Department for Energy Security & Net Zero

The role of gas storage and other forms of flexibility in security of supply

Energy security plan update

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Any enquiries regarding this publication should be sent to us at:
gsnm@energysecurity.gov.uk

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1. Introduction

Introduction

As set out in the Energy Security Plan (Powering Up Britain) natural gas ("gas") will continue to play a critical but different role in our energy system for decades to come. Even when we meet our net zero targets in 2050, we are still likely to require gas. It will be vital in both delivering our energy security and supporting our transition to net zero.

The UK has a secure and diverse energy system. Diversity of gas supplies, sources and routes to market are key features that support the UK's continued gas security. The UK's gas supply mix includes the UK Continental Shelf (UKCS), the Norwegian Continental Shelf (NCS), two bi-directional interconnectors to continental Europe and three Liquefied Natural Gas (LNG) terminals. GB also has eight geological gas storage sites, seven onshore and one offshore. The average UK supply mix from 2018-2022 was 44% UKCS, 34% NCS, 19% LNG[1] and 3% Interconnectors[2].

During spells of cold weather in winter 2022/23 our gas system remained well supplied, and the markets responded effectively, including through a December cold snap, which saw highest daily demand since the 2018 'Beast from the East'. This demonstrates the current high resilience of the UK energy system.

UK gas system resilience is supported by market flexibility and dynamic price signalling, including flexible sources of gas supply, primarily in the form of geological gas storage, LNG, and interconnector imports. Market flexibility is essential to promoting global security of supply, ensuring gas is delivered when needed, continuing to balance supply and demand. Security of supply in the UK is delivered through an effective gas market with investment in infrastructure driven by price signals. Through these price signals, the market has responded to declining domestic gas production with strong growth in gas import capacity[3].

To date, the market has, and continues to, deliver effectively, but there may be a need for additional flexibility in the future, as we become increasingly reliant on imports and on the supply of gas when it is needed to meet peaks in energy demand. We recognise that, over time, the market will become more dependent on these flexible sources of supply. It is right, therefore, that HMG considers their future role in delivering security and resilience to the market, and whether there is anything further that HMG needs to do to ensure continued investment in these flexible supply sources. In this Update, we set out the current gas supply and demand situation and consider the way in which the market may need to operate flexibly in future scenarios to support decarbonisation and ensure energy security.

[1] The split of LNG by source country is: Qatar (8%), Russia (2%), USA (6%), Other (3%)
[2] DESNZ analysis of published Energy Trends data (tables 4.2 and 4.4), available via: https://www.gov.uk/government/statistics/gas-section-4-energy-trends.
[3] UK National risk assessment on security of gas supply 2022 https://www.gov.uk/government/publications/uk-national-risk-assessment-on-security-of-gas-supply-2022

Objectives

The objectives of this Update are to:

- Present the updated picture on gas security of supply and demand, summarising key findings from analysis undertaken since the Energy Security Plan was published in March 2023.
- Explore the future role that flexible sources of gas supply (flexibility) might play in gas security over the medium to long term, and the associated policy considerations for HMG.

Given the key role that flexible sources of gas supply are expected to play in delivering our gas security in future, we are proposing to launch a **Call for Evidence on Flexibility** in the coming months to support the policy development and government decision-making on many of the issues raised in this document.

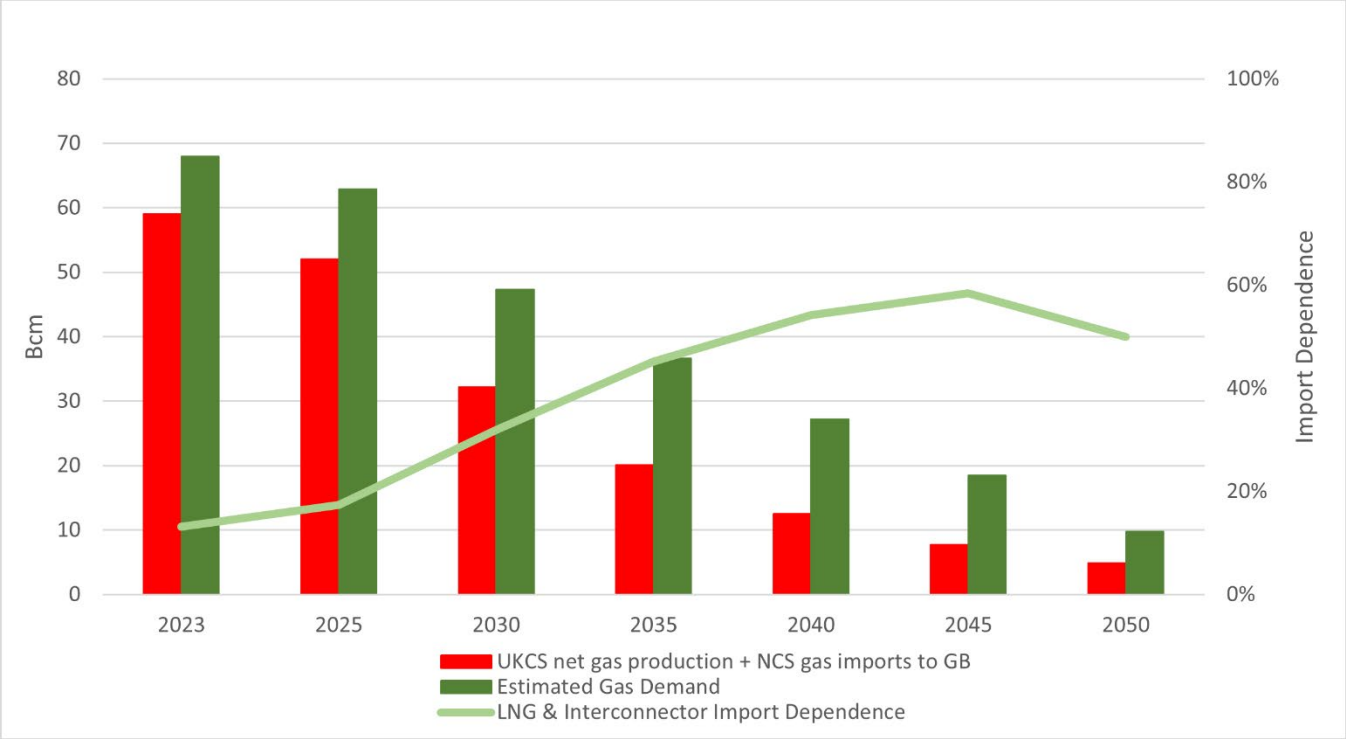
2. Supply and Demand

The Energy Security Plan identified that the gas supply picture is already changing. This will change further in coming years, with declining production of gas from the UKCS and, though more slowly, of gas from the NCS. Even with the Government's commitment to maximising domestic production through issuing new licenses, these additional licences will slow the decline in UK production levels rather than see them increase above current levels. Whilst this will be balanced against a reduction in demand for natural gas as the system decarbonises, production will fall more quickly than demand, making the UK more dependent on gas imports. More detail on what we know about the extent of this change is set out below. A key issue for Government is how to ensure the market has the right signals to deliver continued security and resilience over this significant period of change.

Chart 1 below shows a combined projected UK gas supply and Norwegian gas imports against overall UK gas demand and the resulting import dependency[4]. UKCS net gas production projections are taken from the North Sea Transition Authority's (NSTA) published production and expenditure projections for the UKCS, which incorporate a year-on-year decline rate of 10% for natural gas production[5], with NCS gas import data taken from National Grid's 2023 Future Energy Scenarios[6].

[4] DESNZ analysis using data from the Net Zero Strategy, available via: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1066450/nzs-charts-tables-v1.1.xlsx, worksheet "2. The Journey to Net Zero".
[5] NSTA 2023, Production and expenditure projections, available via: https://www.nstauthority.co.uk/data-and-insights/insights-and-analysis/production-and-expenditure-projections/
[6] https://www.nationalgrideso.com/document/283061/download
Data are an average of the three Net Zero consistent scenarios.

Chart 1: Projected UKCS gas supply and NCS gas imports, compared to UK Gas Demand[7]



2.1 Demand

In 2022, annual UK gas demand was 72bcm[8], which accounted for 38% of total energy demand[9]. Future UK gas demand depends on decisions taken about how to decarbonise the economy and, principally, on the extent of electrification and use of hydrogen. DESNZ modelling suggests gas demand is expected to fall from 72bcm in 2022 to ~47bcm in 2030; by 2040, that decreases further to around 27bcm. By 2050, we expect gas demand to be around 10bcm. Although this analysis models a reduction in total annual gas demand, there are still risks around high peak demand days.

There is also a risk that annual gas demand could be higher than outlined above, such as in a future world where hydrogen plays a significant role in decarbonising the economy. In that pathway, natural gas could be used to produce blue hydrogen[10], however we feel this represents a more extreme case, both as green hydrogen[11] could have a greater role, and

[7] DESNZ analysis using data from the Net Zero Strategy, available via: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1066450/nzs-charts-tables-v1.1.xlsx, worksheet "2. The Journey to Net Zero" and data from NSTA 2023, Production and expenditure projections, available via: https://www.nstauthority.co.uk/data-and-insights/insights-and-analysis/production-and-expenditure-projections/

[8] Demand data taken from DUKES data, Table 4.1. Available via: https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes. Available via: https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes Figures have been converted from TWh to bcm.

[9] DUKES, Chapter 4 (July, 2023) available via: https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes

[10] This is where gas is reformed into hydrogen and carbon, with the hydrogen used to provide low carbon energy.

[11] This is where hydrogen is generated by renewable or low-carbon electricity.

because mixed scenarios with lower levels of hydrogen demand owing to wider adoption of electric heating, are more probable.

Chart 1 above illustrates how natural gas interconnector imports as a percentage of total UK gas demand is likely to increase over time. In 2023, this is estimated to be approximately 13% and is forecast to increase and peak in 2045 at just under 60%, before falling to around 50% by 2050. To help contextualise this in volumetric terms, these LNG and interconnector gas imports used for domestic demand are forecast to increase from around an estimated 9bcm in 2023, to 17bcm by 2035, before slowly decreasing to 11bcm in 2045 and 5bcm by 2050. This suggests that while gas import dependency is predicted to increase, the volumes of gas imports required to meet UK demand do not increase at the same rate and in fact falls over time post 2035, mainly due to the general decrease in overall gas demand.

Electricity generated from unabated gas currently plays a critical role in ensuring our electricity system remains stable and secure. As we move towards a system with a growing proportion of renewable generation and an expansion of flexible low carbon alternatives, unabated gas plants will run less frequently in the future. However, whilst these low carbon flexible technologies scale up, we anticipate electricity generated from unabated gas will continue to be needed to ensure security of electricity supply. Some of the low carbon alternatives to unabated gas will also rely on gas, whether that is in plants equipped with Carbon Capture and Storage or plants using blue hydrogen derived from gas.

By 2050, it is likely that most gas use will involve CCS, with industry and any hydrogen production accounting for baseline gas demand. We also expect a greater number of, and more volatile, periods of peak demand – which will fall more slowly than annual demand – such as in times of low renewable electricity generation, where gas generation is then used to meet electricity demand.

Ensuring the UK has sources of supply which can quickly flex up and down in response to demand will be critical to maintaining security of supply and will be explored through the proposed Call for Evidence.

2.2 Supply

Production of the UKCS and NCS is declining, and as such, the UK is becoming more dependent on sources such as interconnectors and LNG. UKCS natural gas production peaked in the year 2000 and the UK has been a net importer since 2004 to meet domestic demand[12]. In 2022, UKCS gas production comprised around 41% of gross supply, with the remainder met via imports. Over the last 5 years, the UKCS has represented ~50% of the UK's natural gas demand. By 2030, this is expected to fall to around 33%[13].

The UKCS is a super mature basin and as such overall production levels are expected to decline over the long-term as commercially recoverable resources become depleted. As reiterated in our Energy Security Plan, Government remains committed to maximising the vital production of UK oil and gas as the UKCS declines. On 31 July 2023, the Prime Minister and

[12] DUKES 2023 Chart 4.1 'Supply and demand for natural gas, 1996-2022'
https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2023
[13] DESNZ analysis using data from the Net Zero Strategy, available via:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1066450/nzs-charts-tables-v1.1.xlsx, worksheet "2. The Journey to Net Zero" and data from NSTA 2023, Production and expenditure projections https://www.nstauthority.co.uk/data-and-insights/insights-and-analysis/production-and-expenditure-projections/

Secretary of State committed to future oil and gas licencing rounds as part of a push to strengthen our energy security.

The Government has also introduced the Offshore Petroleum Licensing Bill to Parliament. This Bill will safeguard our domestic energy supplies and increase certainty for the oil and gas industry by requiring the North Sea Transition Authority (NSTA) to run an annual process inviting applications for new production licences in the UK's offshore waters, subject to key tests being met:

- That the UK is projected to remain a net importer of both oil and gas,
- That the carbon emissions associated with the production of UK gas must be lower than the average of equivalent emissions from imported liquefied natural gas (LNG).

The Bill will enhance the UK's energy security and reduce dependence on higher-emission imports from overseas, backing our domestic oil and gas industry that supports more than 200,000 jobs as we grow the UK economy and realise our net zero target in a pragmatic, proportionate and realistic way.

The NSTA is currently running the 33rd offshore oil and gas licensing round and on 30 October announced the first 27 new licences in areas prioritised because they have the potential to go into production more quickly than others. Further offers are expected in the coming months. The next round and any out-of-round application window will likely commence after the 33rd licensing round, subject to the usual processes such as a climate compatibility test.

NCS production is also expected to decline. In recent years, the UK has on average received 34% of its gas from Norway; after the mid mid-2020s, NCS production is expected to decline at ~3% a year until 2032[14]. The Norwegian Petroleum Directorate estimate that they have exploited approximately 50% of expected resources to date with the remaining half providing the basis for production over several decades[15].The exact split of GB imports is unclear, not least because Norwegian supply into the UK market is likely to continue to be influenced by price differentials and arbitrage opportunities between the UK and continental Europe. However, using data from National Grid's FES 2023 analysis, we have attempted to estimate total UK gas demand against NCS imports. Between 2030 and 2050, NCS as a percentage of total UK gas demand equates to around 35-40% of demand throughout that period. This figure is relative static, as although total volumes of NCS imports to the UK are likely to decline over time, UK demand over that same period is also forecast to fall.

As domestic production declines, gas from LNG and interconnector imports could comprise around 40% of all UK gas supply by 2050. We will need to ensure our infrastructure can continue to meet our needs across both sustained periods of high demand and on peak days. This will require assessments of annual, seasonal and daily demand profiles to ensure deliverability can meet changing patterns of gas demand. Thus, flexible sources of gas supply are expected to play a greater role in future in delivering our gas security. We intend to explore this further in the upcoming Call for Evidence.

[14] Norwegian Petroleum Directorate, available at: https://www.norskpetroleum.no/en/production-and-exports/production-forecasts/
[15] Norwegian Petroleum Directorate, available at: https://www.npd.no/en/facts/publications/reports/resource-report/resource-report-2022/2-remaining-petroleum-resources/

3. Flexible Sources of Gas Supply

3.1 Introduction

Energy system flexibility can be considered as the ability to adjust supply and demand to achieve an energy balance. The energy system (including the gas system) needs to continuously match supply to demand which is known as energy balancing[16]. For the gas system there are three main sources of infrastructure-based gas supply flexibility[17] available; geological storage, LNG, and interconnectors, and they all share similar properties:

- They are able to respond to peaks in demand.
- They can be dialled up or down depending on the specific needs across days and seasons.
- The contribution they make to gas supply is driven by market signals: they respond to price differentials in GB and continental Europe to direct gas to where demand is highest.

The current and future roles that each form of flexibility may play in delivering gas security are considered in the following sections.

As set out above, with the declining UKCS production, we expect gas demand to be met through increased reliance on LNG imports and on supply through the continental European interconnectors to manage peaks in demand. Greater reliance on overseas imports could be combined with increased domestic gas storage deliverability to ensure the UK can meet gas demand at short notice.

Clearly, as the gas demand and supply profiles change, the role of storage, LNG and interconnectors will also change. We expect these to play two key roles of contributing towards baseload supply (mainly LNG) and providing continued, probably increased, flexibility. We recognise that, in addition to understanding the role that each individual source of flexible supply plays in delivering gas security, it is equally important how one form of flexibility might complement or mitigate the supply risks to another.

System resilience i.e., how supply meets demand, is the key for a future proofed system. We are undertaking work to determine the optimum balance for these flexibility sources; early analysis indicates that we will need a range of all three sources, being able to meet different flexibility requirements as they have their individual strengths such as **speed of access** i.e., how quickly can we get access to the gas (storage and interconnectors) as well as **scale of flexibility**, i.e., how much total gas can be delivered (LNG), as well as **reliability of access** i.e., could it be impacted by geopolitical events (storage).

Each flexibility source can provide different responses to the market; for example, storage can act as an immediate response to peaks in demand, the high gas deliverability rates enable some storage sites to provide within-day balancing to the gas system. It is likely that this

[16] National Grid Energy System Operator, available at: https://www.nationalgrideso.com/document/189851/download#:~:text=What%20is%20flexibility%3F,to%20achieve%20that%20energy%20balance.

[17] This Update does not consider other sources of flexibility such as price sensitive portion of the NCS or demand-side flexibility (DSR) as these are of a smaller scale and DSR is not a supply side mitigation.

immediate response will be required more frequently in the short to medium term, particularly to support electricity generation. The expansion of renewable electricity generation will mean more and varied peaks and troughs on the system for which unabated gas generation currently provides flexibility provision and will include low carbon forms of flexibility in the future including gas powered CCUS and Hydrogen to Power plants. A more sustained peak in demand, as a result of a cold snap for example, could be met by LNG imports which have a response time of ~1 – 14 days.

Given their varied and complementary strengths, our current expectation is that a balance across all three forms of infrastructure-based gas supply flexibility provide a more secure energy system than an overreliance on one source which could leave the gas system exposed. If one flexibility source was chosen to meet winter demand on its own, it is likely that a substantial increase in capacity of that source would be needed to ensure peaks in demand could be met. This would likely mean throughout most of the year there would be an excess of capacity that remains unused, which is inefficient and could drive up costs unnecessarily. For example, to use storage in this way, focusing on winter 2022/23, there would need to be a doubling of gas storage capacity from ~3bcm to 6bcm[18]. This is not an effective way to mitigate supply and demand gaps, reiterating the need for diversity within flexibility sources.

In addition, we believe that less overall LNG may be required to meet peak demand if there is also adequate storage capacity available. Storage sites provide a place to store gas when there is a surplus of LNG coming into the country and provide quick access to gas on GB shores at times of high winter demand whilst LNG tankers are en route.

Given the shared infrastructure with continental Europe, with our two bi-directional gas interconnectors, prices on the GB market continue to be impacted by prices on European markets. For example, over summer 2022, GB's significant LNG import infrastructure led to the GB market being used as a delivery hub to support European ambition to fill gas storages ahead of winter 2022/23. 2022 saw record volumes of LNG imports, but also record volumes of interconnector exports. This was because the market directed LNG into the UK's terminals, and the UK directed the gas across our interconnectors and into continental European gas systems, including into European gas storage.

Therefore, it is in our interests that the EU continues to fill its significant gas storage capacity, - and for the GB market to support this through LNG exports - as this provides a large reserve of gas to help manage a cold winter and increases the likelihood that gas is available to import from continental Europe should the GB market require it.

Under current market conditions LNG will continue to arrive in the UK and indeed demand for LNG is expected to increase over time. More storage capacity could boost domestic security of supply and complement our strategy of flowing gas through the interconnectors to Europe to support storage fullness on the continent.

[18] DESNZ analysis based on published Energy Trends data, Tables 4.1 and 4.3, available at: https://www.gov.uk/government/statistics/gas-section-4-energy-trends. This assumes UKCS and NCS supply but no supply from Interconnectors or LNG.

3.2 Geological Gas Storage

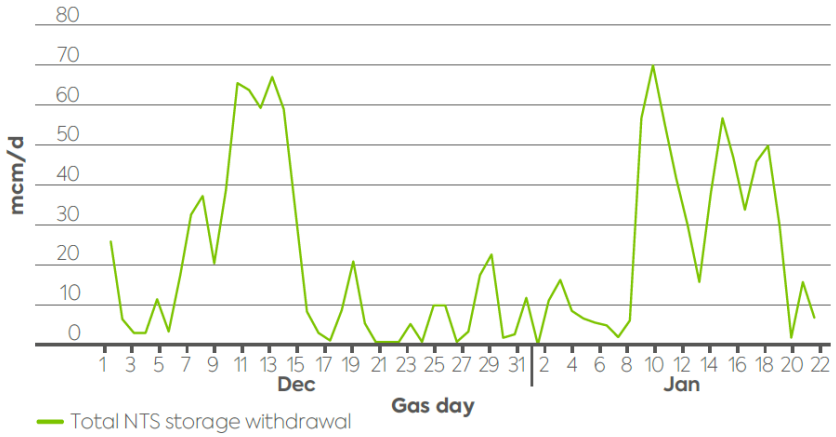
A natural gas geological storage facility can be defined as a site that can hold natural gas for an indefinite period. Comprising of four parameters: cushion gas volume, working gas volume, injection capacity and withdrawal capacity. GB[19] currently has two types of geological gas storage: salt caverns and depleted hydrocarbon fields (gas and oil). It is also physically possible to store natural gas in saline aquifers, however these are not currently used in the UK.

Current Role

GB storage acts as an important flexibility provider, balancing fluctuations on supply and demand. It offers flexibility to the market when other sources of supply such as the UKCS, NCS or LNG are more expensive or not available. As outlined in the previous section, the diverse sources of supply available to the UK, including direct access to gas supply from UKCS, has meant that the UK is not reliant on natural gas storage in the way that mainland Europe is, where it relies on gas storge to provide a baseload supply source in winter.

During winter 2022/23, geological storage behaved as expected, providing flexible supplies on to the National Transmission System (NTS) when needed[20]. This played a crucial role over winter, providing flexible supply (driven by market signals) during periods of high demand and then re-filling during lower demand periods. This was particularly evident during cold snaps in December 2022 and January 2023, as demonstrated in the graph below. On 17 January 2023, a total of 70.2mcm of gas entered the NTS from storage withdrawal, the highest volume observed in the last 18 months[21].

Chart 2: Total NTS withdrawal[22]



The eight geological gas storage sites in GB, provide ~3.1bcm of capacity and maximum deliverability rates of 124mcm/day[23]. To put that in context, average daily GB January demand

[19] GB not UK, as there are no gas storage facilities in Northern Ireland.
[20] National Gas Transmission, Winter Review and Consultation, June 2023 available at: https://www.nationalgas.com/document/143291/download
[21] National Gas Transmission, Winter Review and Consultation, June 2023 available at: https://www.nationalgas.com/document/143291/download
[22] National Gas Transmission, Winter Review and Consultation, June 2023 available at: https://www.nationalgas.com/document/143291/download
[23] National Gas Transmission, Winter Outlook 2023, available at: https://www.nationalgas.com/electricity-transmission/documents/144421-gas-winter-outlook-2023-24

over the last five years equated to 315mcm/day[24]. These gas storage sites are operated on a merchant basis, whereby storage sites and stocks are privately owned meaning they respond to market signals for injection and withdrawal. Shippers (gas market traders) fill their purchased capacity at storage sites with gas when prices are lower in the summer and sell gas onto the market in winter when the price is generally higher. Storage operators provide the injection and withdrawal services at the request of their customers, the shippers.

Within GB, five of the sites are salt caverns, two are depleted gas fields, one is a depleted oil field and only one of these is offshore. Seven sites are considered medium-range storage sites with the offshore facility considered as seasonal or long-range storage. The medium-range storage sites can empty and refill over the course of winter and tend to be less tied to seasonal patterns (of injecting in summer and withdrawing in winter) when compared with long-range storage. Depending on the size, age, and pressure of the facility some sites can empty and refill within days whereas others can take weeks.

Historically, faster-cycling storage sites would also follow a loose seasonal pattern of injection in summer when prices are lower and withdrawal in winter – when prices are higher to make a profit – like long-range seasonal facilities.

The average asset life of a geological storage facility is 40 to 50 years. Storage sites opened in GB between 1979 and 2014, with Rough re-opening in 2022 following a closure of ~5 years. Therefore, it is likely that we will see some decommissioning of facilities starting to occur in the late 2030s and early 2040s, depending on the age and quality of the facility. Over the past 20 years multiple storage projects have received planning permission but at least seven have not progressed to reach Final Investment Decision, and open[25].

We recognise that market dynamics have shifted over recent years, and the summer/winter price differentials narrowed over the 2010s, partly due to the rise in year-round LNG supplies. This reduced revenue certainty which is essential for site operation to continue and/or expand. Whilst the storage market saw favourable returns over the winter 22/23, we understand this was because stocks were traded in line with the significant gas price volatility over that period. Volatility could also influence future site decisions such as investment and decommissioning plans, as if operators believe the market will remain volatile for an extended period of time, their assets may be more profitable than previously thought and justify investment in longer life, or expansions.

Given the need for revenue certainty, the gas storage industry has consistently indicated that:

- There are currently no plans[26] to bring online new storage facilities, and
- any commercial decision to bring new natural gas storage online would need to take account of the future system demand for hydrogen storage.

At the same time the lead-in times for development of new storage capacity are substantial - general industry consensus is that the development of storage infrastructure in new underground salt caverns is a process that can take between 7 – 9 years, from planning and consents through to construction. This is, however, site dependant as some may be quicker than this.

[24] DESNZ analysis using National Gas Transmission data, sourced via: https://data.nationalgas.com/find-gas-data
[25] National Gas Transmission, Gas Ten Year Statement 2021, available at: https://www.nationalgas.com/document/137861/download
[26] No plans with Final Investment Decisions (FID) reached.

Future role and policy considerations

Although gas will support the transition to net zero, the precise level of natural gas storage required (in terms of both capacity and deliverability onto the NTS) will depend on the decarbonisation pathway chosen and how much potential for disruption to supply is accepted.

We are therefore undertaking analysis that examines how much natural gas storage might be required to isolate the UK against various security of supply risks, including a cold snap, loss of LNG or loss of interconnectors set against the context of declining baseload supply sources. This will be based on demand and supply projections out to 2050, with the results providing an indication of how much natural gas storage we would need in these scenarios to mitigate against those risks.

In addition to considering the role of storage as the gas system transitions to net zero, we will also need to consider the need and the case for government intervention to enable it. This will depend on whether or not the likely changes in gas supply positions – such as an increased reliance on LNG – will naturally result in increased market demand for storage.

To date, some current market participants have indicated that they believe government support is required to stimulate the storage market in a timely manner to ensure that development of such projects do not result in under provision of storage into the market at a future, critical time.

We also know that there can be an economic cost to the country from a lack of energy security; one approach we can explore to monetise energy security is to use Value of Lost Load (VoLL) as a metric i.e., a value associated with an interruption of energy supplies. VoLL is typically expressed as either a consumer's willingness to pay to prevent a loss of energy supply, their willingness to accept an outage, or by calculating the economic impact of that outage. This needs testing and evidencing further.

The invasion of Ukraine has significantly disrupted energy markets, leading to high volatility of the international market and sustained higher gas prices. Whilst having additional gas held in storage for use during peaks in winter could reduce exposure to price volatility on the day ahead market, this is unlikely to result in any material savings for UK consumers. The nature of the global market and the existence of more storage in any form could increase the demand for gas during the summer injection season, potentially leading to increased summer prices. One view is that wholesale gas prices across the EU and UK spiked in summer 2022, in part, due to operators having an 80% target mandated by 1st November 2022 in the EU, leading to a scramble for available gas.

Government incentives, if deemed necessary, could be regulatory, financial or both. We consider that regulatory change to implement business models would likely require new legislation. We would expect any such business model to be cost effective, avoid unnecessary complexity, be flexible in support over time, and be adaptable to the future energy system. In particular, given future decarbonisation pathways and likely need for hydrogen storage, any natural gas business model would need to align with the hydrogen storage business model which the Government has committed to designing by 2025.

The forthcoming Call for Evidence will explore all these issues in greater detail and seek evidence from stakeholders to support policy development and decision making.

Diversification of natural gas storage

As the country becomes more reliant on gas imports there is a question as to whether we need to diversify our gas storage provision beyond the majority medium cycle gas storage that we currently have. Some diversification options might include:

- **Strategic gas storage** which is a reserve of gas that is held back from normal (market) use by governments to use, such as for security of supply or to cope with unexpected events. Strategic reserves can support increased energy independence and a stronger guarantee on energy security, as they provide the possibility of rapid emergency response. However, they are complex logistical and technical exercises that can carry significant costs associated with building, filling and operating any facilities.

- Having larger, **long-range seasonal storage** that can provide a constant steady flow of gas into the gas system and is viewed as a source of supply, rather than a response to peak demand. This could reduce the capacity level required for medium or faster-cycling storage within the wide system as the seasonal storage can smooth peak demand extremes.

- Setting **mandatory fullness targets** involve governments setting a percentage fullness target for gas storage sites throughout winter. These can be imposed on suppliers as compulsory stock obligations, shippers, or site operators. Targets can provide some degree of certainty of gas being in store when needed, but the impacts of targets for storage viability varies depending on who is obligated. For example, if placed on suppliers it can provide a stable revenue stream but could add additional costs to consumers. If placed on storage operators it can limit flexibility to respond to market signals and reduce opportunities.

Any diversification of storage type without an associated increase in storage capacity would need to be considered carefully, as it could restrict the current flexible role that storage plays in responding to peaks in demand thereby inadvertently threatening security of supply. For example, if mandatory fullness targets were set too high it could result in all operators holding onto gas in store for extended periods, rather than releasing gas onto the system at times of need.

Interaction with low carbon gases

As government considers the pathways to decarbonisation, the introduction of low carbon alternatives to natural gas may also see different uses for geological storage. Hydrogen, CCUS and Biomethane will all require some form of storage, albeit to differing degrees.

Carbon Dioxide (CCUS)

To keep the UK on track to meet carbon budgets and achieve Net Zero, the Government is committed to capture and store 20-30 million tonnes CO2 (MtCO2) per year by 2030 across the economy and at least ~50 MtCO2 by the mid-2030s[27] with a significant increased forward CCUS demand forecasted by the CCC between 70 million tonnes to 175 million tonnes per year by 2050[28] to bring all UK greenhouse gas emissions to Net Zero.

To meet the UK's net zero targets, the NSTA as the regulator for the storage of CO2 on the UKCS, estimate that up to 100 separate stores could be required for domestic

[27] Net Zero Strategy: Build Back Greener (2021)
[28] Sixth Carbon Budget, Climate Change Committee, 2020

storage[29]. Typically, CO2 will be stored in geological formations offshore, within depleted oil or gas fields, or saline aquifers. This involves injecting CO2 underground at depths of around 800 metres or more, where the CO2 will be securely contained. These are a different set of requirements from natural gas, and also hydrogen.

Hydrogen

Natural gas storage sites can be converted to store hydrogen. Hydrogen storage has the potential to play a key role in managing imbalances in hydrogen network entry and exit flows, provide security of supply and support demand for offtakers, producers.

At this time, exact requirements to support the hydrogen economy are unknown – it will depend on the level of hydrogen roll out (i.e., high vs low hydrogen production and demand scenarios). Initial evidence from the Energy System Operator's Future Energy Scenarios (FES) suggests that, by 2030, there could be a need for ~0.3 to 0.6bcm of hydrogen storage and, by 2050, there could be up to 20 times more required[30].

Salt caverns are suitable for natural gas and hydrogen storage, and can be converted for use by both gases, over a minimum of 3 years, depending on the age, quality, and size of the salt caverns. It will be important to avoid inadvertent conflict between these potential uses of salt caverns. To mitigate this, we are considering how best to plan for hydrogen storage infrastructure, and how this will work effectively alongside a continuing need for natural gas storage.

Biomethane

Illustrative modelling outlined in the Biomass Strategy[31] suggests that around 30 - 40TWh (~2.7 - 3.6bcm) of annual biomethane production by 2050 could help the UK achieve net zero cost-effectively[32]. Current support schemes are expected to deliver 8TWh (0.7bcm) of annual biomethane injections by 2030. We will consult on introducing a policy framework for biomethane to follow the current Green Gas Support Scheme (GGSS). The GGSS is currently open to new applications until November 2025. We recently consulted on an extension of the scheme as part of the Mid-Scheme Review, and on 21 October 2023 we announced our intention to extend the scheme to 31 March 2028; full details will be published in the Mid-Scheme Review government response in due course.

Biomethane could be stored along with natural gas and will be considered alongside natural gas in planning around this storage.

We will seek input from external stakeholders on these interactions with low carbon alternatives through our forthcoming Call for Evidence and will conduct targeted engagement with key stakeholders active across the storage value chain.

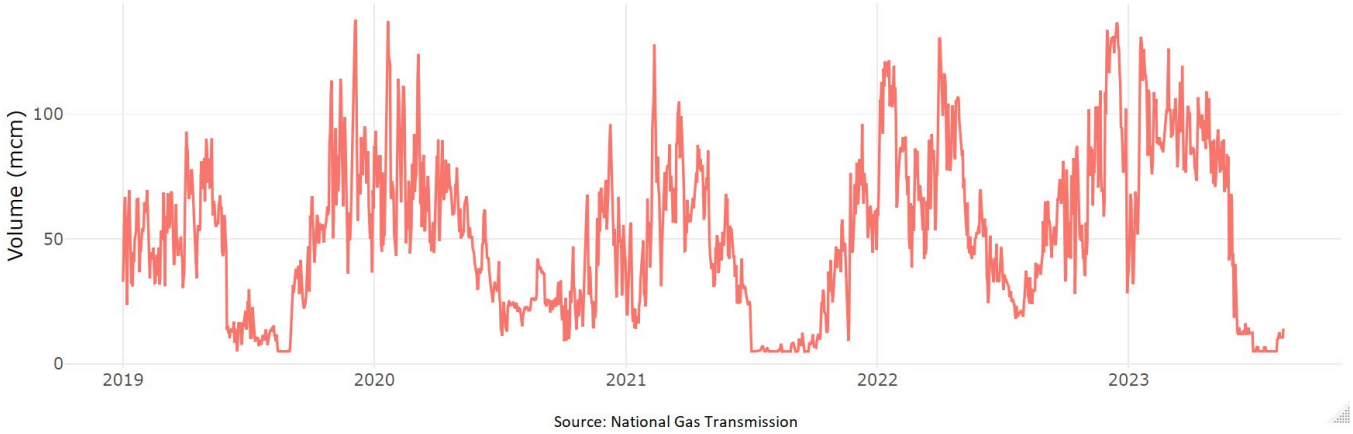
[29] NSTA, Carbon capture and storage – the road to net zero, available at: https://www.nstauthority.co.uk/news-publications/news/2023/carbon-capture-and-storage-the-road-to-net-zero/
[30] National Grid ESO, Future Energy Scenarios, available at: https://www.nationalgrideso.com/future-energy/future-energy-scenarios
[31] Biomass Strategy 2023, available at: https://www.gov.uk/government/publications/biomass-strategy#:~:text=This%20strategy%20sets%20out%20the,where%20further%20action%20is%20needed.
[32] Figures are based on illustrative pathways and are subject to modelling limitations and uncertainty.

3.3 Liquefied Natural Gas (LNG)

Over the past few decades, Liquefied Natural Gas (LNG) has become an increasingly important method of moving natural gas to market. LNG refers to natural gas which has been cooled to around -160 degrees Celsius, changing its state from gas to liquid. This means it can be transported by ship, as the volume is around 600 times smaller than the gaseous state. Once at its destination, LNG is regasified and used in the same way as natural gas which has not been liquified[33].

Current Role

Chart 3: Daily LNG send out to the NTS, 2019-August 2023[34]



GB[35] has one of the largest LNG import infrastructures in Europe which provides access to the growing volume of global liquefaction and export capacity. This import infrastructure includes three LNG terminals, providing an aggregate annual import capacity of around 51bcm and peak daily supply of 150mcm/day.

Our three LNG terminals are located at two sites: Dragon and South Hook LNG terminals are co-located in Milford Haven, Pembrokeshire; Grain LNG is on the Isle of Grain, Kent. Grain and South Hook terminals have expansion projects underway. These are expected to add approximately 29mcm/day of additional capacity, futureproofing LNG as a flexible source of gas.

LNG provides a flexible source of supply which can increase or decrease in response to movements of gas prices. The volumes of LNG flowing into the UK respond to the differences in gas prices in the UK relative to other markets in Europe and in East Asia.

GB LNG imports hit a record high of 26bcm in 2022, up 74% on the previous year. GB's significant regasification infrastructure meant that, over 2022, GB was used as a land-bridge for increased natural gas exports via the interconnectors to Northern Ireland, Ireland and continental Europe. This was a function of the interconnected markets responding to gas demand across Europe. Following curtailment of Russian gas supplies to Europe in the aftermath of the Russian invasion of Ukraine, and after the EU put in place a minimum storage

[33] DESNZ Special Article – Energy trends collection, March 2023, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147129/Supply_of_Liquefied_Natural_Gas_in_the_UK__2022.pdf
[34] National Gas Transmission Data Portal, available at: https://data.nationalgas.com/
[35] GB not UK as there are no LNG facilities in Northern Ireland

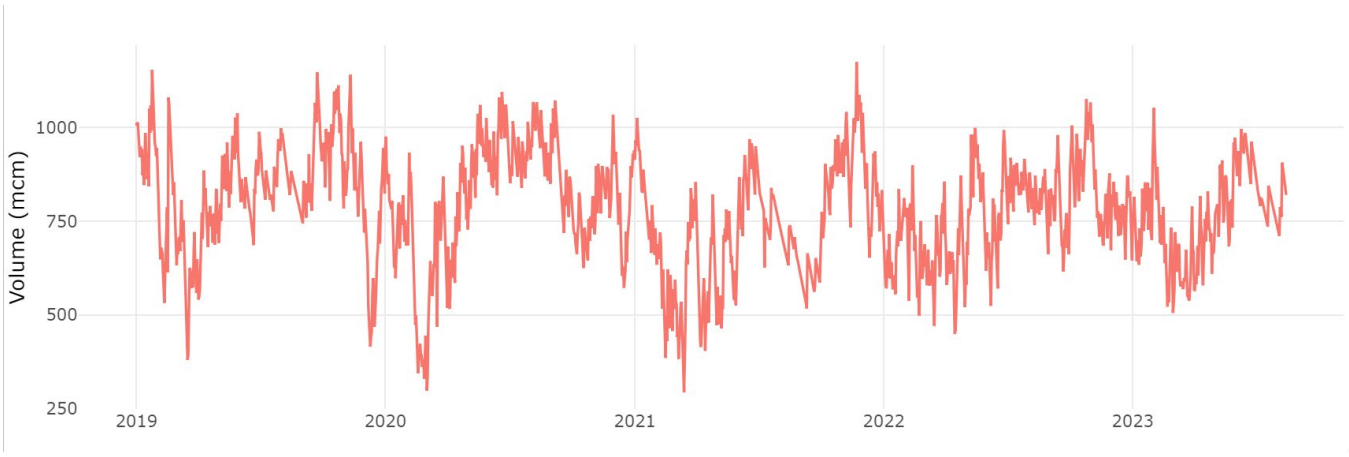
filling obligation, gas demand in continental Europe rose significantly, with prices following suit. Following the Russian invasion of Ukraine, exports to Europe from GB were at their highest at 24bcm – over 3 times greater than seen in 2021[36].

In the current GB gas market, LNG imports tend to arrive under flexible and short-term contractual arrangements. This means that, aside from some low minimum contractual obligations to bring in enough cargoes to keep LNG terminals cool, LNG cargoes land in GB when the NBP price rises sufficiently relative to other global gas markets to incentivise firms to deliver this to GB. While this is a more flexible approach than other GB gas supply sources, it has been able to attract sufficient cargoes of LNG when needed: we saw record levels of LNG imports in 2022, and the LNG market consistently responds to high prices in GB to deliver LNG cargoes.

This is in contrast to markets such as East Asia, which relies heavily on LNG for its gas supply. In East Asia, LNG is generally supplied under less flexible long-term contracts which are only divertible at the discretion of LNG buyers based in those countries, when they determine they do not need additional LNG cargoes.

While LNG vessels take around 14-17 days to arrive in the UK, they can be diverted from their destination in the event of a spike in demand and subsequent rise in prices. During 2018's 'Beast from the East', we saw vessels arriving within days to meet heightened demand.

Chart 4: Daily level of UK LNG storage stocks, 2019-August 2023[37]



Source: National Gas Transmission

Total on-site storage capacity is approx. 2.1 mcm of LNG, which is equivalent to ~1.2bcm once regasified. This is managed commercially, with the firms holding capacity rights to use the LNG terminals holding the rights to storage capacity in the tanks.

LNG terminals must maintain a small minimum level of LNG in storage tanks to keep them cool, often between 5-10% of capacity, but beyond this LNG shippers can use the storage tank capacity to manage their rate of send-out of LNG into the National Transmission System (NTS) and hedge in expectation of future price movements.

[36] DESNZ Special Article – Energy trends collection, March 2023, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1147129/Supply_of_Liquefied_Natural_Gas_in_the_UK__2022.pdf

[37] National Gas Transmission Data Portal, available at: https://data.nationalgas.com/

Future Role

While total gas demand will decrease as the UK transitions to net zero, the UK's import dependence for both LNG and interconnector gas supply is projected to rise from a predicted 13% in 2023 to around 32% by 2030. This is forecast to peak at around 58% in 2045, falling to 50% by 2050. It is likely that LNG will make up a significant proportion of these future gas imports. There may be changes to the role LNG supply plays, moving from a flexible source of gas which increases or decreases in line with demand, to providing some baseload supply, plus a flexible portion of supply on top of this.

There will also be important interactions between LNG and geological storage. An increasing proportion of gas held in geological storage sites will come into the UK as LNG, and directing imported LNG into geological storage will enable greater use of LNG capacity across the year by incentivising the market to import LNG during lower demand periods over the summer months because there will be more availability to hold the gas in storage. This would potentially see LNG terminals used more throughout the year to meet demand, rather than to meet short-term demand during the winter months. Additionally, the total deliverability of LNG, storage and interconnectors should be considered. If GB has large storage sites with high levels of deliverability, this may reduce the need for further capacity increases at LNG terminals or across the interconnectors as the overall system is able to meet demand. At the same time, the inverse is true, and a small volume of storage capacity may require additional LNG deliverability to ensure demand can be met during peak periods.

The ongoing expansion of Grain and South Hook LNG terminals will increase total annual import capacity to 59bcm. This further supports the analysis above, suggesting the UK will have enough import capacity to meet demand. The seasonal pattern of gas demand will be a key determinant in ensuring the UK has sufficient import capacity to meet demand, as, if demand for imports falls largely or entirely in the winter months, it may exceed import capacity.

However, gas demand is likely to become more volatile as gas is increasingly used to meet power demand on days of low wind/solar availability, with peak demand falling more slowly than annual gas demand. Further analysis is needed to determine that the deliverability of LNG terminals, and the capability of the NTS to accept high volumes of LNG, is sufficient to meet projections of future peak demand days. The Gas Supply Security Assessment announced in the Energy Security Plan will factor in LNG deliverability as part of its methodology. We will also seek input on the adequacy of LNG infrastructure in our forthcoming Call for Evidence.

As detailed in Chart 4 LNG supply to the NTS is highly variable, responding to GB gas demand levels and gas prices in GB relative to other markets. In a future of increasing reliance on LNG markets to provide gas security, it is right to consider the ability of LNG market participants to ensure a reliable, readily available supply of LNG at short notice, particularly in the event of market or infrastructure disruption elsewhere on the GB network, or the global energy market. It could be that more long-term, firm contracting behaviour may be preferable, but long-term contracts can come with costs as well as benefits, in being less flexible and responsive to market conditions. The lack of long-term LNG contracting in the UK gas market could suggest the UK's gas market policy, regulation and market structure may not incentivise this behaviour. The Government will use the forthcoming Call for Evidence to gather input on contracting behaviour and views on how this might change as the structure of the UK's gas supply sources changes over time, and the potential impact of more firm contracting on the gas market.

The role of LNG storage could also be an option to support increased security of LNG supply, alongside geological storage. Some countries use LNG storage to provide a strategic gas reserve. National Gas Transmission (NGT) can contract with gas market participants, including

LNG capacity holders, to hold gas in storage to act as NGT's required Operating Margin (OM) gas reserve. Increasing or expanding the use of LNG reserves, via minimum levels of LNG to be held in on-site storage or other requirements, could reduce market participants' flexibility to send out or hold gas in response to prices, but it may provide benefits in ensuring that a minimum level of LNG is available at short notice should there be an unforeseen spike in demand. There may be a justification to manage LNG storage stocks separately from geological storage sites because LNG is less well-suited for longer-term storage due to weathering and boil-off which occurs when LNG is stored for long periods, and because the LNG terminals can rapidly increase their deliverability from zero to maximum, therefore any use of LNG as a strategic reserve may need to be managed differently from medium-range storage sites.

The future role of LNG terminals must also be considered, as there is potential to repurpose infrastructure to participate in global trade of hydrogen and potentially other gases. Repurposing an LNG terminal could support future clean growth in the UK, by enabling hydrogen import/export, but it would likely impact GB gas security in removing an entry point for flexible gas supply. We will continue to engage with market participants to understand the potential for repurposing of LNG infrastructure.

Government is undertaking further policy development on the future role of LNG as we undergo the transition to net zero, recognising gas remains a key transition fuel. This will explore whether current and planned infrastructure will provide sufficient capacity to meet future demand projections and more volatile demand profiles, determining our level of confidence that the global LNG market will direct supplies to the UK under a range of scenarios, including market or infrastructure disruption. It will also consider whether there is a need for Government intervention to incentivise the market to ensure continued LNG supply into the UK.

As we import more gas, we are also mindful that the level of greenhouse gas emissions from overseas extraction, liquefaction and shipping of LNG varies considerably and is, in many cases, higher than UKCS production. NSTA research shows that the production and transportation emissions of CO2 associated with LNG imports are on average over quadruple the global emission intensity of UKCS gas production[38]. Further research and analysis is needed to develop our understanding of the methane emissions intensity of different sources of gas supply. We will explore ways to minimise methane and CO2 emissions from LNG production to ensure the emissions intensity of GB gas supply is as low as possible. We continue to work with international partners, as set out in the UK Methane Memorandum[39], to tackle methane emissions.

Before any decisions are made, we will seek input from external stakeholders on these issues through our forthcoming Call for Evidence, plus targeted engagement with appropriate stakeholders active across the LNG value chain and experts on global LNG markets. We require more evidence to consider how the market will manage these assets as we transition to net zero, including whether they will be repurposed to trade other gases such as hydrogen or carbon dioxide.

[38] NSTA, Carbon emissions intensity analysis, available at: https://www.nstauthority.co.uk/the-move-to-net-zero/net-zero-benchmarking-and-analysis/carbon-emissions-intensity-analysis/
[39] DESNZ, UK methane memorandum, available at: https://www.gov.uk/government/publications/united-kingdom-methane-memorandum

3.4 Interconnectors

Gas interconnectors are owned and operated commercially by private entities; they are transporters offering a service to gas shippers, who acquire the gas and decide in which direction to flow it in based on price differentials between the UK's National Balancing Point (NBP) and Dutch Title Transfer Facility (TTF), the predominant gas trading exchange for northwest Europe.

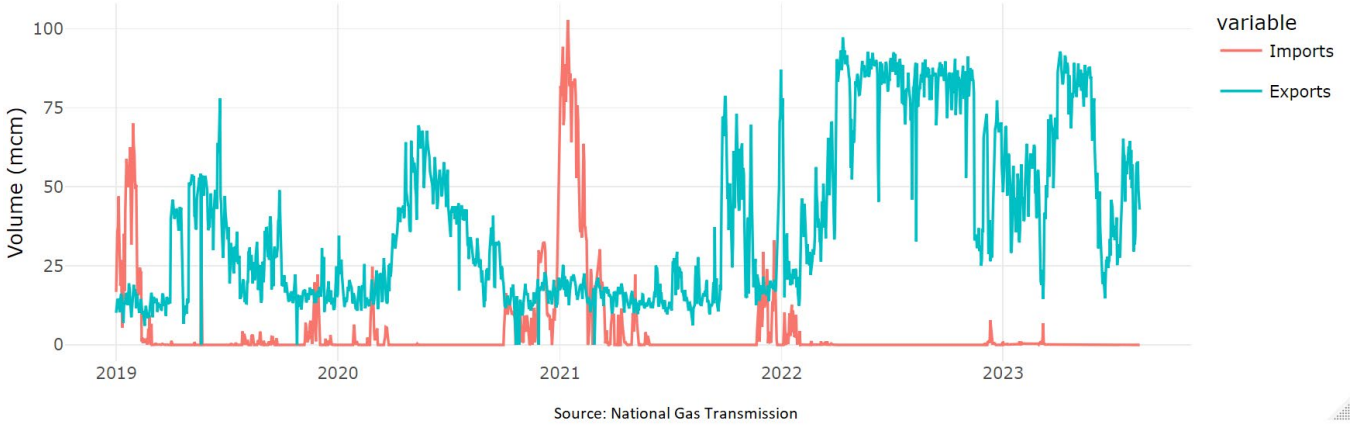
Great Britain has two interconnector pipelines which currently transport gas between neighbouring countries:

- Interconnector Limited, between Belgium and the UK (INT).
- Bacton-Balgzand Line, between the Netherlands and the UK (BBL).

GB's other interconnectors are uni-directional, facilitating exports from GB to Ireland and Northern Ireland.

Current Role

Chart 5: Daily interconnector imports and exports, 2019-August 2023[40]



Interconnectors are an important source of flexibility. In modelling of supply and demand scenarios in NGT's Winter Outlook 2022/23, on a peak demand day, the continental European interconnectors were estimated to provide up to 89mcm/day, or 15% of peak gas supply. The maximum capacity of the interconnectors is up to 125mcm/day. The use of this capacity will depend on price differentials between the UK and continental European markets. Further, the interconnectors are highly flexible, with the two bi-directional pipelines able to switch direction in under 24 hours. This means they can respond quickly to changes in prices.

Historically, the interconnectors operated a broadly seasonal pattern of imports and exports: importing gas into GB during the winter months when demand is high and exporting from GB during the summer when demand is low. However, following the Russian invasion of Ukraine, we saw record exports over 2022, including sustained exports throughout winter.

Export volumes have fallen during 2023. This is attributable to two factors. First, European storage sites began the summer filling season with a much higher level of gas in storage relative to 2022. Second, Europe added some additional LNG import capacity through the

[40] National Gas Transmission Data Portal, available at: https://data.nationalgas.com/

installation of floating storage and regasification units (FSRUs), which led to less use of the UK's LNG terminals and interconnectors as a delivery hub for LNG into continental Europe.

Future Role

As interconnector flows depend primarily on the spread of prices between the NBP and TTF, the future contribution of interconnectors to GB gas supply depends on a range of geopolitical and economic factors which will impact gas supply and demand across the wider European region. These include:

- The rate of decarbonisation and reductions in gas demand across the UK and Europe.
- The rate of decline of UK Continental Shelf (UKCS) gas production and Norwegian Continental Shelf (NCS) production, and to which countries market signals direct NCS gas.
- The speed at which continental European countries build additional LNG infrastructure and source alternative gas supplies to replace reduced Russian supplies.
- The future role of hydrogen in the UK and European energy systems, including whether there is large-scale use of natural gas to produce blue hydrogen and whether one or both interconnectors convert to transporting hydrogen.
- The future role of carbon capture, usage and storage in UK and European energy systems and whether one or both interconnectors convert to transporting CO2.

These factors will determine whether the interconnectors return to their historic trend of a summer/winter export/import pattern, continue to be used predominantly for exports to continental Europe throughout the year, or shift towards a new pattern of predominantly importing throughout the year or being used for balancing and flexibility rather than transporting large volumes of gas.

Future policy considerations around interconnectors depend on developing assumptions about the future geopolitical and economic factors which are likely to impact the flow of gas across them. DESNZ will use our forthcoming Call for Evidence to gather further views on this. We will also continue to work with our international partners to improve understanding of European gas decarbonisation policy to improve our modelling of future patterns of gas trading via the interconnectors. This will be supplemented by continued engagement with the interconnector operators and shippers using the infrastructure.

4. Conclusion and Next Steps

Natural gas will continue to play a role in delivering our energy security to 2050, as part of a net zero emissions trajectory. As set out above, the market has, and continues to, deliver effectively, but, as we become increasingly reliant on imports of gas to meet peaks in energy demand on those days when renewables are unavailable there may be a need for additional flexibility in the future. The market has already begun to respond as we have seen some recent investment in gas storage facilities and increases in LNG capacity at two out of our three GB terminals.

This Update is the first step in setting out the key considerations for government regarding policy making on the future role of flexibility in the UK gas system. Analysis is already underway on a range of fronts to explore how natural gas storage as a gas flexibility source could meet any future GB flexibility needs, the economic rationale for storage and the possible impact on gas prices, and to examine the deliverability from LNG terminals and across the NTS. We have also commissioned research to explore the extent of the need and case for market intervention and identify and assess possible HMG interventions, if required. As chapter 3 explored, we will need to find an optimum balance across all forms of flexibility to ensure a secure energy system, replicating the key strengths we currently have on the diverse supply sources. An overreliance on one type of system flexibility could leave the gas system exposed.

Therefore, we plan to issue a Call for Evidence in the coming months to aid the Department's policy development. The Call for Evidence will set out the findings from the current analysis that is underway, look in more detail at the three forms of flexibility set out here to understand the potential roles and possible interventions (if needed) by Government.

This document is available from:

www.gov.uk/government/publications/role-of-gas-storage-and-other-forms-of-flexibility-in-security-of-supply

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