

UNDERGROUND GAS STORAGE

A CRITICAL PILLAR FOR ENERGY SECURITY

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ABBREVIATIONS

AGA	AMERICAN GAS ASSOCIATION
BCM	BILLION CUBIC METRES
CAPEX	CAPITAL EXPENDITURE
CIS	THE COMMONWEALTH OF INDEPENDENT STATES
EIA	ENERGY INFORMATION ADMINISTRATION
EU	EUROPEAN UNION
IGU	INTERNATIONAL GAS UNION
LNG	LIQUIFIED NATURAL GAS
MCM	MILLION CUBIC METRES
OPEX	OPERATIONAL EXPENDITURE
PWR	POTENTIAL WITHDRAWAL RATE
UHS	UNDERGROUND HYDROGEN STORAGE
UGS	UNDERGROUND GAS STORAGE
WGV	WORKING GAS VOLUMES

FOREWORD

The global energy market is undergoing a challenging transition — one that is not just technological or regulatory, but systemic. This shift signifies a true paradigm change, characterised by the emergence of new interactions and interdependencies across value chains, sectors, and regions. These changing dynamics introduce both increased uncertainty and greater vulnerability to unforeseen shocks—whether geopolitical, environmental, or economic.

A system that relies solely on the development of short-term renewable energies would neglect the fact that significant challenges remain unresolved, particularly the need for a renewable endowment requiring extensive storage capabilities over time and space, supported by the expansion of the transmission network that could link increasingly diverse regions and energy systems in the future.

This requires forward-looking investment not only in clean production, but also in the expansion and interconnection of transmission networks, supported by robust storage capacities, allowing regional energy systems to gradually merge and strengthen one another.

In this context, and considering the capital-intensive nature of network industries, it is essential to establish a policy and regulatory framework that fosters long-term visibility and confidence for investors.

This includes recognising the role of Gas storage infrastructures as fundamental assets, vital not only for ensuring system resilience but also for promoting effective competition and achieving national and global sustainability objectives.

Underground Gas storage must be recognised for its systemic importance — not just as a flexibility tool but as a vital part of future energy frameworks. As the energy transition progresses, some values historically considered peripheral — such as flexibility, security, and insurance — need to be reassessed from a new perspective.

Just as the cost of carbon emissions is now treated as an externality to be internalised globally, so too must the “insurance value” of critical infrastructures like Gas storage be fully acknowledged and integrated into energy systems design.

KEY HIGHLIGHTS

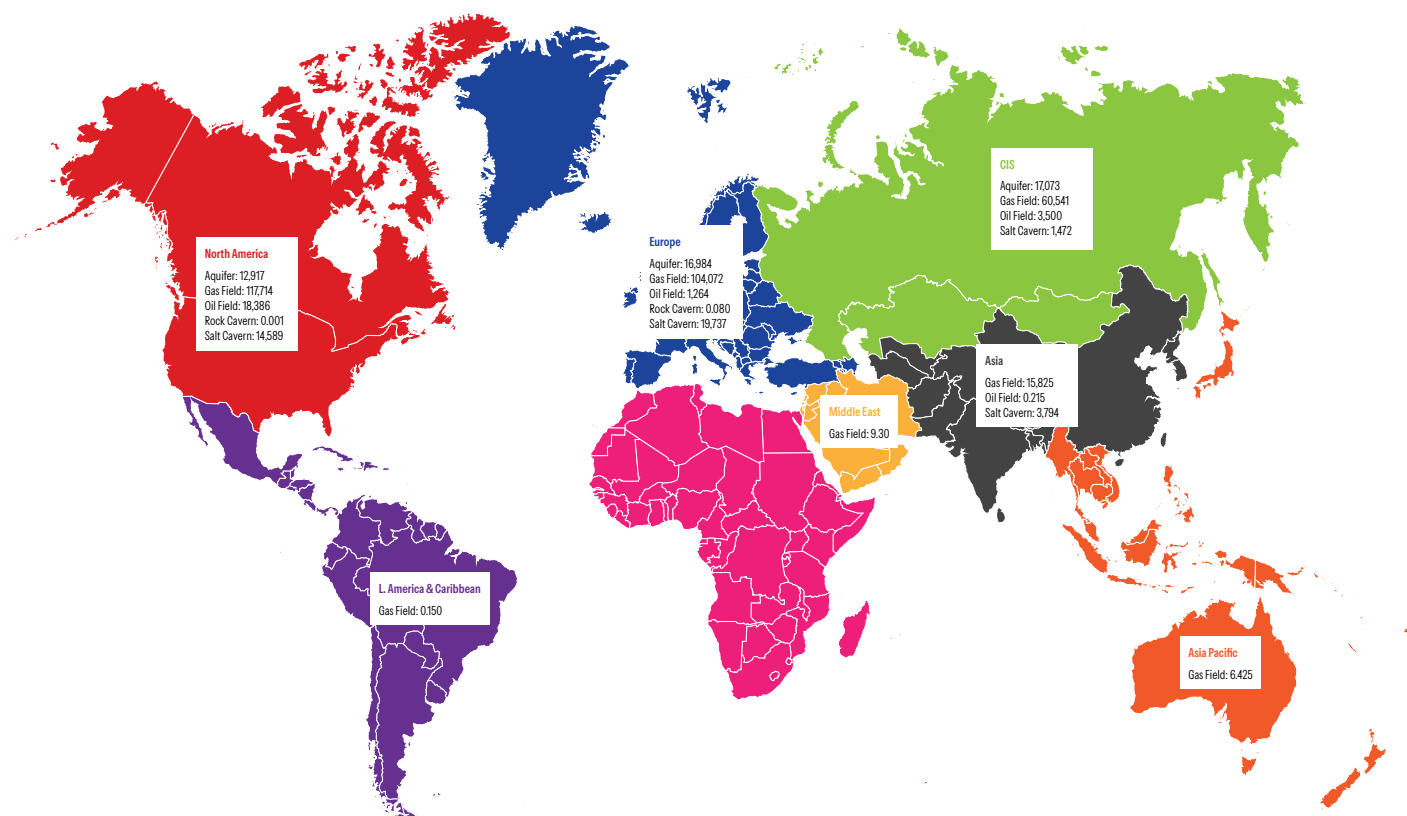


FIGURE 1: TOTAL WORKING GAS VOLUME OF UGS FACILITIES

The total Working Gas Volume (WGV) amounts to 424 bcm, distributed across 699 storage facilities worldwide, with a withdrawal rate of some 7,371 mcm/d. The vast majority of these storage facilities is developed in depleted natural gas fields.

The storage capacity is spread across world regions as follows:

REGION	CAPACITY
NORTH AMERICA	164 bcm
EUROPE	142 bcm
THE COMMONWEALTH OF INDEPENDENT STATES (CIS)	83 bcm
ASIA	20 bcm
MIDDLE EAST	9 bcm
ASIA PACIFIC	6 bcm
LATIN AMERICA	0.2 bcm

Significant regional differences in the development of underground gas storage (UGS) largely reflect the maturity of development of gas infrastructure, which is closely linked to the evolution of gas demand.

In developed markets, UGS appears to be stagnating or experiencing only modest growth. These trends reflect differences in regulatory frameworks, market structures, geological possibilities and the integration of new gas developments, underscoring the ongoing need to adapt UGS strategies to evolving energy markets (national, regional and international).

NORTH AMERICA

North America has seen a slight increase in storage capacity, though new project development remains limited. The storage market is fragmented, with most capacities coming from small-scale porous reservoirs. At this time, Gas storage is the cornerstone of Gas infrastructure for the supply of gas during wintertime.

EUROPE

In Europe, storage capacity growth has slightly increased compared to the 2020-22 levels. Notably, Ukraine is now classified under the Europe region rather than CIS. While storage facilities remain actively used and fundamental for the energy system, conversion to production started in a few cases. Completions of extension projects of some storage facilities helped counterbalance capacity loss at sites chosen for abandonment. Storages in Europe are currently at a crossroads, with their role in the energy transition still to be fully defined.

CIS REGION

The CIS region mainly relies on storage for seasonal balancing and export support. Most of the capacity is linked to large-scale porous reservoirs with average withdrawal rates. Storage facilities are mostly owned by the state.

ASIA

Asia - mainly driven by China's strategic policy shift from coal to Gas - stands out as the only region experiencing robust storage growth. While this expansion is expected to continue in the future, infrastructure development is still lagging behind the pace of the region's growing Gas consumption.

LATIN AMERICA AND AFRICA

Latin America reported one new project (Pilar ESGN Field) while no major developments were noted in Africa.

Globally, there were plans reported for 65.9 bcm of WGV in various stages of planning and development. Greenfield development represents 42% while the remainder consists of expansions of existing facilities. Based on the unpredictable nature of project development, only general trends and estimates are provided in this report.

1. INTRODUCTION

The global energy system is evolving. Although global Gas demand continues to rise steadily, its long-term trajectory – as with most energy sources – remains highly uncertain amid the transition to a decarbonised future.

In the short term, energy markets are already under pressure from persistent seasonal fluctuations and increasingly sharp, regionally concentrated peaks in energy demand. These peak loads must be met rapidly by dispatchable and flexible energy sources—of which Gas¹ remains a cornerstone.

Looking ahead to the medium term, the challenges posed by the energy transition lead to a wide range of possible scenarios, shaped by different technological developments, policy choices, and investment decisions. In this uncertain context, one fact remains clear:

Gas plays a crucial and dual role in the changing energy mix, serving both as a reliable energy source and as a flexible resource capable of managing seasonal changes and sudden demand spikes.

As variable renewable energy sources become more prominent, this flexibility becomes even more vital to offset system volatility and ensure the stability of the grid, reinforcing Gas' essential role in supporting the global energy security.

At the same time, climate change is increasing the system stress through more frequent and severe weather events. Meanwhile, the growing interdependence of electricity and Gas markets—driven by deeper cross-border interconnections—adds new layers of vulnerability, raising the risk of cascading disruptions. In such a complex and exposed landscape, ensuring a stable and resilient Gas supply is crucial to protect both the security of energy supply and the price stability.

Underground Gas Storage (UGS) plays a pivotal role in addressing these challenges. By enabling the storage of large Gas volumes, UGS helps energy markets navigate seasonal shifts, absorb short-term shocks, and ensure reliable timely delivery to consumers. It balances supply and demand, stabilises transmission networks, enhances energy security, supports efficient market operations, and optimises production flows—making it a critical enabler of integrated and resilient energy systems.

UGS offers both **strategic depth and operational flexibility**, acting as a long-term reserve and a rapid response buffer. Its importance becomes especially evident during times of stress—such as extreme weather, supply chain disruptions, or geopolitical crises—when stored Gas can be quickly utilised to protect the system and shield consumers against price spikes or energy shortages.

This report aims to emphasise the vital role of Gas storage in ensuring a secure, stable, and sustainable energy future.

- **Part 1** draws on exclusive data compiled by the International Gas Union's (IGU) Storage Committee to provide a global snapshot of current underground Gas storage capacities and highlight key regional trends and dynamics.
- **Part 2** explores how UGS contributes to energy system resilience and security of supply, offering a conceptual overview of its “insurance value” and underscoring the broader societal benefits of integrating Gas storage more fully into energy system planning.

As the energy transition encounters challenges in adapting to increased electrification, a growing share of renewables, and the rise of hydrogen and other low-carbon gases, UGS will become even more essential. It is uniquely placed to bridge short-term flexibility requirements and long-term resilience objectives.

Looking ahead, sustained international cooperation, continuous innovation, and active knowledge-sharing will be essential to ensure UGS remains a robust, future-proof pillar of the global energy system.

1. In promoting 'Gas', the IGU fully embraces the potential of natural gas, LNG, low-carbon, decarbonised and renewable gases (including hydrogen, biomethane, synthetic gas, e-methane) to drive an even deeper decarbonisation of the energy system.

1.1 STATE OF PLAY OF UGS WORLDWIDE

Underground Gas storage includes unique assets within the Gas value chain, combining geological reservoirs with subsurface and surface infrastructure. For nearly 25 years, the Storage Committee of the IGU has monitored global UGS developments to create a distinctive data source of UGS worldwide, ensuring secure, efficient, transparent, and safe energy systems while supporting better planning, market stability, and environmental responsibility.

The 2025 update provides a summary of UGS activities worldwide and analyses the development of storage capacity region by region.²

Storage facility data were collected directly from storage system operators or national storage association companies via the dedicated portal hosted by the IGU.

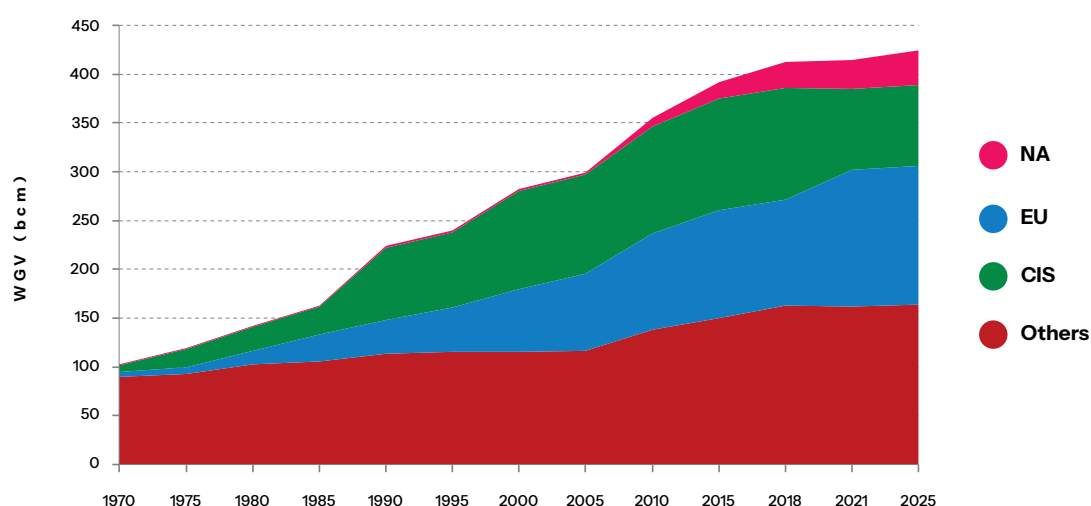
This method generated strong engagement and reliable inputs from storage operators in major regions such as Europe, Asia (China), Latin America, and Asia-Pacific. Considering the large number of storage operators in North America, a different approach was used. Those data were collected by the US Energy Information Administration (EIA) based on the latest data for Gas storage fields (published in 2024) and were supplemented by data from public sources, especially from the American Gas Association (AGA) and company websites.

The data and information presented in this report were collected from bespoke submissions, as well as from open sources.

1.2. UNDERGROUND GAS STORAGE IN THE WORLD

Total WGV is 424 bcm³ worldwide, which represents an increase of 10 bcm when compared to 414 bcm reported in 2022. There are 699 storage facilities in operation globally (as of April 2025), with the peak withdrawal rate of some 7,371 mcm/d compared to 7,221 mcm/d in 2022. The development of WGV over the years is depicted in Figure 2.

FIGURE 2: DEVELOPMENT OF WGV BY REGIONS



Source: IGU Storage Committee (2025)

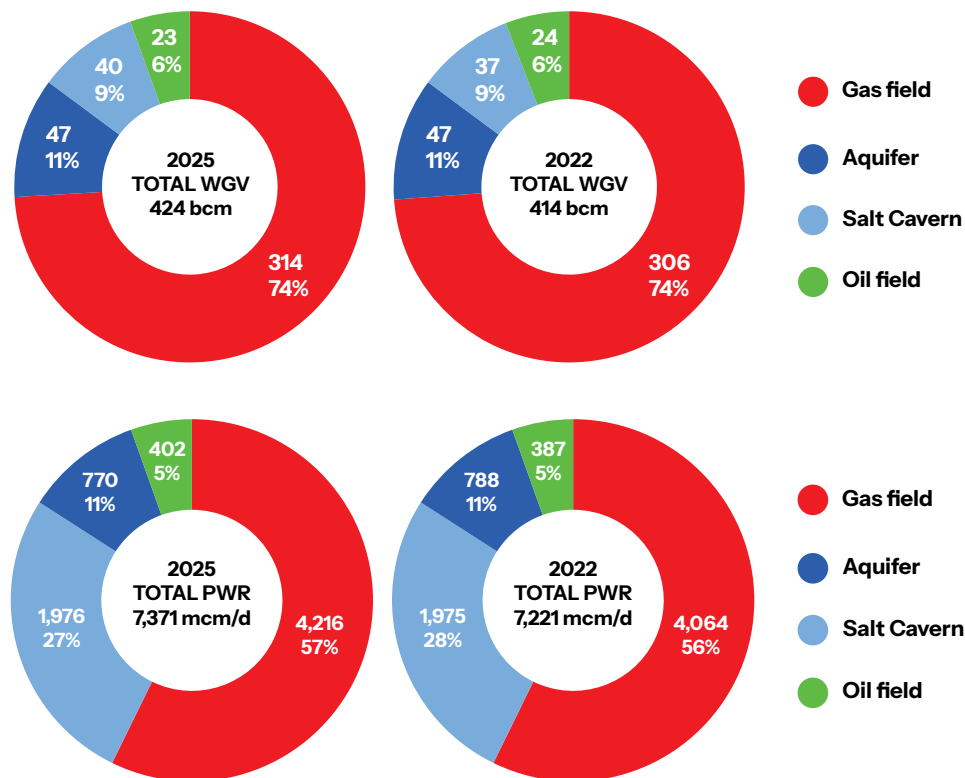
2. The data presented represents the status of Gas storage based on data collected during 2023-2025. Therefore, the situation of some storage facilities could have changed between the reporting and publishing date of this report.

3. The term WGV in the study represents capacity, and not its utilisation, so WGV booked and utilised volumes may differ

While Gas storage is not the only tool for achieving security of supply, it remains the most reliable solution, providing large volumes of Gas that are strategically located near key demand centres, and playing a key role in ensuring energy availability and reliability.

1.3. WGV AND PWR (POTENTIAL WITHDRAWAL RATE) BY STORAGE TYPE

FIGURE 3: DEVELOPMENT OF WGV AND PWR BY STORAGE TYPE



Source: IGU Storage Committee (2025)

The most WGV is developed in natural gas fields representing 74% (314 bcm), but these cover only 57% of the total PWR, followed by saline aquifers 11% (47 bcm). Salt caverns have a 9% (40 bcm) share per WGV, but as high as 27% of PWR, clearly illustrating the high deliverability provided by salt caverns.

1.4. WGV IN OPERATION BY NATION

A summary of the number of UGS facilities, WGV and PWR, by nation is summarised in the table below. China has made the single largest increase – 6 bcm – and is now 6th, in terms of total WGV. With the expansion of the Norg facility, Netherlands outranks France.

NATION	NO. OF UGS FACILITIES	WGV (BCM)	PWR (MCM/D)
USA	403	138.09	3395
RUSSIA	24	68.99	934
UKRAINE	13	32.18	307
CANADA	64	25.52	267
GERMANY	44	22.49	631
CHINA	25	19.83	220
ITALY	13	17.66	244
NETHERLANDS	5	13.74	283
FRANCE	14	11.77	220
AUSTRIA	9	8.58	94
HUNGARY	5	6.10	72
IRAN	2	6.00	29
AUSTRALIA	6	5.90	27
TÜRKIYE	2	5.84	81
AZERBAIJAN	2	4.70	14
UZBEKISTAN	3	4.00	47
CZECH REPUBLIC	9	3.90	83
KAZAKHSTAN	3	3.65	27
POLAND	9	3.56	54
UNITED ARAB EMIRATES	6	3.30	4
SLOVAKIA	3	3.23	45
ROMANIA	4	3.17	32
SPAIN	1	2.41	21
LATVIA	1	2.30	13
UNITED KINGDOM	8	1.74	119
BELARUS	3	1.09	34
DENMARK	2	0.95	25
BELGIUM	1	0.84	15
BULGARIA	1	0.55	4
SERBIA	1	0.45	5
CROATIA	1	0.44	6
NEW ZEALAND	1	0.27	1
JAPAN	3	0.26	2
PORTUGAL	1	0.24	7
ARMENIA	1	0.16	6
ARGENTINA	1	0.15	1
SWEDEN	1	0.01	1
TOTAL	699	424.04	7,371

Source: IGU Storage Committee (2025)

The USA operates the highest WGV, followed by Russia, Ukraine, Canada and Germany. Each country has a different driver for WGV development. Growth of WGV >5% was reported in several countries. In the case of Netherlands, Austria and the United Kingdom, this growth is mostly represented by the completion of past projects.

China and Türkiye are developing storages at a rapid pace. Japan increased its capacity in Sekihara storage and resumed the operation of Shiunji Field.

PART 2: ASSESSING THE TRUE VALUE OF GAS STORAGE

2.1. Source of energy system resilience

Underground Gas storage plays a vital role in ensuring security of energy supply by mitigating the risk of disruptions, even during unexpected emergency situations such as major technical or geopolitical events, or extreme weather events.

While Gas storage is not the only tool for ensuring security of energy supply, it remains the most reliable solution, providing large volumes of gas strategically located near key demand centres, and playing a central role in ensuring energy reliability. Unlike other solutions mainly aimed at providing flexibility services, underground Gas storage facilities can guarantee the physical availability of Gas. This enables suppliers to secure firm capacities, even for potentially significant amounts of Gas volumes within record delivery times.

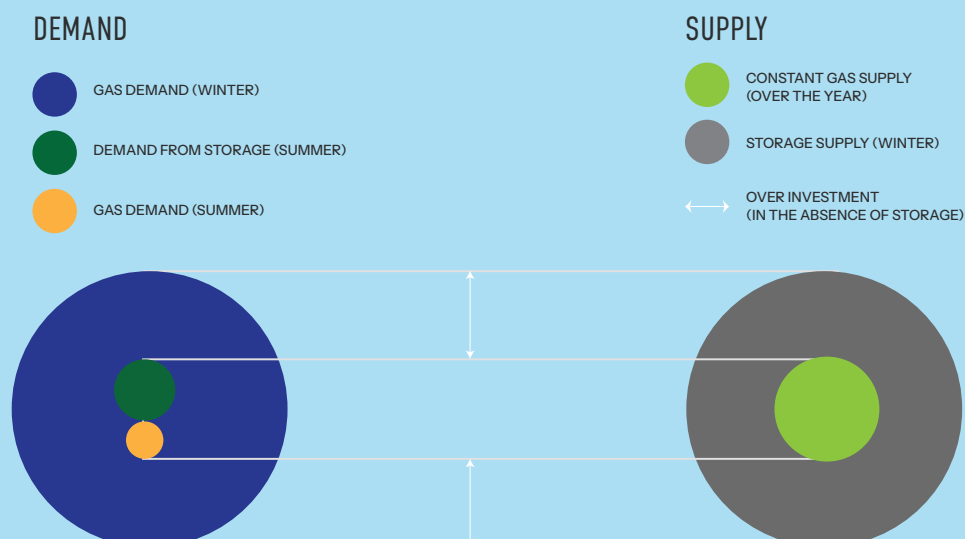
As a physically available back-up resource on the domestic market, Gas storage stands out as a strategic asset—enabling countries to reduce their dependence on traditional external energy suppliers.

Beyond economic stability, Gas storage provides the assurance that the ongoing energy transition will stay on course—by helping to avoid regression toward more polluting energy sources, such as coal, in times of stress or supply disruption. In this respect, Gas storage acts as a safeguard that allows countries to progressively reduce fossil fuels while maintaining their energy security. Gas storage provides the flexibility and reliability needed to accelerate the deployment of low-carbon and renewable energy sources, without compromising the energy system resilience or affordability for consumers.

2.2. The sizing of storage capacities

In mature Gas markets, the sizing of storage capacities has been carried out by optimising the entire Gas system, to meet winter peaks during extreme cold weather. It is therefore possible to assert, based on the scenario developed by planning and competent authorities, that there is no substitute for underground storage to mitigate the actual energy needs during these extreme events.

FIGURE 4: GAS STORAGE LOWERS SYSTEM COSTS BY AVOIDING OVER INVESTMENT IN TRANSMISSION PIPELINES



By providing readily available Gas volumes close to demand centres, Gas storage optimises the energy system. It acts as an additional energy supply, reducing the need to overinvest in Gas transmission infrastructure from distant supply regions, thereby enhancing financial efficiency.

Locating Gas storage facilities near consumption hubs not only reduces the need for costly network reinforcements, but it also decreases the reliance on flexibility mechanisms within the power system—mechanisms that are often constrained in both scale and duration. As a result, Gas storage helps avoid substantial capital expenditures (CAPEX) and curbs future operational costs (OPEX), contributing to a more efficient and resilient energy system.

Looking ahead, the continued deployment of renewables will bring new challenges of energy surplus and deficit across the grid. Only scalable energy storage solutions—such as underground Gas storage—are equipped to manage these structural imbalances effectively over time, ensuring both system reliability and economic efficiency.

2.3. Underground storage as a notable advantage in tackling energy system pressures

In numerous countries, substantial Gas storage capacities concentrated within a sizable region have the potential to reshape the global market landscape. When properly utilised, they can help prevent repeated price surges in Gas-use intensive regions.

CASE STUDY: LNG Price Surges during 2020-22 **- The Shielding Role of Gas Storage**

Phase 1 (2020–2021)

During the first wave of LNG price surges in Asia, the market volatility remained contained mainly to that region. European prices were mostly insulated, thanks in large part to high storage levels across the EU, which were filled up to 92%. These reserves provided a buffer that absorbed global shocks and helped maintain price stability on the European continent.

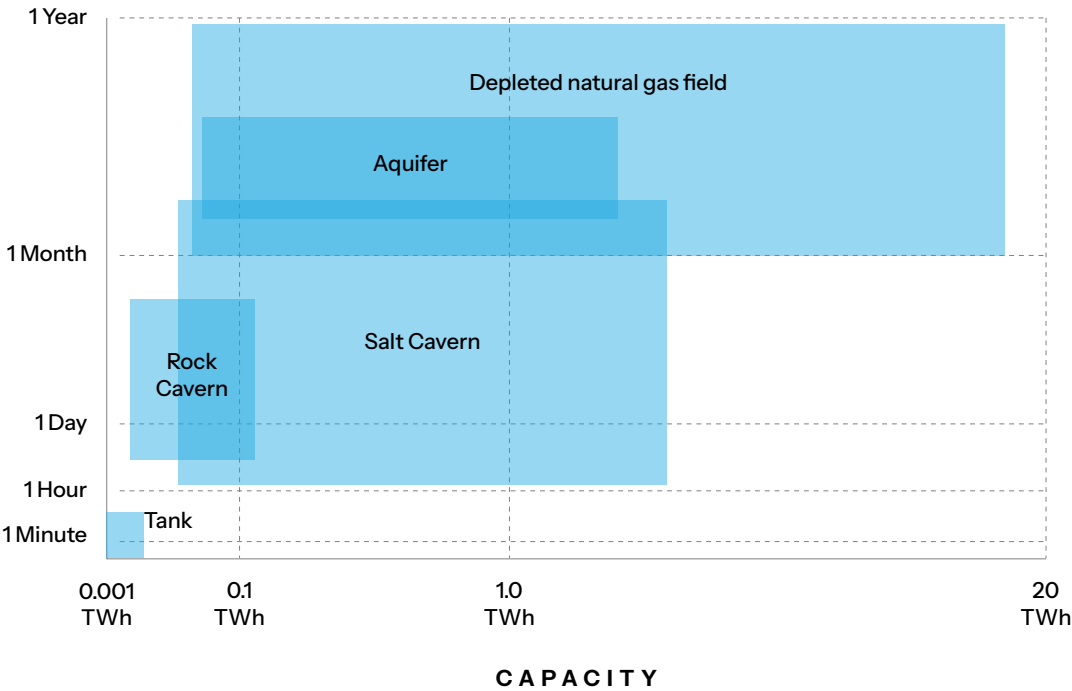
Phase 2 (2021–2022)

In contrast, the second surge in LNG prices had a far more pronounced effect on Europe. With European storage levels significantly lower —peaking at just 75%—the continent was left more exposed to global market tensions. As a result, price pressures spilled over into Europe, contributing to the early signs of what would become a broader energy crisis.

In response, the European Union (EU) adopted the Gas Storage Regulation in June 2022, marking the initial coordinated attempt to strengthen Gas storage requirements across Member States. This policy shift highlights the critical role of underground Gas storage in enhancing supply security and mitigating market volatility.

This phenomenon is well documented in articles from the Oxford Institute for Energy Studies. See M Fulwood, 'ASIA LNG Price Spike: Perfect Storm of Structural Failure?' OIES Energy Comment (Oxford Institute for Energy Studies 2021)

FIGURE 5: COMPARISON OF UHS TYPES IN TERMS OF CAPACITY AND DISCHARGE TIME (FLEXIBILITY TYPE)



ATTENTION: INTERVALS ON THE CAPACITY AXIS ARE EXPONENTIAL, I.E. UHS CAN HAVE ALMOST 1 MILLION TIMES THE CAPACITY OF A BATTERY.

Source: Guidehouse (2024)

The deployment of renewable energy sources only underscores the importance of designing a system where the integration of systems, gases and electricity, must consider the role of Gas storage which itself evolves with the need to extend the duration of this valuable resource to serve customers facing the triple challenge of affordable, continuous, and cleaner energy.

PART 3: SECURITY OF ENERGY SUPPLY AND GAS STORAGE

The insurance value of Gas storage refers to the inherent benefit provided by underground Gas storage facilities in mitigating risks and uncertainties associated with supply and demand dynamics. Underground Gas storage serves as a form of insurance against unforeseen events or fluctuations in the Gas market, providing a buffer to maintain stability and reliability in energy supply chains.

While storage may seem less critical during periods of abundant supply, it remains vital as an arbitrage tool for ensuring energy provision at minimal costs to consumers, thereby underpinning a flourishing economy.

In competitive markets where reliability is assured, the true value of Gas storage may be overlooked, especially in environments of ample supply. This oversight could lead to challenges if storage capacity, lacking regulatory support, becomes economically unviable, ultimately jeopardising the provision of consistent long-term services, particularly during unexpected events.

FIGURE 6: ILLUSTRATION OF ECONOMICS OF SEASONAL MODULATION – SUMMER VS WINTER



While Gas injection into storage during the summer can lead to a slight increase in prices during low-demand periods, this effect is more than offset by the substantial price mitigation it enables in winter—when demand is significantly higher and the number of consumers affected is much greater.

During the colder months, stored Gas plays a crucial role in shielding end-users from sharp price spikes and extreme market volatility. Ultimately, the collective savings generated by lower winter prices outweigh the modest summer cost increases, delivering meaningful value and stability for consumers.

Underground Gas storage is therefore a critical tool for sectoral integration in enhancing the resilience of energy systems, particularly during the transition to more sustainable energy sources.

Overall, the “insurance value” of storage lies in its ability to provide a reliable, flexible, and resilient energy infrastructure over the long term, one that can adapt to changing market conditions, mitigate risks, and support the transition to a more sustainable energy future. This situation had been particularly pronounced for countries that had a strong dependence on Gas suppliers or for countries where long-distance import Gas pipelines were built.

PART 4: THE NEED FOR A “WHOLE-SYSTEM” APPROACH

Government actions depend not only on objectively assessing risks but, also, on understanding societal perceptions of risk, which can vary based on socio-economic status, cultural background, and personal experiences.

This perception evolves and takes market conditions into account. Market perception also varies depending on whether one seeks to understand the position of private market players operating within the market, such as suppliers, or the society as a whole.

Fortunately, some governments around the world have started taking steps to complement the price signals provided by the market. They are implementing measures to maintain sufficient Gas storage capacity over time while ensuring minimum filling requirements for these facilities. This trend was evident in regions with established storage infrastructure, where certain Gas storage operators voiced concerns about potentially mothballing or closing some sites. These worries stemmed from the fact that storage sites were devalued by the wholesale market, being viewed mainly as flexibility tools competing directly with the market itself.

In other regions, there has been a notable interest in safeguarding against high LNG prices during specific times of the year, leading some governments to invest in expanding storage capacities.

In general, the strong interest shown by countries in Gas storage stems from the need to avoid putting the entire energy system at risk. This is due to the interdependence of energy sectors, which requires the availability of strategic reserves, the potential economic repercussions of supply disruptions, and the imperative to maintain global competitiveness.

4.1 Safeguarding against energy risks

Given the potential for sudden market shifts—such as severe cold spells or supply disruptions along major corridors—there is a clear need for the society to protect itself against these unforeseen risks.

Due to differences in national market structures and stages of Gas market development, countries and regions have adopted various approaches to safeguard energy supply security. These range from market-based mechanisms and regulatory interventions to more traditional security measures related to Gas storage, such as maintaining strategic reserves or imposing minimum storage obligations.

In recent years, policymakers across the globe have introduced or reinforced such measures to preserve or expand Gas storage capacity and to ensure that sufficient Gas volumes are stored in advance of the winter season.

4.2. Targeted intervention

While all Gas assets across the energy system contribute to mitigating energy crises, underground Gas storage plays the most critical role in the face of unexpected events, demonstrating that – at present – no viable substitute exists for this asset.

As the power mix shifts increasingly towards renewables, the electricity grid becomes more exposed to volatility and requires structural adaptation. In this context, the need for long-duration energy storage becomes essential to ensure firm capacity and maintain grid reliability.

The interaction between the Gas system - whether methane or hydrogen-based – and the electricity system must therefore become a priority for enhancing the overall resilience of the energy system.

This shift calls for an end to siloed thinking, where sectors operate independently and market designs are tailored only to the fundamentals of their respective domains (Gas or electricity). Instead, a more integrated, system-wide approach is required to reflect the interdependencies of a decarbonising and increasingly interconnected energy landscape.

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FIGURES

Figure 1: Total working gas volume of UGS facilities

Figure 2: Development of WGV by regions

Figure 3: Development of WGV & PWR by storage type

Figure 4: Gas storage lowers System Costs by avoiding Overinvestment in transmission Pipelines

Figure 5: Comparison of UHS types in terms of capacity and discharge time (flexibility type)

Figure 6: Illustration of economics of seasonal modulation – summer vs winter

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