment," the Regulation stipulates:

By 1 September 2022, ENTSOG shall carry out a Union-wide simulation of gas supply and infrastructure disruption scenarios, including scenarios of prolonged disruption of a single supply source. The simulation shall include the identification and assessment of emergency gas supply corridors and shall also identify which Member States can address identified risks, including in relation to LNG. The gas supply and infrastructure disruption scenarios and the methodology for the simulation shall be defined by ENTSOG in cooperation with the GCG. ENTSOG shall ensure an appropriate level of transparency and access to the modelling assumptions used in its scenarios. The Union-wide simulation of gas supply and infrastructure disruption scenarios shall be repeated every four years unless circumstances warrant more frequent updates.

The previous ENTSOG Union-wide security of supply simulation reports were published in October 2017 and November 2021. Since then, the European gas transmission grid and market conditions have undergone significant changes. At the request of the Gas Coordination Group[2] ("GCG"), ENTSOG conducted a revision of the simulations earlier than required by the Regulation, in 2024. Consequently, the methodology and assumptions for ENTSOG's Union-wide security of supply simulation report 2024 have been thoroughly reviewed by ENTSOG in collaboration with the GCG. In addition, the composition of risk groups, as defined in Annex I of Regulation, as well as the disruption scenarios, were reassessed by ENTSOG and the GCG for the assessment in this report.

Union-wide simulation of gas supply and infrastructure disruption scenarios (SoS simulation) 2024

On 19 June 2024 and 3 October 2024, the methodology and assumptions for ENTSOG's Union-wide simulation 2024 have been reviewed by ENTSOG and the GCG. Part of the assumptions from 2021 edition of the report were found to be valid and relevant.

The 2022 Russian invasion of Ukraine severely disrupted European gas markets and raised energy security concerns in Europe. Global natural gas flows were significantly reoriented, impacting the European gas transmission grid infrastructure and market conditions. As a result, Europe has become a major importer of liquefied natural gas, with its gas market becoming increasingly integrated and global. Given the significant changes, the GCG agreed to implement the following updates to the methodology and assumptions for ENTSOG's Union-wide security of supply simulation 2024:

- The composition of risk groups along with the infrastructure disruption scenarios were reassessed. Consequently, the 12 supply and infrastructure disruption scenarios cover all the emergency supply corridors as well as the four Risk Groups of Member States: North Sea, North African, South-East and LNG supply.
- The duration of offshore infrastructure disruption scenarios has been extended to six months in the 2024 edition, compared to two months in the 2021 report edition.
- TSOs were asked to review and update the high demand values used in 2021 edition in the context of market evolution and major change of the European gas supply and demand structure. National gas TSOs asked to provide this review by including specific situation of their country (the transition

[2] The Gas Coordination Group is a standing advisory group, coordinating security of supply measures, especially during crises

from L- to H-gas and/or the switch to another type of energy source in power production, heating, industry etc.).

- Ukraine and Moldova are included in the modelling perimeter, and exports to Ukraine and Moldova have been considered in the simulations. Given that the transit contract between Ukraine and Russia expires in December 2024, the 2024 Union-wide simulation additionally includes the gas demand on the left bank of the Dniester River in Moldova. The transit of EU gas through Ukraine (considering the available capacities) can be utilized by EU shippers.
- Considering the evolution of the gas system anticipated over the next four years, the Union-wide simulation 2024 accounts for the gas infrastructure existing at the time of data collection (June–July 2024) as well as projects expected to be commissioned by December 31, 2025. This 'timestamp approach' enables the simulation to reflect the configuration of emergency gas corridors applicable during the implementation of the next national plans. The selection of relevant projects is based on the technical data submitted to ENTSOG by project promoters for TYNDP 2024 (excluding less advanced projects) and verified by national TSOs.
- The LNG maximum supply potential is based on historical data from the last two winter seasons (W2022/23–W2023/24). New LNG projects and expansions expected to be commissioned by January 2026 are considered, potentially adding an additional 600 GWh/day.
- The scenario reflecting lower LNG supply potential (LNG Low) is addressed in one of the disruption scenarios (LNG supply risk group). It is based on the average supply over the last two winter seasons (W2022/23–W2023/24) and anticipates a situation if Europe would not be able to attract enough LNG, particularly to replace Russian LNG.
- For the 2024 edition of the Union-wide security of supply simulation, the lowest historical storage filling level considered excludes the summer of 2021 (75% at the EU level) when Gazprom did not replenish its European gas storage facilities ahead of the winter season - the storage level on 1st October was 82%.

The model assumes cooperative behaviour among all countries. This concerns:

i. an avoidance of eventual risk of demand curtailment or sharing it if impossible to avoid between the countries if technically possible;
ii. LNG supply distribution between terminals according to security of supply needs;
iii. storage utilization according to security of supply needs.

However, the model does not factorize commercial supply agreements.

The input data for the simulations including gas demand under different climatic conditions, infrastructure capacities and estimates for gas production were submitted by TSOs, Associated Partners and Observers to ENTSOG as part of a specific data collection process in June - July 2024.

The supply and infrastructure disruption scenarios as well as the methodology and assumptions are further detailed in the next chapters.

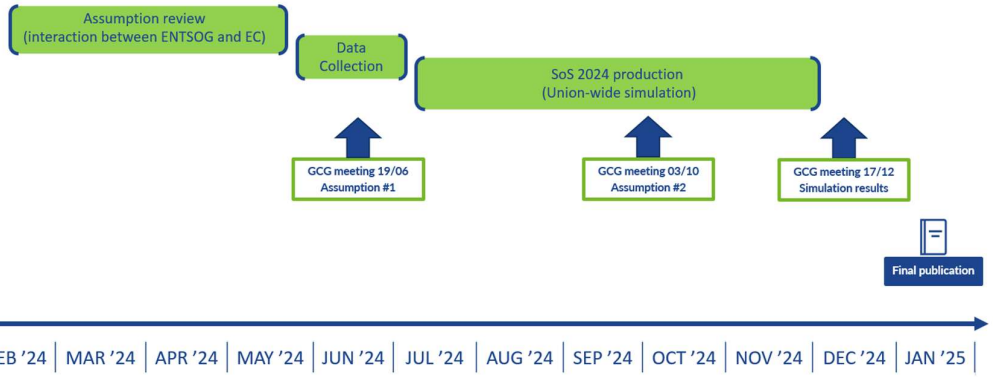


Figure 1. Timeline of the Union-wide security of supply simulation 2024

2. Supply and infrastructure disruption scenarios

Russia's invasion of Ukraine triggered energy security concerns in Europe. The need to replace Russian pipeline supply gas and change in gas flow pattern led to the changes in the structure of regional cooperation among Member States within the risk groups. These changes are driven by increased interconnectivity, new infrastructure, and the increasing role of global LNG. Consequently, the composition of risk groups, as defined in Annex I of the Regulation, along with the disruption scenarios, was reassessed by ENTSOG and the GCG during the preparation of ENTSOG's Union-wide security of supply simulation 2024. As a result, the 12 supply and infrastructure disruption scenarios cover all the Emergency Supply Corridors as well as the four Risk Groups of Member States: North Sea, North African, South-East and LNG supply.

The increased role of gas supply in the form of LNG to Europe was addressed by the new "LNG" risk group which includes all Member States. In the disruption scenario the LNG availability has been reduced to a low scenario (based on the average supply over last two winters W2022/23 and W2023/24), which anticipates a situation where not enough LNG is not attracted to Europe, particularly to replace Russian LNG.

All disruption scenarios assume a complete disruption of Russian pipeline supply during the winter period. Consequently, the Eastern gas supply risk group and related disruption scenarios have not been retained due to changes in their major supply infrastructure and significant overlap with the North Sea risk group.

The disruption scenarios related to L-gas, which was part of the North Sea risk group, were discontinued due to the conversion of gas markets from L-gas to H-gas. This led to a sharp decline in the demand for L-gas, primarily contributing to the closure of the Groningen field in 2024.

Table 2. Disruption scenarios Union-wide security of supply simulation 2024

Risk Group	#	Disruption scenario	Disruption location / duration
North Sea	1	Disruption of the largest offshore infrastructure to continental EU (Europipe 2)	offshore / 6 months
	2	Disruption of the largest onshore infrastructure from Norway (Emden station)	onshore / 2 weeks
	3	Disruption of the largest infrastructure to Denmark (Nybro area)	onshore / 2 weeks
	4	Disruption of the largest offshore infrastructure to the UK (Langeled)	offshore / 6 months
	5	Disruption of Forties pipeline system	offshore / 6 months
North African	6	Disruption of the largest offshore infrastructure to Italy (Transmed)	offshore / 6 months
	7	Disruption of the largest offshore infrastructure to Spain (Medgaz)	offshore / 6 months
	8	Disruption of all imports from Algeria, including LNG	offshore / 6 months
	9	Disruption of all imports from Libya	offshore / 6 months
South-East	10	Disruption of all imports from Turkey to Greece (TANAP + Kipi import point)	offshore / 6 months
	11	Disruption of the largest onshore infrastructure to Greece (TANAP)	onshore / 2 weeks
LNG	12	S-1 LNG. Limited availability of LNG supply	6 months

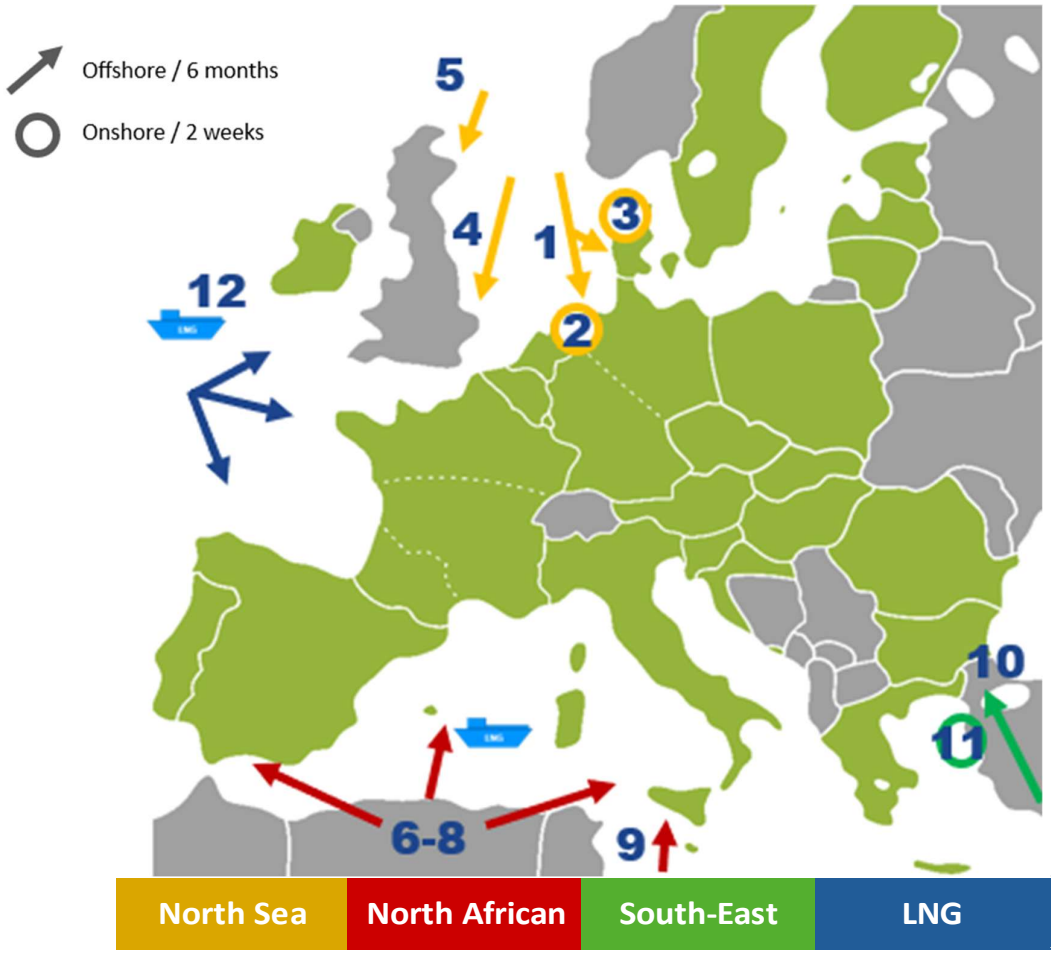


Figure 2. Disruption scenarios allocation Union-wide security of supply simulation 2024

3. Methodology and assumptions

Under the methodological context, the Union-wide security of supply simulation, as defined with the GCG, is designed to assess the gas system under challenging situations in terms of:

- Level of demand: assessing energy efficiency needs or measures needed related to demand reduction during high-demand events.
- Disruption duration and timeframe: analysing the impacts of various disruption scenarios over different periods.
- Initial gas storage levels at the beginning of the winter season: investigating low initial levels to address risks related to storage, including those associated with capacity hoarding, market manipulation, underinvestment, etc.

The assumptions cover simulation cases along with the corresponding demand assumptions, disruption scenario duration, supply potential *(*pipeline supply, LNG supply, national gas production, gas withdrawn from the underground storage facilities and LNG tanks flexibility), infrastructure, modelling and results interpretation, treatment of storages including the initial inventory levels[3].

[3] The corresponding data are available in the Annexes

3.1. Simulation cases and demand assumptions

For every scenario, 3 different cases are simulated to assess the impact of 3 high demand events:

I. Aa historical high demand winter[4] (Cold Winter) – country level historical highest gas demand since winter 2009-2010 revised by TSOs.

II. A period of 2 weeks of exceptionally high demand, occurring with a statistical probability of once in 20 years - also called 2-week cold spell.

III. One day (peak day) of exceptionally high demand, occurring with a statistical probability of once in 20 years.

For 2024 edition TSOs were asked to review and update the high demand values used in 2021 edition in the context of market evolution especially after the invasion of Ukraine and drastic change of the European gas supply and demand structure. National gas TSOs were asked to provide this review by including specific situation of their country (the transition from L- to H-gas and/or the switch to another type of energy source in power production, heating, industry etc.).

As shown in **Figure 3**, a 6% decrease in Cold Winter demand was observed from the 2021 to the 2024 edition. This decline is attributed to a general downward trend across most EU countries, with a few exceptions—Belgium, Germany, Greece, Ireland, and Poland. These countries anticipate an increase in demand due to factors such as reduced capacity factors of coal and oil power plants (new power plants) or the gasification of new regions (new large consumer).

The total winter demand of EU countries in this assessment, as part of the Union-wide security of supply simulation 2024 edition, is 4.5% higher than the demand observed simultaneously across the EU over the past five years (W2019/20 – W2023/24)[5]. This deviation is driven by the successive records of mild winters being set, as well as the fact that the historically highest winter demand did not occur simultaneously in every European country.

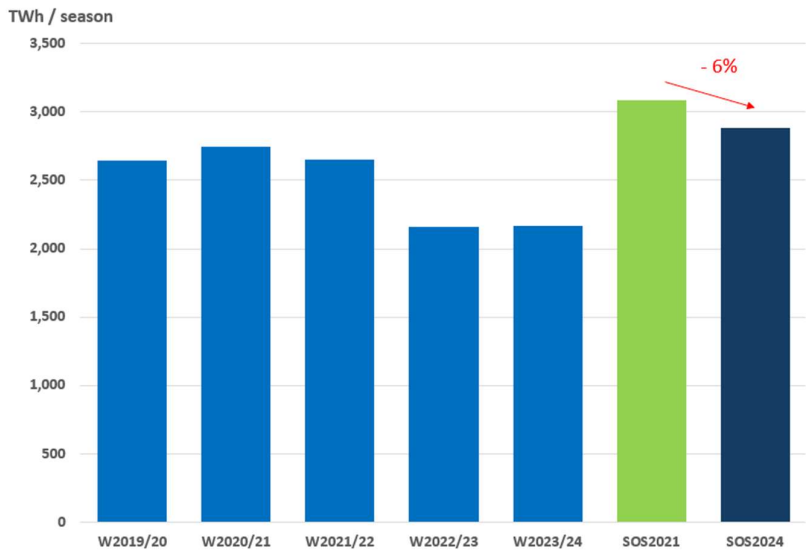


Figure 3. Comparison of demand values in EU for historical winters, SoS 2021 and SoS 2024 Cold Winter demand assumptions, TWh/season

The high demand cases are meant to capture the capability of the gas system to cope with the most challenging demand situation (peak day / Design Case) and a long high-demand period (2-week cold spell).

[4] Period from 1 October to 31 March, covering the six months in between with 182 days in total

[5] Compared to W2020/21, reflecting higher demand over the past five years (W2019/20 – W2023/24)

Figure 4 and **Figure 5** show a 2-week cold spell and peak day demand decrease of 5% and 1% respectively, observed from the 2021 to the 2024 edition. The 1-in-20-years approach results in the total 2-week cold spell demand being 18% higher, and the peak day demand 30% higher, than the simultaneous demand observed across the EU over the past five years (W2019/20 – W2023/24)[6].

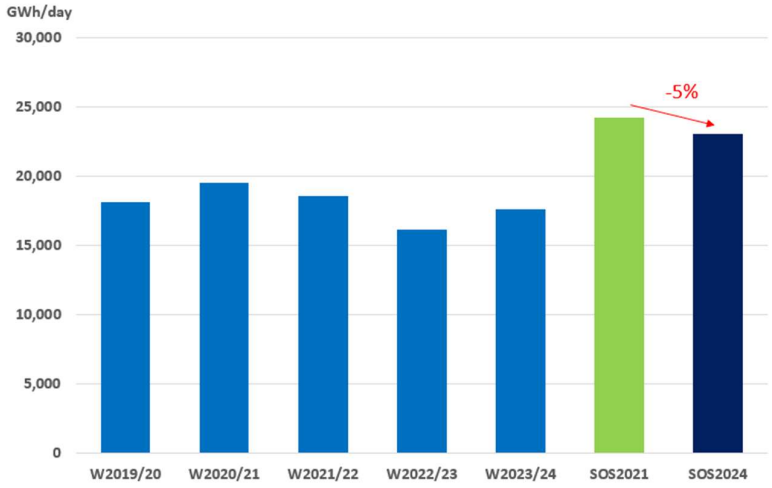


Figure 4. Comparison of 2-week cold spell values in EU for historical winters, SoS 2021 and SoS 2024 assumptions, GWh/day

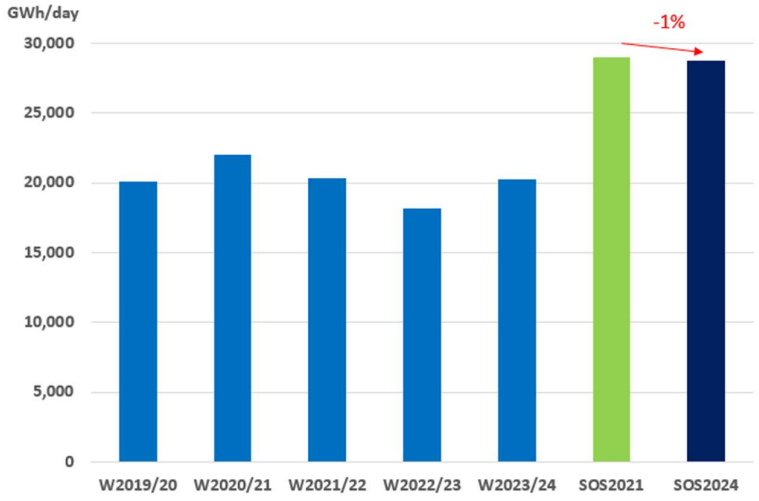


Figure 5. Comparison of peak day demand values in EU for historical winters, SoS 2021 and SoS 2024 assumptions, GWh/day

In addition to the demand within the EU member states, the demand of non-EU countries that are only supplied via the European gas infrastructure (United Kingdom, Bosnia and Herzegovina, Switzerland, North Macedonia, Serbia) have been considered in the simulations.

Ukraine and Moldova are included in the modelling perimeter. The demand in Ukraine and Moldova is satisfied by Ukrainian national production, reserves in Ukrainian storage facilities, and imports from EU countries. Consequently, the export to Ukraine and Moldova have been considered in the simulations. Given that the transit contract between Ukraine and Russia expires in December 2024, the 2024 Union-wide simulation additionally includes the gas demand on the left bank of the Dniester River in Moldova. The transit of EU gas through Ukraine (considering the available capacities) can be utilized by EU shippers.

[6] Compared to W2020/21, reflecting higher demand over the past five years (W2019/20 – W2023/24)

In general, demand and exports to non-EU countries (United Kingdom, Bosnia and Herzegovina, Switzerland, North Macedonia, Serbia, Ukraine, and Moldova) represent approximately 16% of the total European winter demand; consequently, EU demand accounts for 84% of the total European winter demand in this assessment, as part of the Union-wide security of supply simulation 2024 edition.

Transit to Kaliningrad and exports to Turkey are not included in the simulation scenarios.

3.2. Demand and disruption timelines

The disruption periods are defined to assess the impact of the various scenarios along with a low initial storage level during these high demand events. They are not defined based on their probability of occurrence but based on agreed periods instead. However, the most challenging situations tend to occur in second part of the winter when temperatures are still relatively low, temperature peaks are common, and storage facilities are partially depleted.

The duration of offshore infrastructure disruptions has been extended to six months in the 2024 edition, compared to two months in the 2021 report edition. Consequently, the offshore disruptions are simulated for the period from October to the end of March. The onshore infrastructure disruptions with a duration of two weeks are simulated during February.

During the disruption periods, exceptionally high demand periods are considered with an occurrence probability of once in 20 years: 2-week cold spell and peak day. For these exceptional cases, an initial average storage level of 35% of WGV at the beginning of the event for all EU storage is applied[7].

Table 3. Simulation cases timeframes

Simulation case	Historical high demand winter (Cold Winter)	2-week in 20 years	Peak day in 20 years
Simulation period	From 1 October to 31 March, covering the six months in between with 182 days in total	14 consecutive days in February	1 day in February
Gas demand[8]	Highest winter demand since 2009/10 (at country level and then aggregated for EU)	Exceptionally high demand, occurring with a statistical probability of once in 20 years.	Exceptionally high demand, occurring with a statistical probability of once in 20 years.

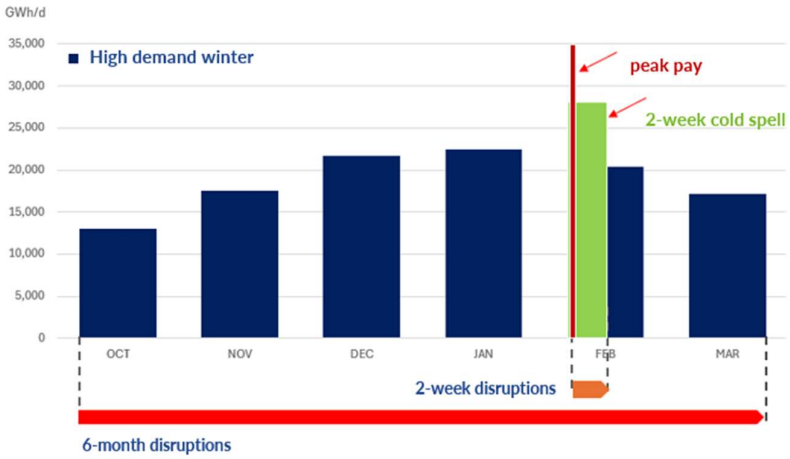


Figure 6. Demand assumption and disruption timeframes

[7] See chapter 3.5. 'Underground gas Storage' for further information

[8] TSOs were asked to review and update the high demand values used in 2021 edition in the context of market evolution especially after the invasion of Ukraine and drastic change of the European gas supply and demand structure. National gas TSOs asked to provide this review by including specific situation of their country (the transition from L- to H-gas and/or the switch to another type of energy source in power production, heating, industry etc.)

- *Specificity of scenario 8 - Disruption of all imports from Algeria, including LNG:* disruption scenario #8 considers the disruption of the imports from Algeria via both pipelines and LNG cargos. Regarding the LNG supply, it is assumed that a period of 1 month, starting from 1 October is necessary to attract more LNG cargos to substitute the Algerian LNG (see **Figure 7**).

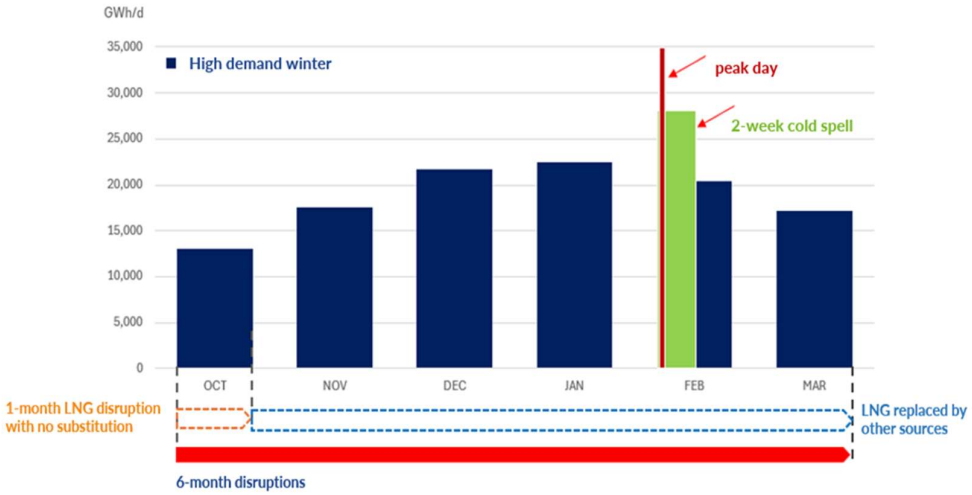


Figure 7. Demand assumption and disruption timeframes for scenario #8

3.3. Supply potential

Supply limitations are set for different time scales (monthly values for winter season, weekly values for the 2-week cold spell case, daily values for the peak day case) so that the maximum flow of each source cannot exceed reasonable levels based on historical observations[9].

Table 4. Maximum supply potential

GWh/day			NP	DZ	LY	CA	NO	LNG Ref	LNG Low
Winter Season	Max per 30 days		1984	1220	180	390	3800	6100	5100
			180 mcm/d	111 mcm/d	16 mcm/d	35 mcm/d	345 mcm/d	555 mcm/d	464 mcm/d
High Demand[10]	2-week cold spell	week 1	2036	1225	190	395	4000	[11]	[11]
			185 mcm/d	111 mcm/d	17 mcm/d	36 mcm/d	364 mcm/d	[11]	[11]
		week 2	2036	1225	190	395	4000	6200	5200
			185 mcm/d	111 mcm/d	17 mcm/d	36 mcm/d	364 mcm/d	564 mcm/d	473 mcm/d
	Peak day		2036	1285	200	400	4000	[11]	[11]
			185 mcm/d	117 mcm/d	18 mcm/d	36 mcm/d	364 mcm/d	[11]	[11]

The maximum supply potential of the various sources providing gas via pipeline[12] (Algeria, Libya, Caspian Sea, Norway) is based on historical data from the last 5 winter seasons (W2019/20 – W2023/24) and updates provided by TSOs. By default, for seasonal assessments, it is calculated as the maximum 30-day

[9] The supply potential should not be considered as a forecast. The actual supply mix will depend on market behaviour and other external factors. Moreover, the model does not factorize commercial supply agreements

[10] Additional LNG that can be taken from the tanks

[11] Limited to the observed supply potential in February

[12] No supply potential from Russia is assumed, as all disruption scenarios are based on the assumption of a full disruption of Russian pipeline supply.

rolling average supply per winter season over the last five years (if not specified by TSOs). For 2-week cold spell assessments, it is calculated as the maximum 14-day rolling average, and for peak day assessments, as the highest single-day supply over the same period.

For LNG supply potential, additional assumptions are made:

- The supply potential is based on historical data from the last two winter seasons (W2022/23–W2023/24).
- New LNG projects and expansions expected to be commissioned by January 2026 are considered, potentially adding an additional 600 GWh/day (this estimate applies an average utilization rate of 53%, based on a total technical capacity of 1,135 GWh/day for the new LNG facilities)[13].
- The scenario reflecting lower LNG supply potential (LNG Low) is addressed in one of the disruption scenarios (LNG supply risk group). It is based on the average supply over the last two winter seasons (W2022/23–W2023/24) and anticipates a situation if Europe would not able to attract enough LNG, particularly to replace Russian LNG.
- LNG flows during the first week of the 2-week cold spell simulations and during peak day simulations are limited by the February LNG flows from the whole winter simulation. In all 2-week cold spell and peak day cases the modelling accounts for the additional amount of LNG that can be withdrawn from the tanks (LNG terminals tank flexibility).
- *Specificity of scenario 8 - Disruption of all imports from Algeria, including LNG:* the model considers that the flows to the different LNG terminals are reduced by the share of Algerian LNG in their LNG mix in 2023[14].

Table 5. Share of Algerian LNG in the LNG mix per country in 2023

Algeria's share in the LNG supply mix			
Belgium	2%	**Lithuania**	3%
Croatia	0%	**Poland**	0%
Finland	6%	**Portugal**	0%
France	14%	**Spain**	8%
Germany	0%	**The Netherlands**	1%
Greece	14%	**United Kingdom**	2%
Italy	14%		

3.4. National gas production

The EU production levels are based on the best estimates from the TSOs for expected flows from production facilities in January 2026.

In recent years, a reduction in gas production has been observed in Europe, primarily driven by the decline in domestic production from the largest gas producer in the EU — the Groningen gas field in the Netherlands, which was closed on April , 2024. The national production level considered in the 2024 simulations is nearly identical to the actual production during the previous winter season, W2023/24. According to the national production values submitted by TSOs for the SoS 2024 edition, the United

[13] Information about the projects is available in chapter 3.7. 'Infrastructure'

[14] Source: https://giignl.org/wp-content/uploads/2024/07/GIIGNL_2024-Annual-Report.pdf

Kingdom leads gas production in Europe with a production of 892 GWh/day (81 mcm/day). At the EU level, Romania and the Netherlands lead, with 257 GWh/day and 252 GWh/day respectively (23 mcm/day).

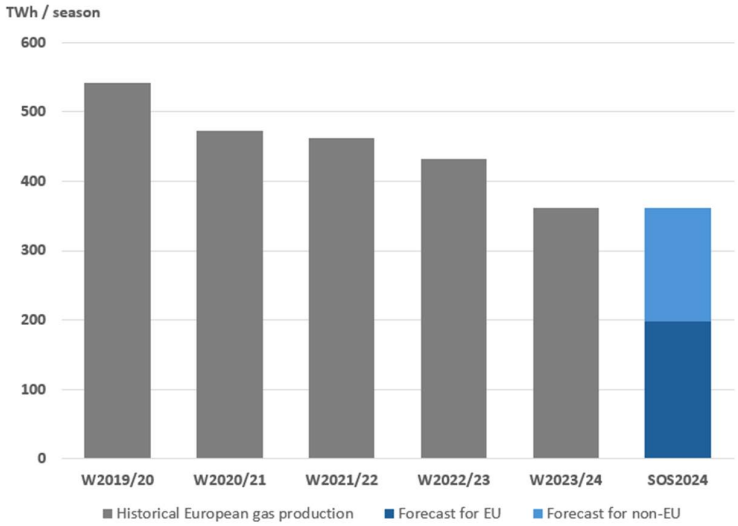
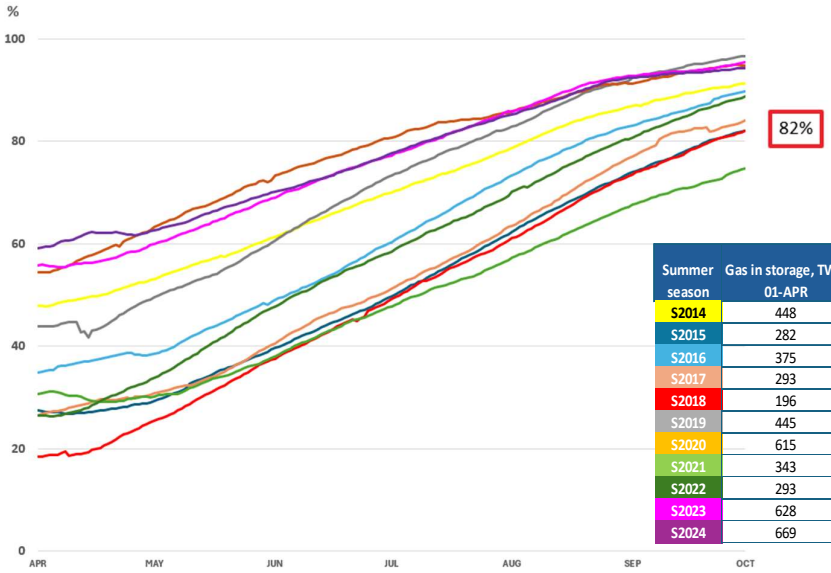


Figure 8. National production history and SoS assumption, TWh/season

3.5. Underground Gas Storage

In winter, supply flexibility in the European gas system is largely ensured by gas storage facilities. Storage is essential assets to cope with the high demand variation during the winter season. The capability of the gas system to cope with the winter demand variation depends on the storage filling levels at the beginning of the winter and the analysis is prepared annually by ENTSOG in its Winter Supply Outlook[15].

For the 2024 edition of the Union-wide security of supply simulation, the lowest historical storage filling level considered excludes the summer of 2021 (75% at the EU level) when Gazprom did not replenish its European gas storage facilities ahead of the winter season - the storage level on 1st October was 82% (see **Figure 9**[16]). Therefore, for all EU storage, 82% of their WGV is assumed on 1st October[17].



Summer season	Gas in storage, TWh 01-APR	Filling level, % 01-APR	Gas in storage, TWh 01-OCT	Filling level, % 01-OCT
S2014	448	48%	893	91%
S2015	282	27%	863	82%
S2016	375	35%	1003	90%
S2017	293	26%	931	84%
S2018	196	18%	912	82%
S2019	445	44%	1081	97%
S2020	615	54%	1074	95%
S2021	343	31%	835	75%
S2022	293	27%	991	89%
S2023	628	56%	1091	96%
S2024	669	59%	1082	94%

Figure 9. EU injection history and SoS assumption, %

[15] https://www.entsog.eu/outlooks-reviews

[16] Source: https://agsi.gie.eu/

[17] The lower storage level is kept for Latvia in line with AGSI+ historical data of 50.05%

For the 2-week cold spell and peak day assessments, the analysis is done with the assumption that these high-demand events typically occur late in winter when UGS are no longer at their maximum stock level. Consequently, they cannot deliver their maximum withdrawal capacity, and high-demand situations may arise simultaneously. To represent challenging situation in terms of the initial gas storage level at the high demand event simulations, an initial storage level of 35% of WGV for all EU storage is applied for both the 2-week cold spell and peak day assessments[18].

- *Specificity of scenario 8 - Disruption of all imports from Algeria, including LNG:* disruption scenario #8 includes an additional sensitivity analysis for 2-week cold spell and peak day assessments. It is conducted with an initial storage level that varies by country to reflect more precisely geographical impact (32% average at the EU level).

ENTSOG model considers injection and withdraw capacities provided by SSOs and TSOs. In addition to the withdrawal and injection capacities, withdrawal and injection curves for storage facilities are considered. These curves define the abilities of storage facilities to withdraw or inject gas depending on the filling level. The curves are provided by Storage System Operators via GSE[19].

Finally, some European countries could be reserving a part of their own gas stock constituted as strategic UGS reserves. The model assumes the actual constraints on the utilization of the strategic UGS and strategic reserves. Therefore, these strategic UGS are utilized after the main reserves have been depleted. The availability of strategic storage reserves is depending on the country's specific regulation.

3.6. LNG terminals tank flexibility

LNG infrastructure is characterised by the regasification capacity available along the winter season and the peak send out capacity available during high demand situations. The LNG tank volumes have operational characteristics specific for each terminal. LNG stored in the tanks fluctuates within a normal operating range and a minimum amount of LNG that must be kept in the tanks for a safe operation. In case of high demand events such as cold spells or peak days, this minimum amount can be lowered and part of the tanks can be used as a buffer volume, waiting for more LNG carriers to unload[20]. This flexibility is modelled based on historical data provided by the LNG System Operators via ALSI[21].

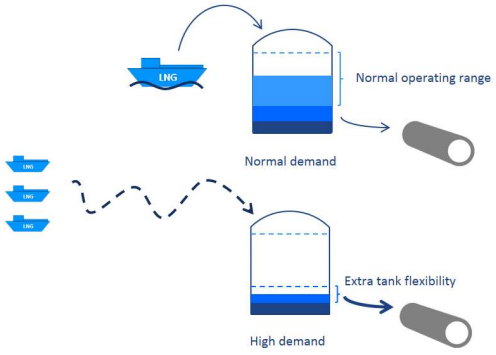


Figure 10. LNG tank flexibility

3.7. Infrastructure

ENTSOG is using the Plexos modelling tool. The gas topology at European level is used to model the European gas infrastructure with the most relevant accuracy. This enables the national assessment of

[18] Data available in Annex III

[19] Data available in Annex III

[20] Data available in Annex IV

[21] Source: https://alsi.gie.eu/

relevant risks affecting the security of gas supply to benefit from the Union wide simulation of supply and infrastructure disruption scenarios and further extend the local assessment with a higher granularity.

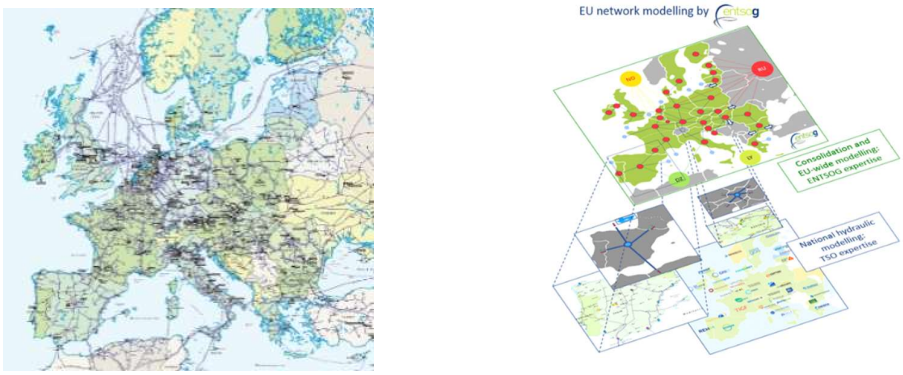


Figure 11. ENTSOG model overview

The simulations consider the existing European gas infrastructure and projects to be commissioned before January 2026. This assumption is made to reflect the configuration of the emergency gas corridors at the time of application of the next national plans. The choice of the relevant projects is based on the technical data submitted to ENTSOG by promoters for TYNDP 2024[22] (excluding less advanced projects) and verified by national TSOs (see **Table 6**)[23].

Table 6. TYNDP2024 projects included for the SoS assessment

Project name	Code
FSRU Ravenna	LNG-F-1142
Upgrade of LNG terminal in Świnoujście	LNG-F-272
LNG terminal in northern Greece / Alexandroupolis - LNG Section	LNG-F-62
Zeebrugge-Opwijk (phase 1)	TRA-A-1275
LNG evacuation pipeline Zlobin-Bosiljevo-Sisak-Kozarac	TRA-A-75
Reverse flow at IP Cieszyn - Polish section	TRA-F-1031
TENP Security of Supply plus	TRA-F-1095
Export enhancements phase 1	TRA-F-1145
LNG Terminal Brunsbuettel - Grid Integration	TRA-F-1199
Compressor station at Ambelia	TRA-F-1278
Compressor Station Komotini (former Kipi)	TRA-F-128
TENP Security of Supply	TRA-F-402
FSRU Ravenna Connection	TRA-F-566
Pipeline Nea Messimvria – Evzoni/ Gevgelija and Metering Station	TRA-F-967
Booster Compressor Station for TAP in Nea Messimvria	TRA-F-971
UGS Chiren Expansion	UGS-F-138
System Enhancements - Stogit - on-shore gas fields	UGS-F-260
Enhancement of Incukalns UGS	UGS-F-374
Increase the capacity at IP Moffat (IE)	-
Wilhelmshaven FSRU Excelerate Excelsior	-
Ostsee FSRU Transgas Power	-
Mukran FSRU Neptune	-

[22] Source: https://www.entsog.eu/tyndp#entsog-ten-year-network-development-plan-2024

[23] Capacities used in the simulation can be found in Annex V

3.8. Modelling results interpretation

The Security of Supply results should be interpreted as an assessment of the ability of the gas infrastructure to allow for an efficient cooperation of the EU Member States to cope with an unusual cold winter season under different scenarios. The EU-wide simulation is not a forecast of the expected gas supply situation. The actual utilisation of the gas infrastructure, supply directions and the development of the gas storage levels, will be also determined by the decisions of the market participants.

The simulations identify situations where a country can receive some help from its neighbouring countries in order to avoid or mitigate the exposure to demand curtailment. An infrastructure limitation can be observed when the capacities between countries are completely used, and no additional gas can flow to the country with the highest exposure to demand curtailment.

- *Comparison with reference case*

For the purpose of giving more insight to the flows during the disruption scenarios, a reference case without disruption has been defined (reference scenario). The comparison of the scenarios' results with the reference case is described in the results analysis and gives more information on the reaction to the disruption scenarios.

To define the reference scenario in which EU Member States aim to achieve a 30% UGS stock level at the end of the cold winter season, demand-side response measure is simulated. This approach ensures that the disruption scenario results can be interpreted and compared to the reference scenario without pre-empting any reactions or potential solutions to the identified situations.

- *Demand curtailment allocation*

Whenever a simulation result indicates possible exposure to demand curtailment (or additional demand side response need), the actual allocation of this curtailed demand between the countries depends on several factors amongst which the cooperation of member states and contractual arrangements are most relevant. In some instances, infrastructure limitations can limit the cooperation possibility. It is assumed in the simulation that all member States cooperate to avoid demand curtailment to the extent possible and by sharing the curtailment equally.

The allocation of the demand curtailment within the member states can be further investigated as part of the national and regional risk assessments.

- *Storage use*

Simulations of the whole winter season assess the capability and the flexibility of the gas infrastructure and supply to cope with a high winter demand. The model prepares for this high demand level by injecting in the UGS as long as the import flows allow for it.

High-demand cases (2-week cold spell and peak day) consider storage levels of 35% of WGV for all EU storage. Disruption scenario #8 includes an additional sensitivity analysis - it is conducted with an initial storage level that varies by country (32% average at the EU level), reflecting the results of the whole winter disruption scenario simulation.

- *Units*

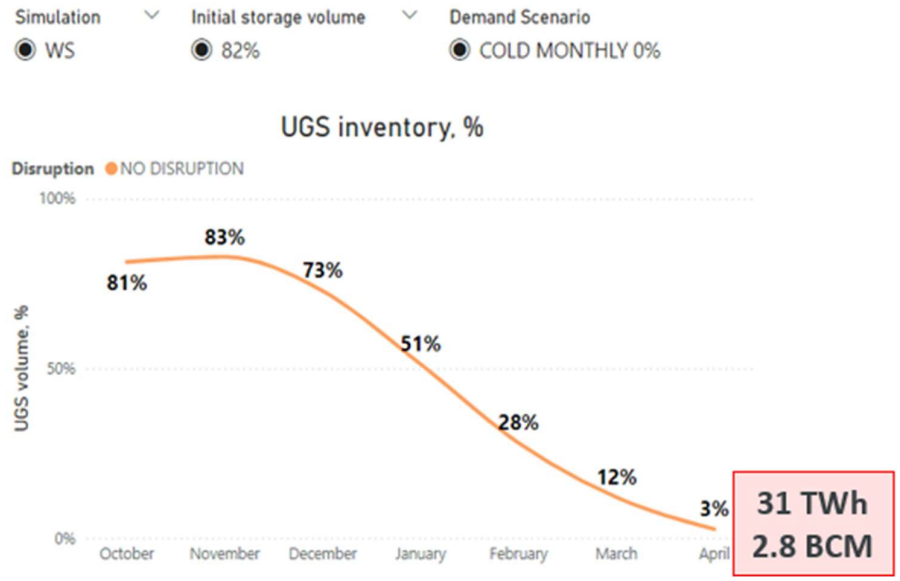
All the data used in the simulation are expressed in energy (TWh or GWh). For better readability of the results analysis, ENTSOG presents the results in both energy and volumes. ENTSOG derives volumes from energy by applying a single conversion factor of 11 kWh/m^3.

4. Results analysis

ASSUMPTION USED IN THE REFERENCE CASE

Simulation results

Whole winter



In the Cold Winter, if no additional demand side measures would be introduced (either policy-based or price response-based), EU would need to use UGS more extensively, resulting in reaching 3% of UGS stock level on EU average at the end of the winter season. **This situation underscores a noteworthy risk that must be pre-emptively addressed.**

The demand response during entire winter in EU
287 TWh
26 BCM

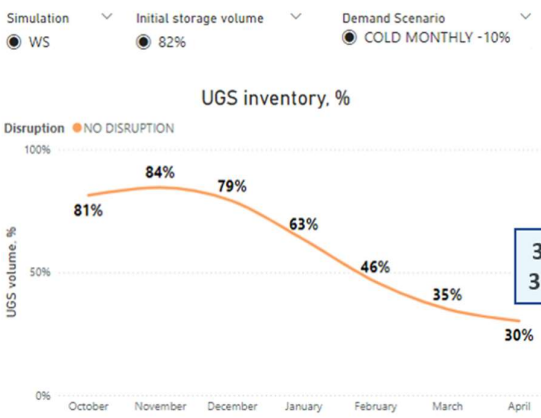
If EU Member States aim to achieve the 30% UGS stock level at the end of the Cold Winter season, Europe would need a demand response estimated at the level of 10% of the Cold Winter demand.

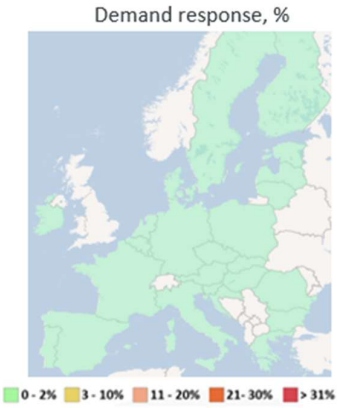
Situation where this measure is already applied is the reference case for all infrastructure disruption scenarios.

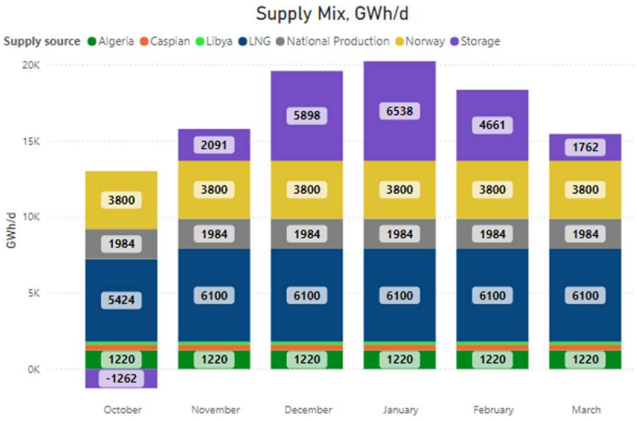
REFERENCE SCENARIO	Reference case
Risk group:	Not applicable
Disruption duration:	No disruption

Simulation results

Whole winter







Supply

Storage: At the end of investigated period (end of March) all EU countries reach 30% target stock level. Gas could still be injected in the storages in October up to 84% of total WGV where withdraw is observed in all countries starting from November to the end of March. Supply flexibility provided by storages is observed especially in months of highest demand: December, January, and February.

Pipeline and LNG supply: Supplies are utilized at their max potential from November to March. Supply shows some potential flexibility in October, which is reflected in lower LNG supply and the possibility to replenish storage stocks.

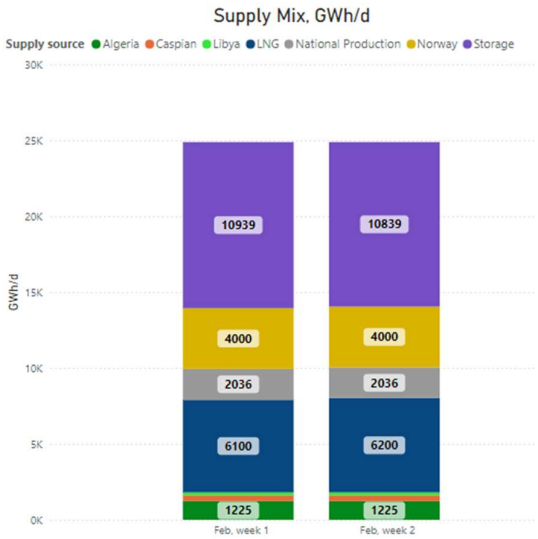
Algeria	Caspian	Libya	Norway	LNG	Production EU	Production (EU27+UK+RS)
1,220 GWh/d	390 GWh/d	180 GWh/d	3,800 GWh/d	5,987 GWh/d	1,092 GWh/d	1,984 GWh/d
111 mcm/d	35 mcm/d	16 mcm/d	345 mcm/d	544 mcm/d	99 mcm/d	180 mcm/d

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

REFERENCE SCENARIO — Reference case

2-week / 20 years



Supply

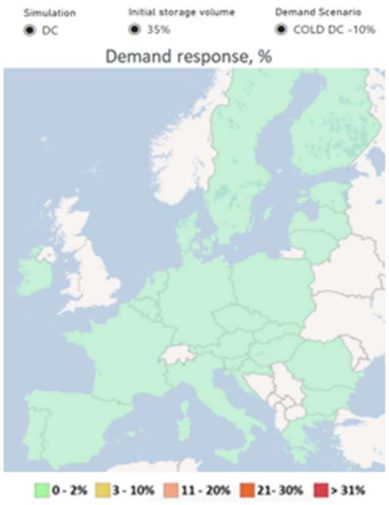
Storage: Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

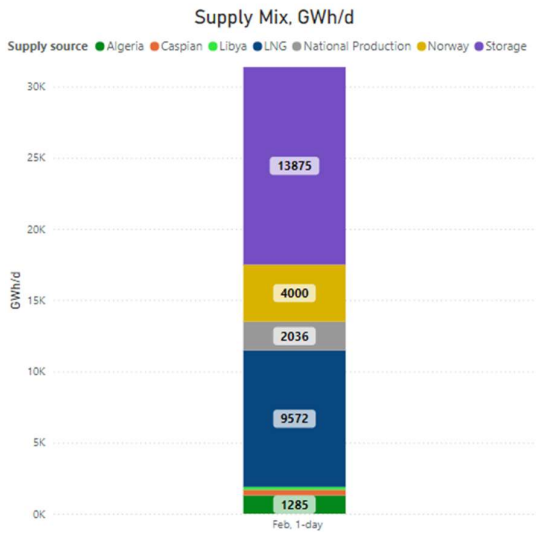
Algeria	Caspian	Libya	Norway	LNG	Production EU	Production (EU27+UK+RS)
1,225 GWh/d	395 GWh/d	190 GWh/d	4,000 GWh/d	6,150 GWh/d	1,144 GWh/d	2,036 GWh/d
111 mcm/d	36 mcm/d	17 mcm/d	364 mcm/d	559 mcm/d	104 mcm/d	185 mcm/d

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day/ 20 years





REFERENCE SCENARIO Reference case

Supply

Storage: Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.
LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Algeria	Caspian	Libya	Norway	LNG	Production EU	Production (EU27+UK+RS)
1,285 GWh/d	400 GWh/d	200 GWh/d	4,000 GWh/d	9,572 GWh/d	1,144 GWh/d	2,036 GWh/d
117 mcm/d	36 mcm/d	18 mcm/d	364 mcm/d	870 mcm/d	104 mcm/d	185 mcm/d

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

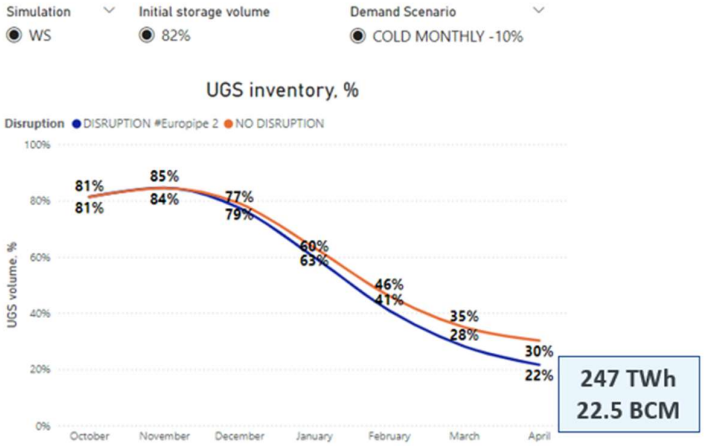
SCENARIO #1 - Disruption of the largest offshore infrastructure to continental EU (Europipe 2)

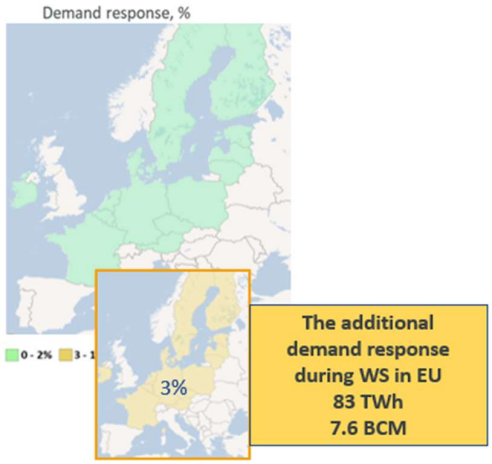
Technical disruption of Europipe 2 pipeline, Europipe 1 remains operational

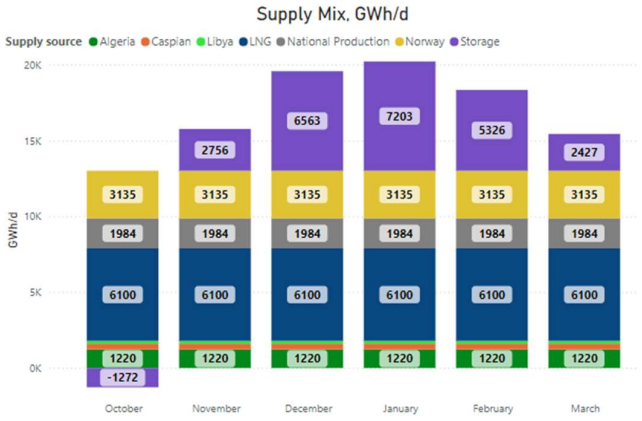
Risk group: North Sea	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Sweden.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach only 22% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Norway.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 3% of the Cold Winter -10% demand (approx. 13% of the Cold Winter or 371 TWh / 34 BCM in EU).

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter. Norwegian gas supply is used up to the reduced import capacity.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #1 - Disruption of the largest offshore infrastructure to continental EU (Europipe 2)

Technical disruption of Europipe 2 pipeline, Europipe 1 remains operational

2-week / 20 years

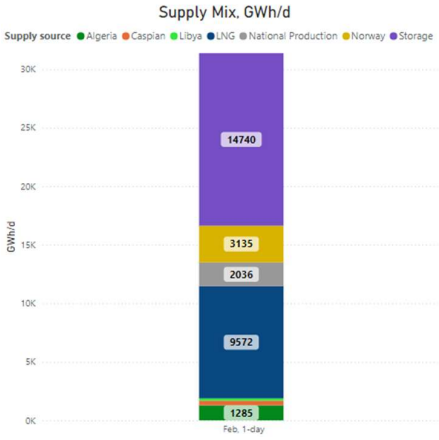
Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential. Norwegian gas supply is used up to the reduced import capacity.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential. Norwegian gas supply is used up to the reduced import capacity.

LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

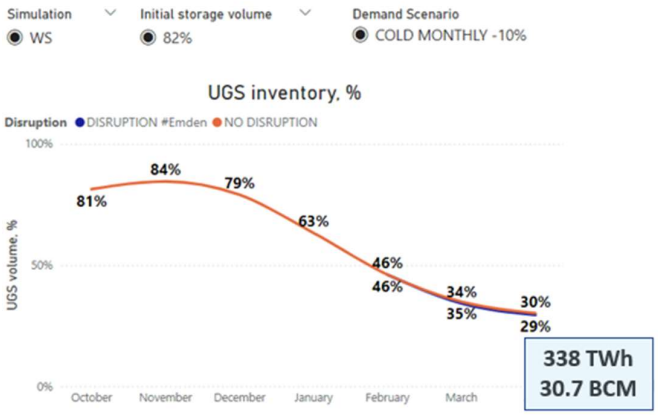
SCENARIO #2 - Disruption of the largest onshore infrastructure from Norway (Emden station)

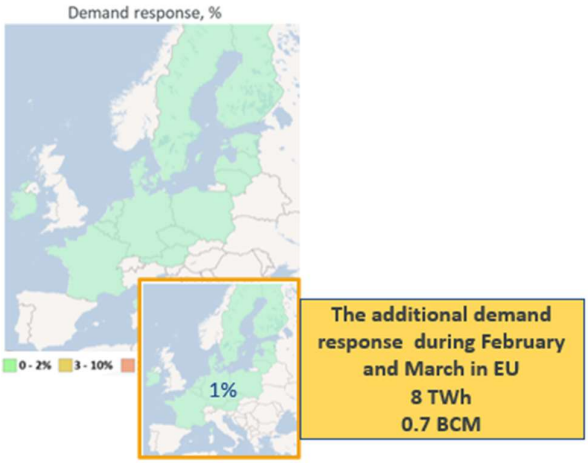
Technical disruption of Emden station

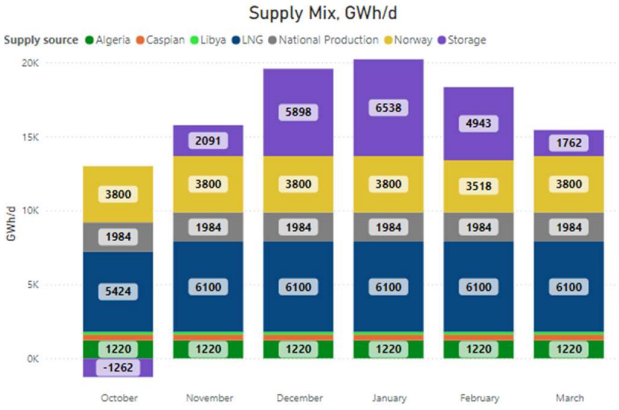
Risk group: North Sea	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Sweden.
Disruption duration:	2 weeks (1 February – 14 February)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 29% (below desired 30%) as of March 31st. Storage usage increases in February, compensating for the decrease in supply from Norway.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response during February and March estimated at the level of 1% of the Cold Winter -10% demand (approx. 10% of the Cold Winter or 295 TWh / 27 BCM in EU).
Pipeline and LNG supply: Supplies are utilized at their maximum potential from November to March. Supply shows some potential flexibility in September, which is reflected in lower LNG supply and the possibility to replenish storage stocks.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #2 - Disruption of the largest onshore infrastructure from Norway (Emden station)

Technical disruption of Emden station

2-week / 20 years

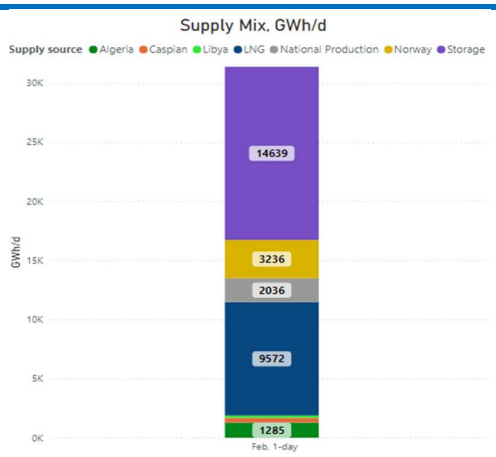
Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

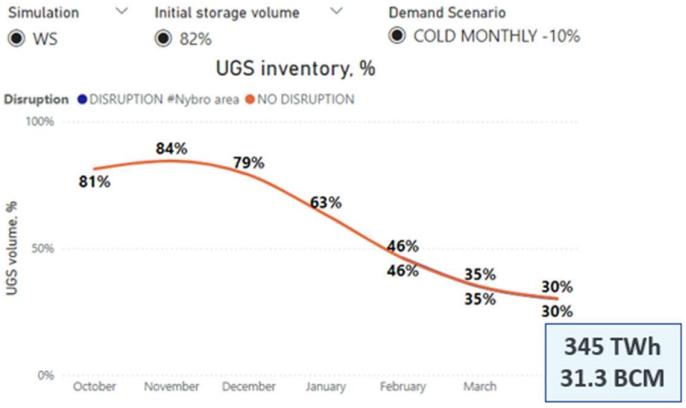
SCENARIO #3 - Disruption of the largest infrastructure to Denmark (Nybro area)

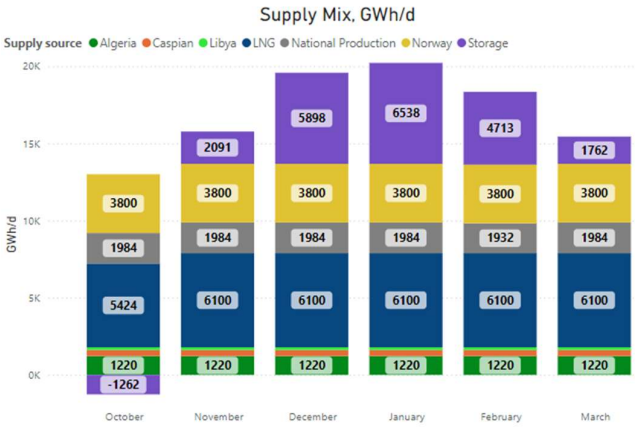
Technical disruption of Nybro receiving terminal (Baltic Pipe and Denmark national production)

Risk group: North Sea	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Sweden.
Disruption duration:	2 weeks (1 February – 14 February)

Simulation results

Whole winter





Supply

Storage: The EU storage level reach 30% as of March 31st. Storage usage increases in February, compensating for the decrease in supply of national production in Denmark.
The demand response during entire winter approx. 10% of Cold Winter demand or 289 TWh / 26 BCM in EU.
Pipeline and LNG supply: Supplies are utilized at their maximum potential from November to March. The infrastructure's flexibility demonstrates its ability to support the redirection of export flows from Norway through the Baltic Pipe to Poland.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #3 - Disruption of the largest infrastructure to Denmark (Nybro area)

Technical disruption of Nybro receiving terminal (Baltic Pipe and Denmark national production)

2-week / 20 years

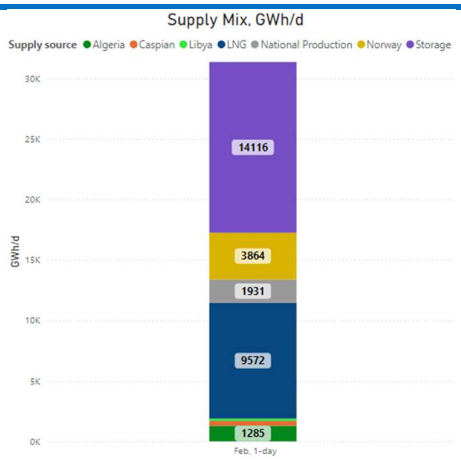
Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway and of national production in Denmark. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway and of national production in Denmark. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

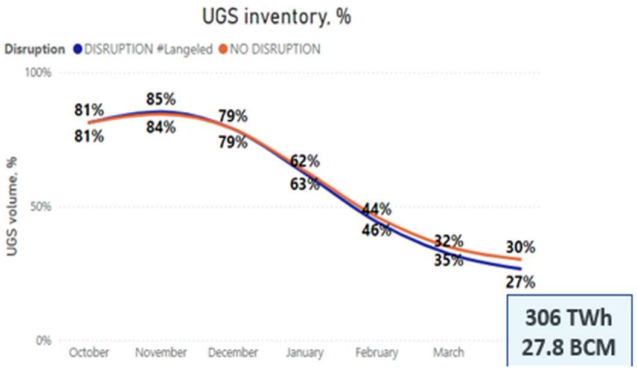
SCENARIO #4 - Disruption of the largest offshore infrastructure to the UK (Langeled)

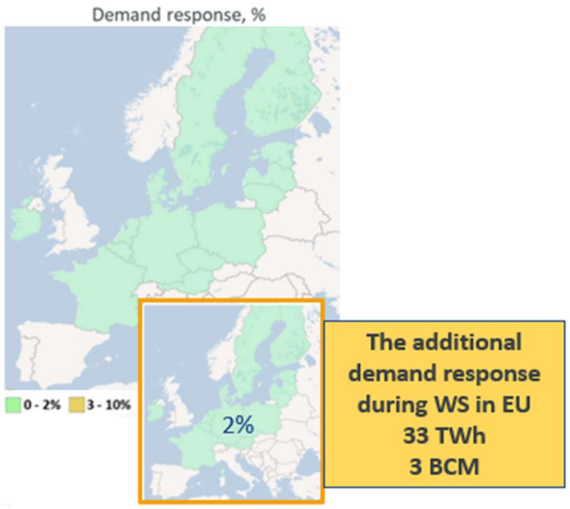
Technical disruption of Langeled pipeline (IP Easington). Imports from NO to the UK (IP St.Fergus) remain operational

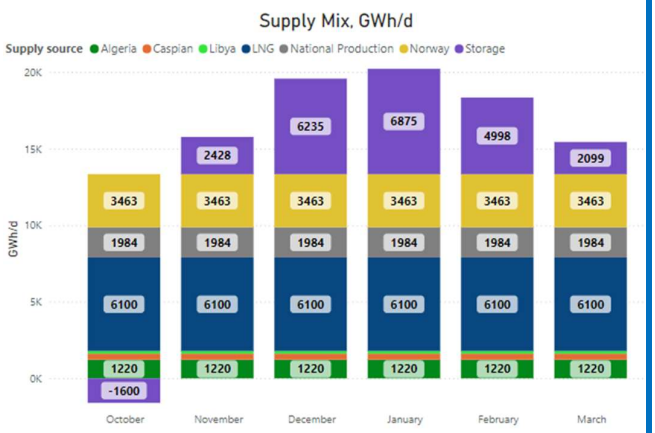
Risk group: North Sea	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Sweden.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 27% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Norway.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 2% of the Cold Winter -10% demand (approx. 11% of the Cold Winter or 320 TWh / 29 BCM in EU).
Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter. Norwegian gas supply is used up to the reduced import capacity.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #4 - Disruption of the largest offshore infrastructure to the UK (Langeled)

Technical disruption of Langeled pipeline (IP Easington). Imports from NO to the UK (IP St.Fergus) remain operational

2-week / 20 years

Supply

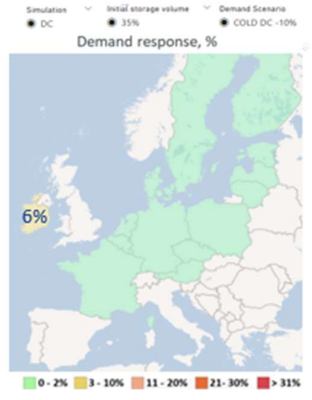
Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage able to provide flexibility needed to meet demand.

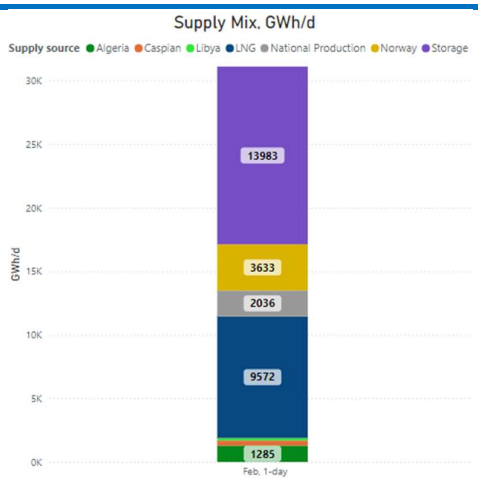
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years





Supply

Storage: Storage usage increases, compensating for the decrease in supply from Norway. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

Ireland is exposed to a demand curtailment (or additional demand side response) of 6% due to internal bottlenecks in the United Kingdom, which prevent the import of gas and its transit to Ireland. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine) can be maintained and supplied up to the available capacity. United Kingdom is exposed to a demand curtailment (or additional demand side response) of 5%.

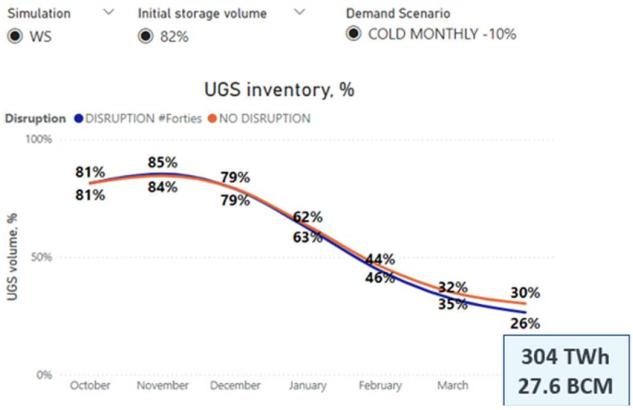
SCENARIO #5 - Disruption of Forties pipeline system

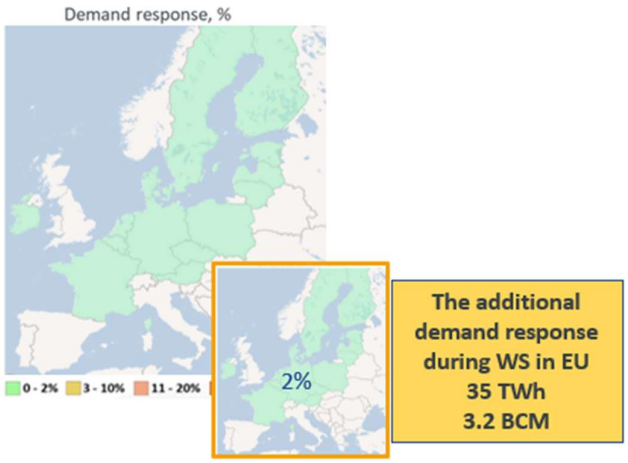
Technical disruption of the Forties Pipeline System is impacting production in the UK

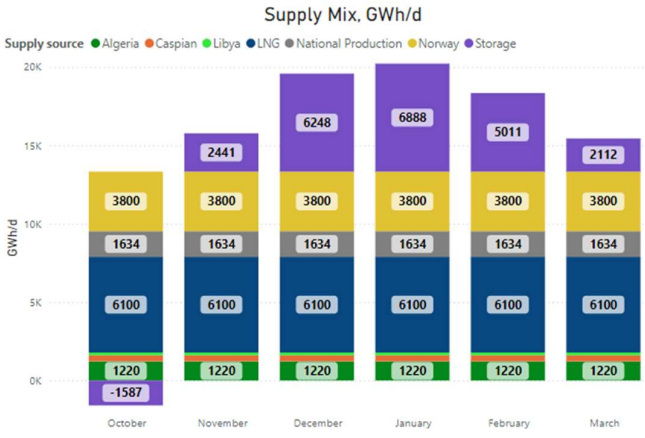
Risk group: North Sea	Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Sweden.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 26% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply of national production in the United Kingdom.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 2% of the Cold Winter -10% demand (approx. 11% of the Cold Winter or 323 TWh / 29 BCM in EU).

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #5 - Disruption of Forties pipeline system

Technical disruption of the Forties Pipeline System is impacting production in the UK

2-week / 20 years

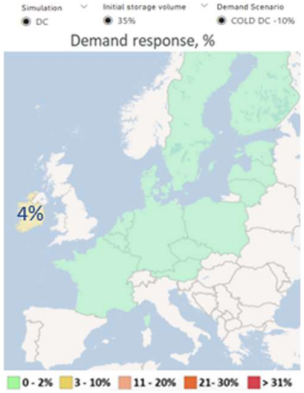
Supply

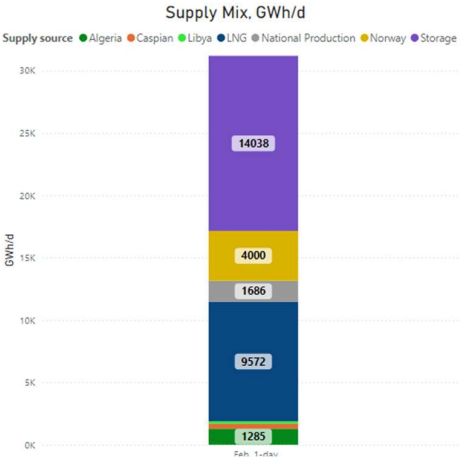
Storage: Storage usage increases, compensating for the decrease in supply of national production in the United Kingdom. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years





Supply

Storage: Storage usage increases, compensating for the decrease in supply of national production in the United Kingdom. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

Ireland is exposed to a demand curtailment (or additional demand side response) of 4% due to internal bottlenecks in the United Kingdom, which prevent the import of gas and its transit to Ireland. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine) can be maintained and supplied up to the available capacity. United Kingdom is exposed to a demand curtailment (or additional demand side response) of 4%.

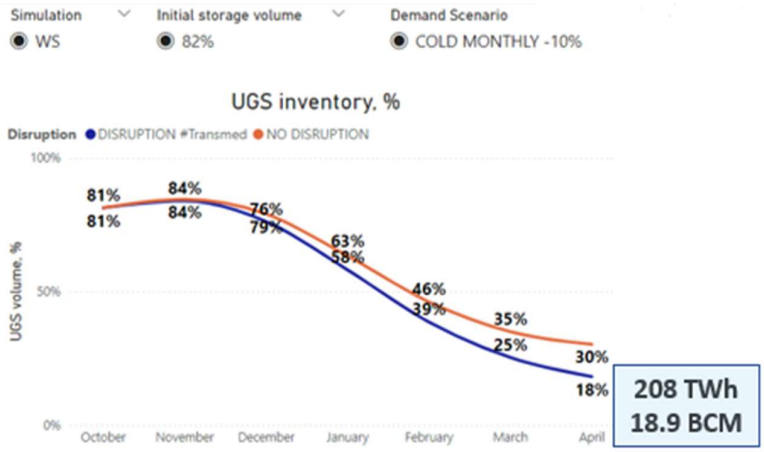
SCENARIO #6 - Disruption of the largest offshore infrastructure to Italy (Transmed)

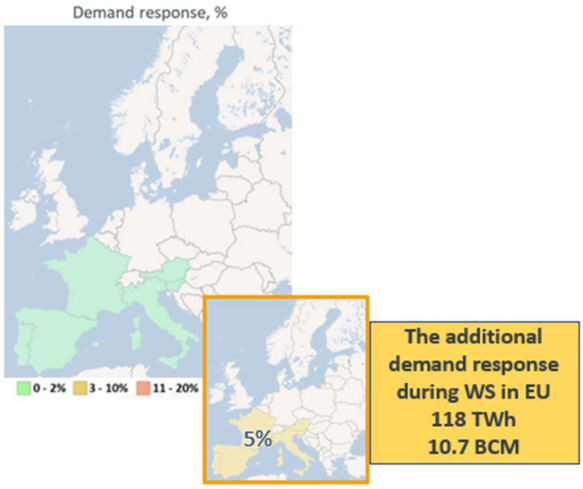
Technical disruption of Transmed pipeline, Medgaz pipeline remains operational

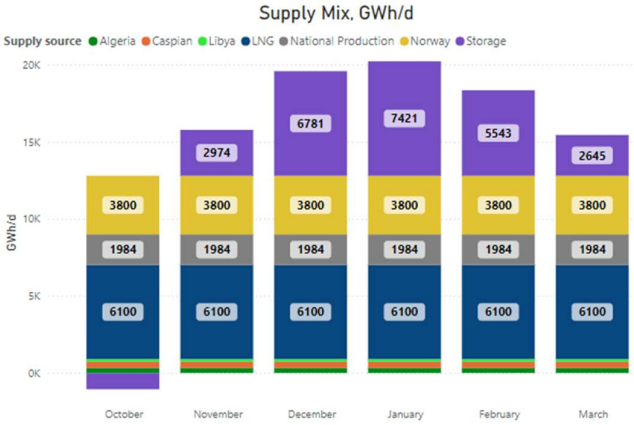
Risk group: North African	Austria, France, Italy, Malta, Portugal, Slovenia, Spain.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 18% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Algeria.

If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 5% of the Cold Winter -10% demand (approx. 14% of the Cold Winter or 405 TWh / 37 BCM in EU).

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter. Algerian gas supply is used up to the reduced import capacity.

Demand including response -10%

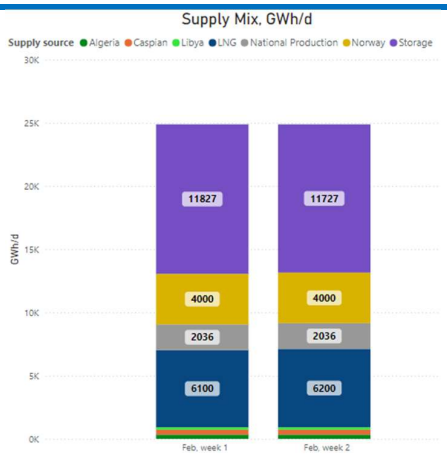
No country is exposed to demand curtailment.

Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #6 - Disruption of the largest offshore infrastructure to Italy (Transmed)

Technical disruption of Transmed pipeline, Medgaz pipeline remains operational

2-week / 20 years



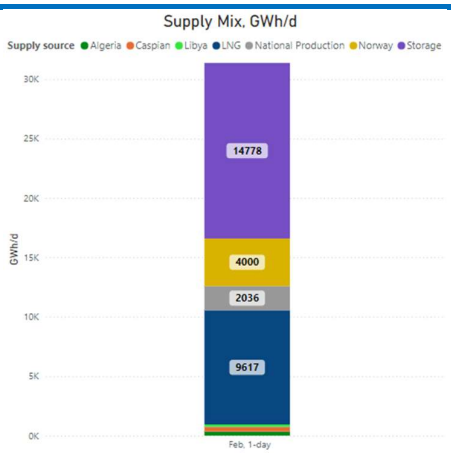
Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential. Algerian gas supply is used up to the reduced import capacity.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential. Algerian gas supply is used up to the reduced import capacity.
LNG tank: LNG tanks provide approx. 3.5 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

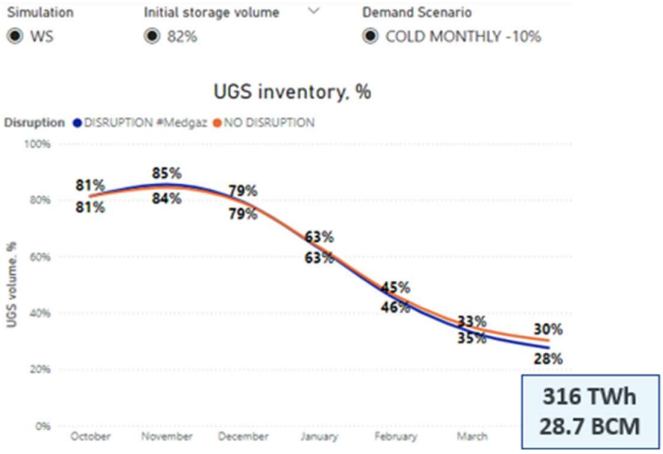
SCENARIO #7 - Disruption of the largest offshore infrastructure to Spain (Medgaz)

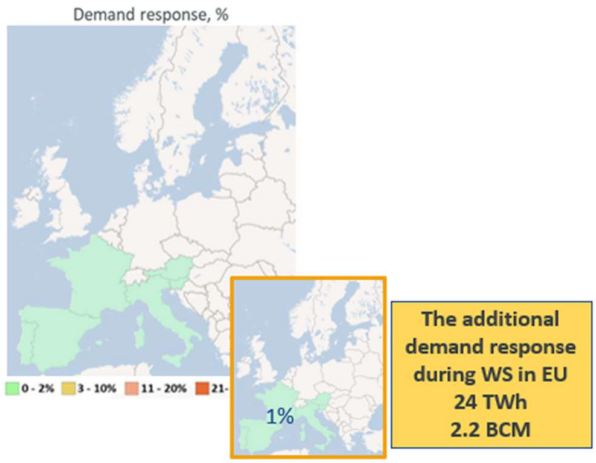
Technical disruption of Medgaz pipeline, Transmed pipeline remains operational

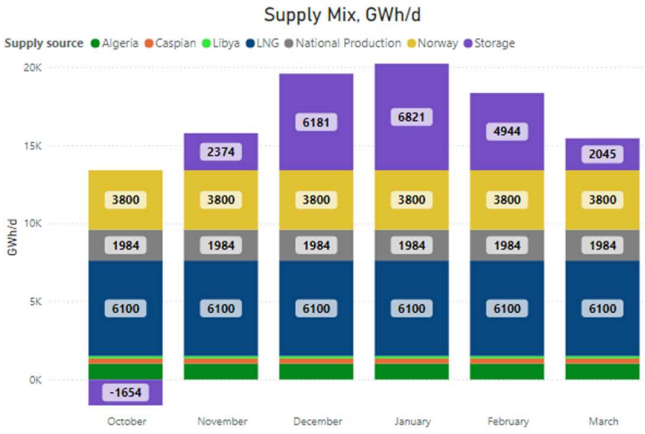
Risk group: North African	Austria, France, Italy, Malta, Portugal, Slovenia, Spain.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 28% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Algeria, the Caspian Sea and Libya.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 1% of the Cold Winter -10% demand (approx. 11% of the Cold Winter or 311 TWh / 28 BCM in EU).
Pipeline and LNG supply: Norway and LNG supplies are utilized at their maximum potential throughout the entire winter. Gas import supplies from Algeria, the Caspian Sea, and Libya are limited by internal bottlenecks in Italy and are not being utilized to their full import capacity.

Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #7 - Disruption of the largest offshore infrastructure to Spain (Medgaz)

Technical disruption of Medgaz pipeline, Transmed pipeline remains operational

2-week / 20 years

Supply

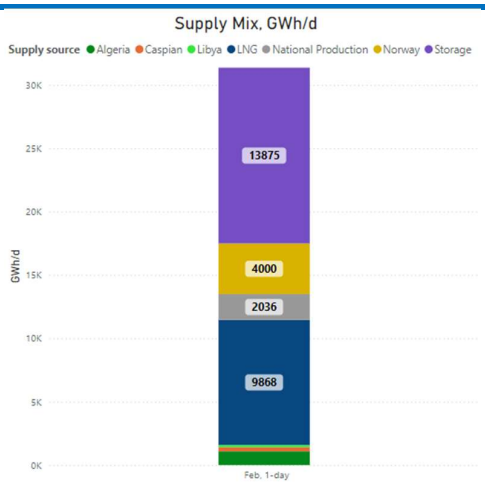
Storage: Storage usage increases, compensating for the decrease in supply from Algeria, the Caspian Sea and Libya. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Norway and LNG supplies are utilized at their maximum potential. Gas import supplies from Algeria, the Caspian Sea, and Libya are limited by internal bottlenecks in Italy and are not being utilized to their full import capacity.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Norway and LNG supplies are utilized at their maximum potential. Gas import supplies from Algeria, the Caspian Sea, and Libya are limited by internal bottlenecks in Italy and are not being utilized to their full import capacity.

LNG tank: LNG tanks provide approx. 3.8 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

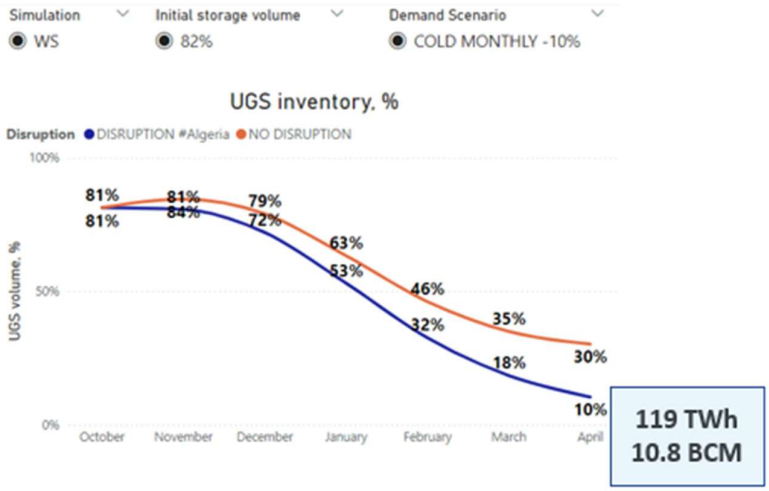
SCENARIO #8 - Disruption of all imports from Algeria, including LNG

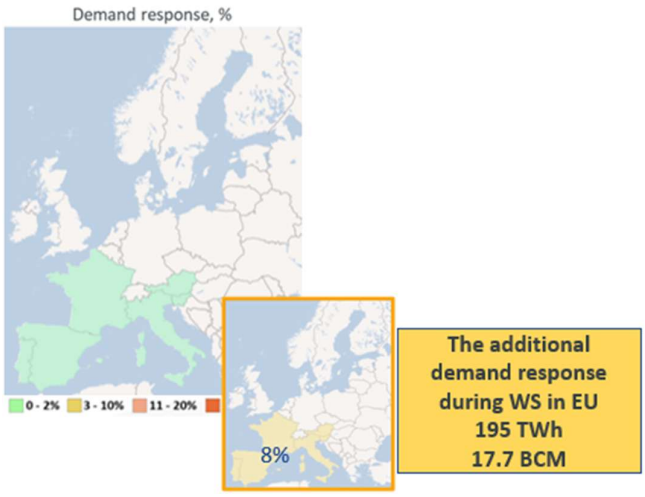
Disruption of all imports from Algeria via both pipelines and LNG cargos (period of one month, starting from 1 October is necessary to attract more LNG cargos to substitute the Algerian LNG)

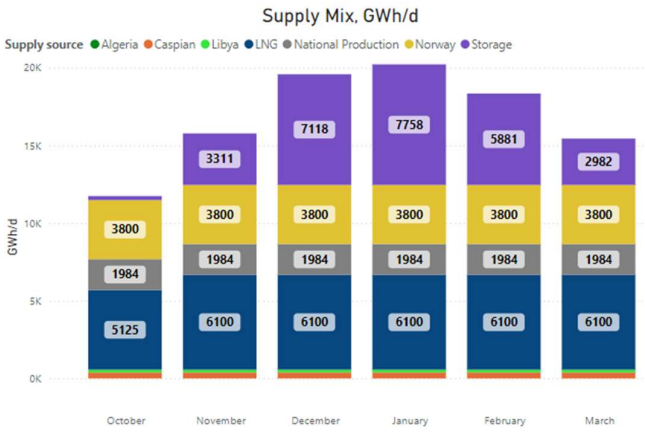
Risk group: North African	Austria, France, Italy, Malta, Portugal, Slovenia, Spain.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 10% (below desired 30%) as of March 31st. Storage usage increases during whole winter, compensating for the decrease in supply from Algeria.
If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 8% of the Cold Winter -10% demand (approx. 17% of the Cold Winter or 482 TWh / 44 BCM in EU).
Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter.

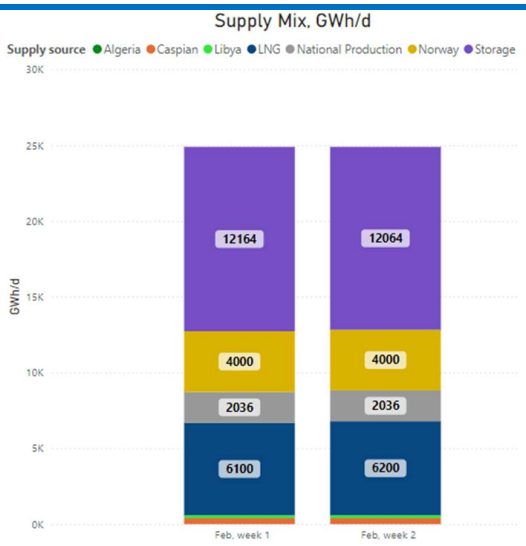
Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #8 - Disruption of all imports from Algeria, including LNG

Disruption of all imports from Algeria via both pipelines and LNG cargos (period of one month, starting from 1 October is necessary to attract more LNG cargos to substitute the Algerian LNG)

2-week / 20 years



Supply

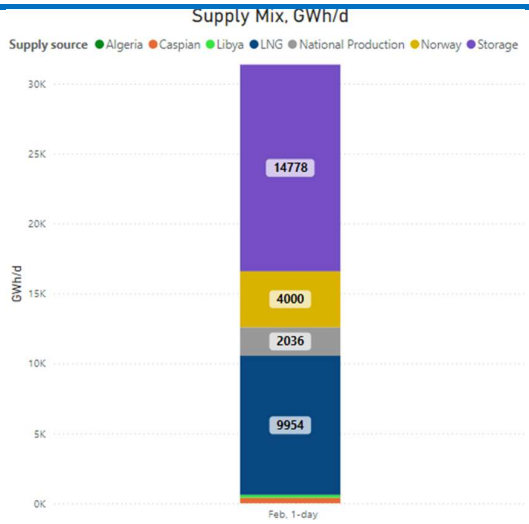
Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.9 TWh/d (0.4 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

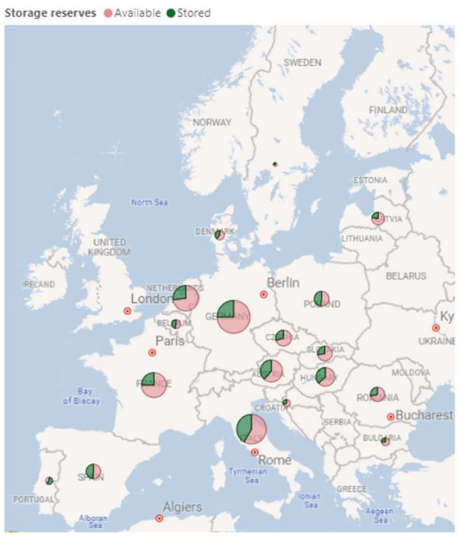
Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #8 - Disruption of all imports from Algeria, including LNG

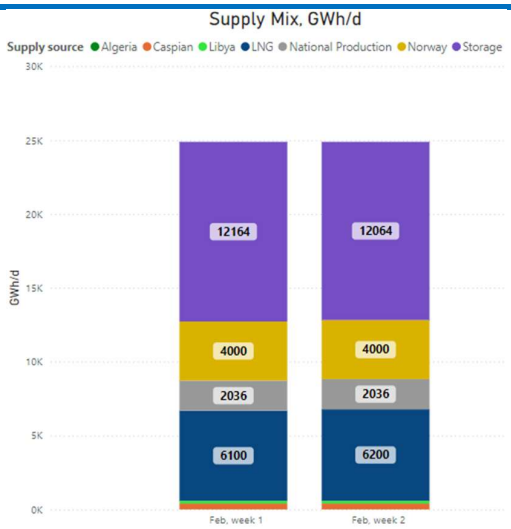
Disruption of all imports from Algeria via both pipelines and LNG cargos (period of one month, starting from 1 October is necessary to attract more LNG cargos to substitute the Algerian LNG)

Sensitivity analysis with an initial level of 32% at the EU level (the level varies by country)



Country	Initial level, %
Austria	39%
Belgium	46%
Bulgaria	26%
Croatia	30%
Czechia	30%
Denmark	39%
France	25%
Germany	25%
Hungary	37%
Italy	42%
Latvia	23%
Poland	48%
Portugal	62%
Romania	29%
Slovakia	28%
Spain	49%
Sweden	25%
The Netherlands	27%

2-week / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage able to provide flexibility needed to meet demand.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

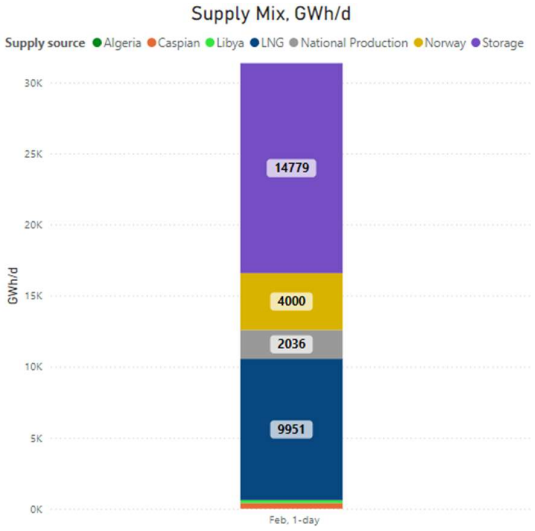
Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #8 - Disruption of all imports from Algeria, including LNG

Disruption of all imports from Algeria via both pipelines and LNG cargos (period of one month, starting from 1 October is necessary to attract more LNG cargos to substitute the Algerian LNG)

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Algeria. Storage is mostly used up to their maximum withdraw potential set by the SSOs.
Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.9 TWh/d (0.4 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

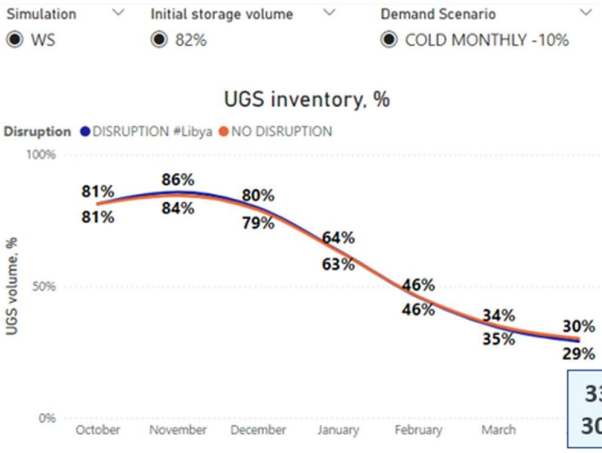
SCENARIO #9 - Disruption of all imports from Libya

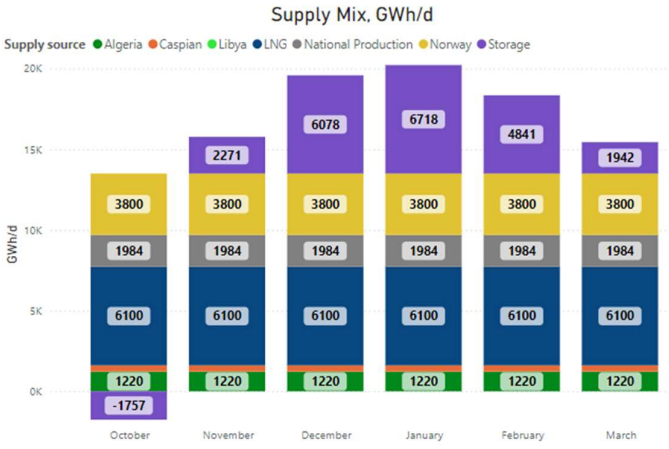
Disruption of all imports from Libya via Green Stream pipeline (IP Gela)

Risk group: North African	Austria, France, Italy, Malta, Portugal, Slovenia, Spain.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter





Supply

Storage: The EU storage level reach 29% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Libya.
The demand response during entire winter in EU approx. 10% of Cold Winter demand or 296 TWh / 27 BCM in EU.

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter.

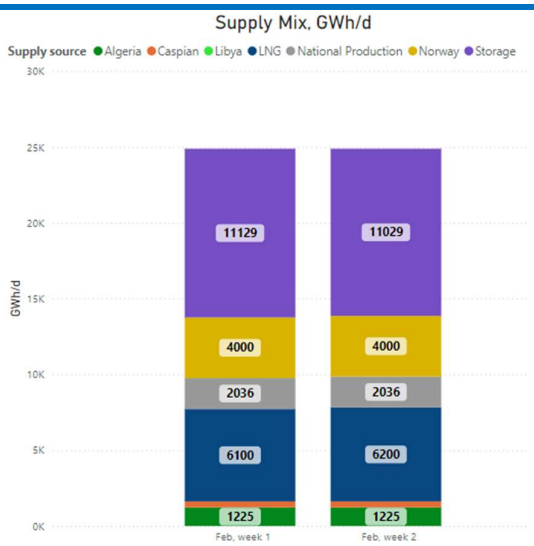
Demand including response -10%

No country is exposed to demand curtailment.
Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #9 - Disruption of all imports from Libya

Disruption of all imports from Libya via Green Stream pipeline (IP Gela)

2-week / 20 years



Supply

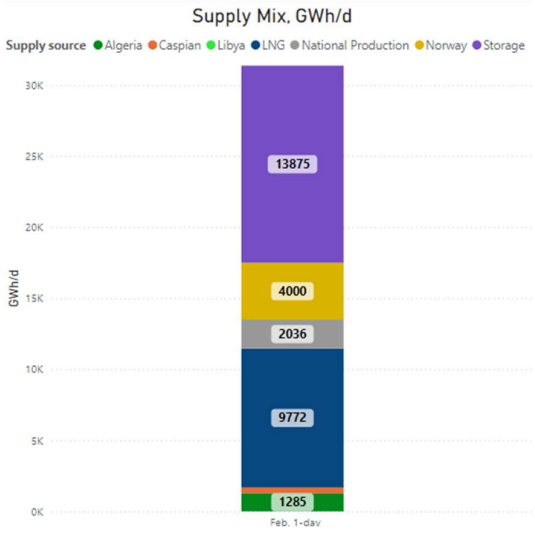
Storage: Storage usage increases, compensating for the decrease in supply from Libya. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Libya. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.7 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

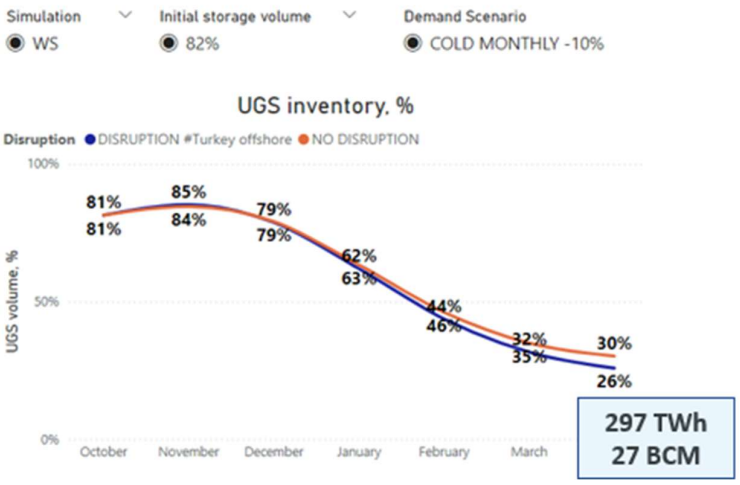
SCENARIO #10 - Disruption of all imports from Turkey to Greece

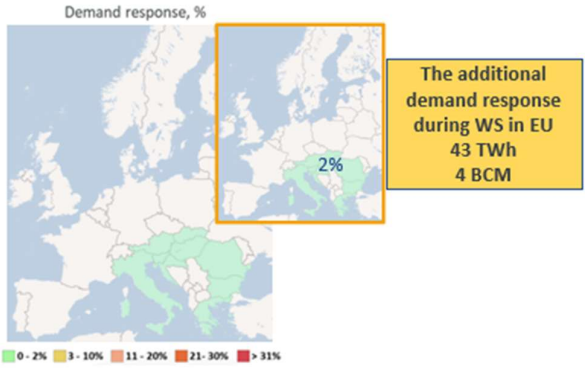
Disruption of all imports from Turkey to Greece (TANAP pipeline & IP Kipi)

Risk group: South-East	Austria, Bulgaria, Cyprus, Greece, Hungary, Croatia, Italy, Romania, Slovenia, Slovakia.
Disruption duration:	6 months (1 October – 31 March)

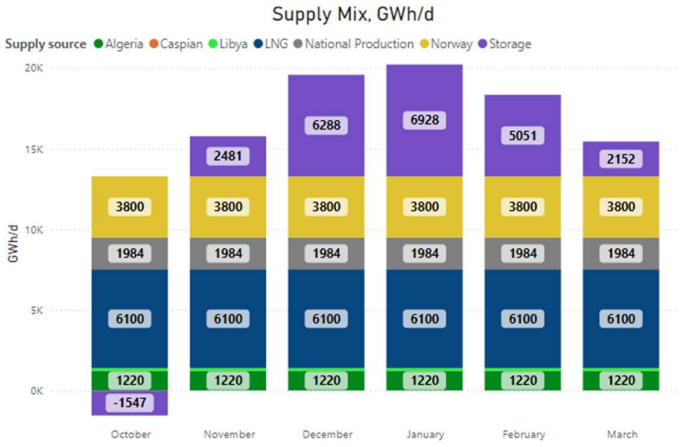
Simulation results

Whole winter





The additional demand response during WS in EU
43 TWh
4 BCM



Supply

Storage: The EU storage level reach 26% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in supply from Caspian Sea.

If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 2% of the Cold Winter -10% demand (approx. 12% of the Cold Winter or 330 TWh / 30 BCM in EU).

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter.

Demand including response -10%

No country is exposed to demand curtailment.

Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #10 - Disruption of all imports from Turkey to Greece

Disruption of all imports from Turkey to Greece (TANAP pipeline & IP Kipi)

2-week / 20 years

Supply

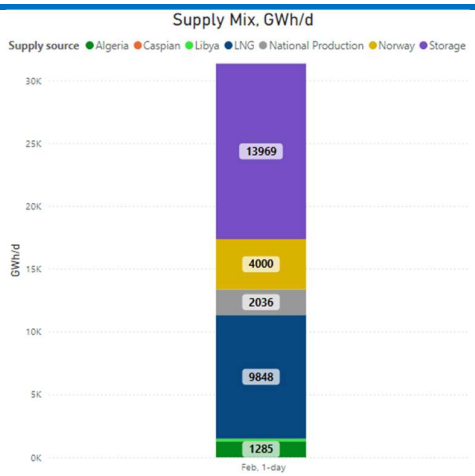
Storage: Storage usage increases, compensating for the decrease in supply from Caspian Sea. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Caspian Sea. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.7 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

Romania, Bulgaria, and Greece are exposed to a 2% demand curtailment (or additional demand side response) due to bottleneck between Hungary and Romania, as well as internal bottleneck in Greece which prevent LNG imports from the Alexandroupolis LNG terminal.

Exports to non-EU countries (Moldova, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity. Bosnia and Herzegovina, North Macedonia, Serbia are exposed to a demand curtailment (or additional demand side response) of 2% due to bottlenecks.

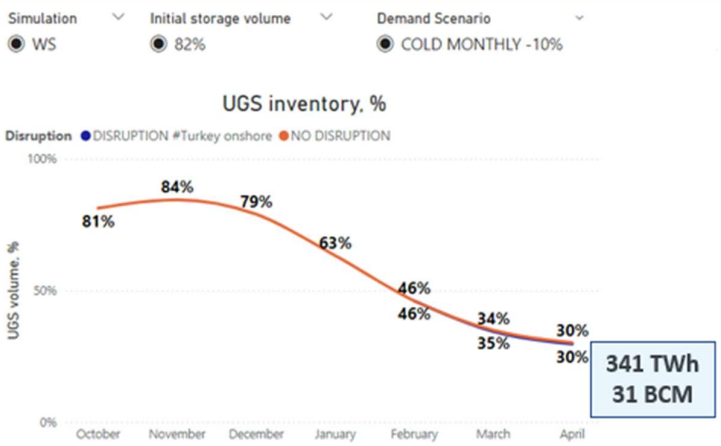
SCENARIO #11 - Disruption of the largest onshore infrastructure to Greece (TANAP)

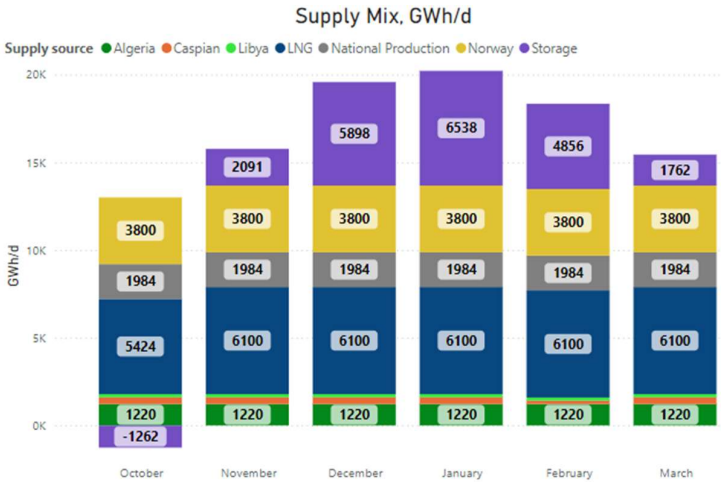
Disruption of onshore TANAP pipeline

Risk group: South-East	Austria, Bulgaria, Cyprus, Greece, Hungary, Croatia, Italy, Romania, Slovenia, Slovakia.
Disruption duration:	2 weeks (1 February – 14 February)

Simulation results

Whole winter





Supply

Storage: The EU storage level reach 30% as of March 31st. Storage usage increases in February, compensating for the decrease in supply from Caspian Sea. The demand response during entire winter approx. 10% of Cold Winter demand or 292 TWh / 27 BCM in EU.

Pipeline and LNG supply: Supplies are utilized at their maximum potential from November to March. Supply shows some potential flexibility in October, which is reflected in lower LNG supply and the possibility to replenish storage stocks.

Demand including response -10%

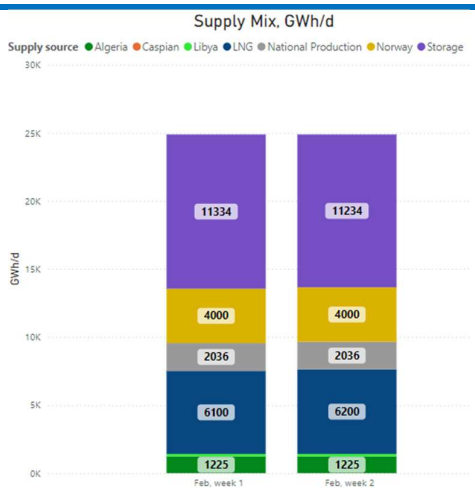
No country is exposed to demand curtailment.

Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #11 - Disruption of the largest onshore infrastructure to Greece (TANAP)

Disruption of onshore TANAP pipeline

2-week / 20 years



Supply

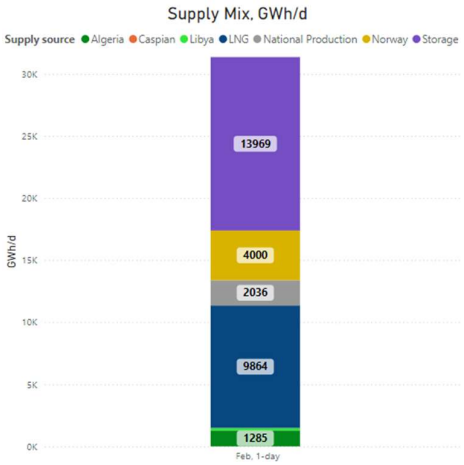
Storage: Storage usage increases, compensating for the decrease in supply from Caspian Sea. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in supply from Caspian Sea. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 3.8 TWh/d (0.3 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

Romania, Bulgaria, and Greece are exposed to a 1% demand curtailment (or additional demand side response) due to bottleneck between Hungary and Romania, as well as internal bottleneck in Greece which prevent LNG imports from the Alexandroupolis LNG terminal. Exports to non-EU countries (Moldova, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity. Bosnia and Herzegovina, North Macedonia, Serbia are exposed to a demand curtailment (or additional demand side response) of 1% due to bottlenecks.

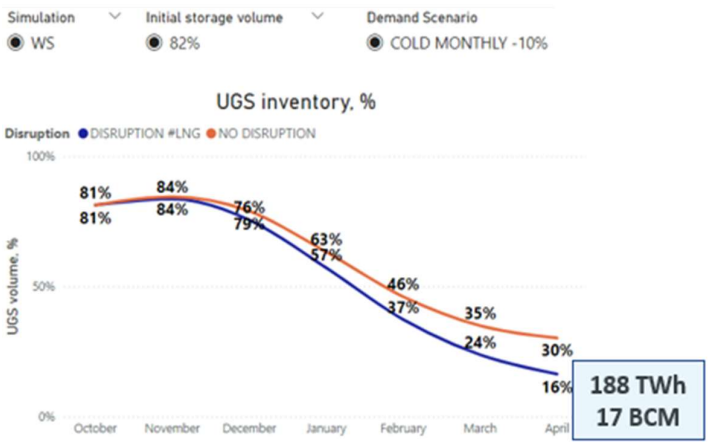
SCENARIO #12 - S-1 LNG. Limited availability of LNG supply

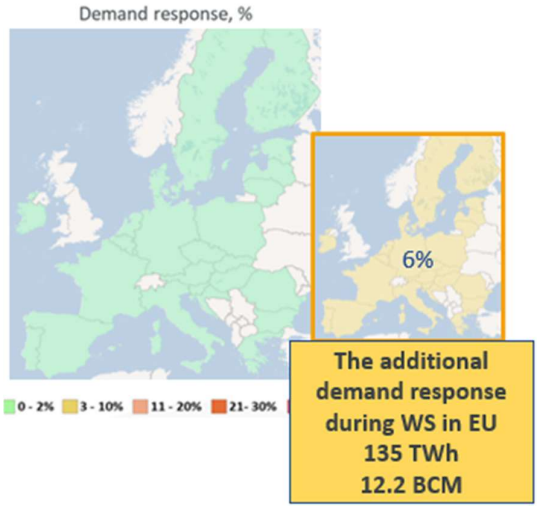
Reflecting lower LNG supply potential which anticipates a situation where not enough LNG is not attracted to Europe

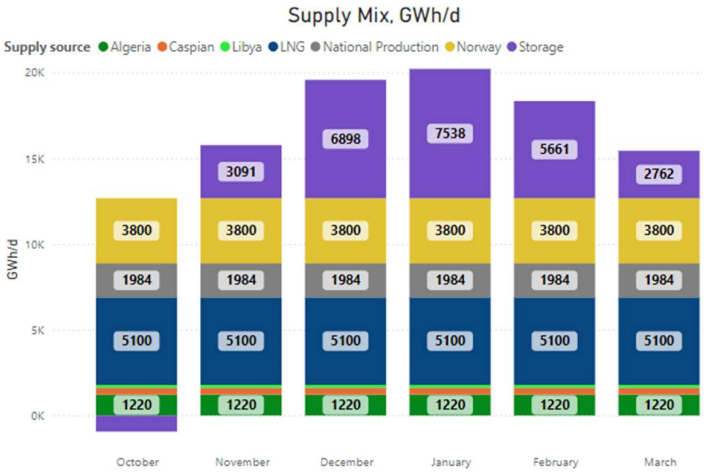
Risk group: LNG	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Croatia, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden.
Disruption duration:	6 months (1 October – 31 March)

Simulation results

Whole winter







Supply

Storage: The EU storage level reach 16% (below desired 30%) as of March 31st. Storage usage increases from November to March, compensating for the decrease in LNG supply.

If EU Member States aim to achieve the 30% UGS stock level at the end of the winter, Europe would need an additional demand response estimated at the level of 6% of the Cold Winter -10% demand (approx. 15% of the Cold Winter or 422 TWh / 38 BCM in EU).

Pipeline and LNG supply: Supplies are utilized at their maximum potential throughout the entire winter.

Demand including response -10%

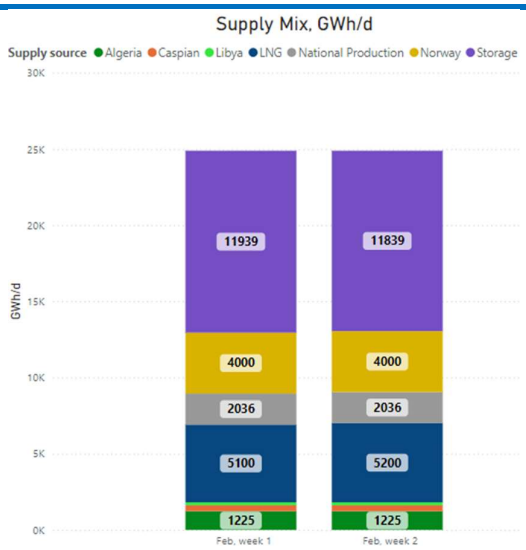
No country is exposed to demand curtailment.

Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

SCENARIO #12 - S-1 LNG. Limited availability of LNG supply

Reflecting lower LNG supply potential which anticipates a situation where not enough LNG is not attracted to Europe

2-week / 20 years



Supply

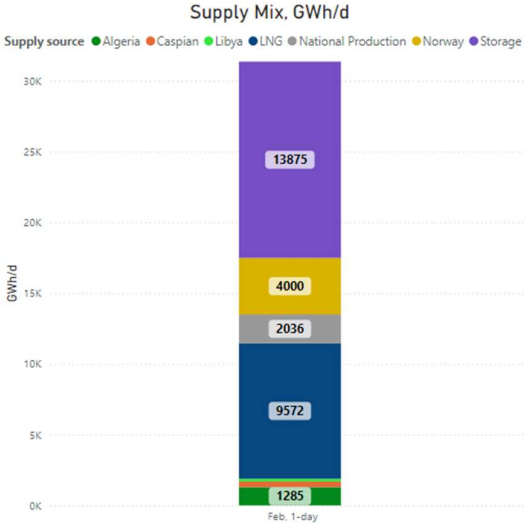
Storage: Storage usage increases, compensating for the decrease in LNG supply. Storage able to provide flexibility needed to meet demand.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

Peak day / 20 years



Supply

Storage: Storage usage increases, compensating for the decrease in LNG supply. Storage is mostly used up to their maximum withdraw potential set by the SSOs.

Pipeline and LNG supply: Supplies are used at their maximum supply potential.

LNG tank: LNG tanks provide approx. 4.5 TWh/d (0.4 BCM/d), which is utilized within the capacity limits of the individual LNG terminals.

Demand including response -10%

No country is exposed to demand curtailment. Exports to non-EU countries (Bosnia and Herzegovina, Moldova, North Macedonia, Serbia, Switzerland, Ukraine and United Kingdom) can be maintained and supplied up to the available capacity.

5. Annexes

The data for the Union-wide simulation of gas supply and infrastructure disruption scenarios 2024 (SoS simulation) is available online as an annex of this report.

Annex I:	Demand
Annex II:	National production
Annex III:	Storage
Annex IV:	LNG
Annex V:	Capacity

Abbreviations:

Country codes are defined according to the ISO standard 3166-1

DC: Design Case, identical with Peak Day

EC: European Commission

ENTSOG: European Network of Transmission System Operators for Gas

EU: European Union

GCG: Gas Coordination Group

GIE: Gas Infrastructure Europe

GLE: Gas LNG terminals operators Europe

GSE: Gas Storages operators Europe

H-gas: High calorific gas

L-gas: Low calorific gas

LNG: Liquified Natural Gas

SoS: Security of Supply

TSO: Transmission System Operators

UGS: Underground Gas Storage

WGV: Working Gas Volumes

WSO: Winter Supply Outlook

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