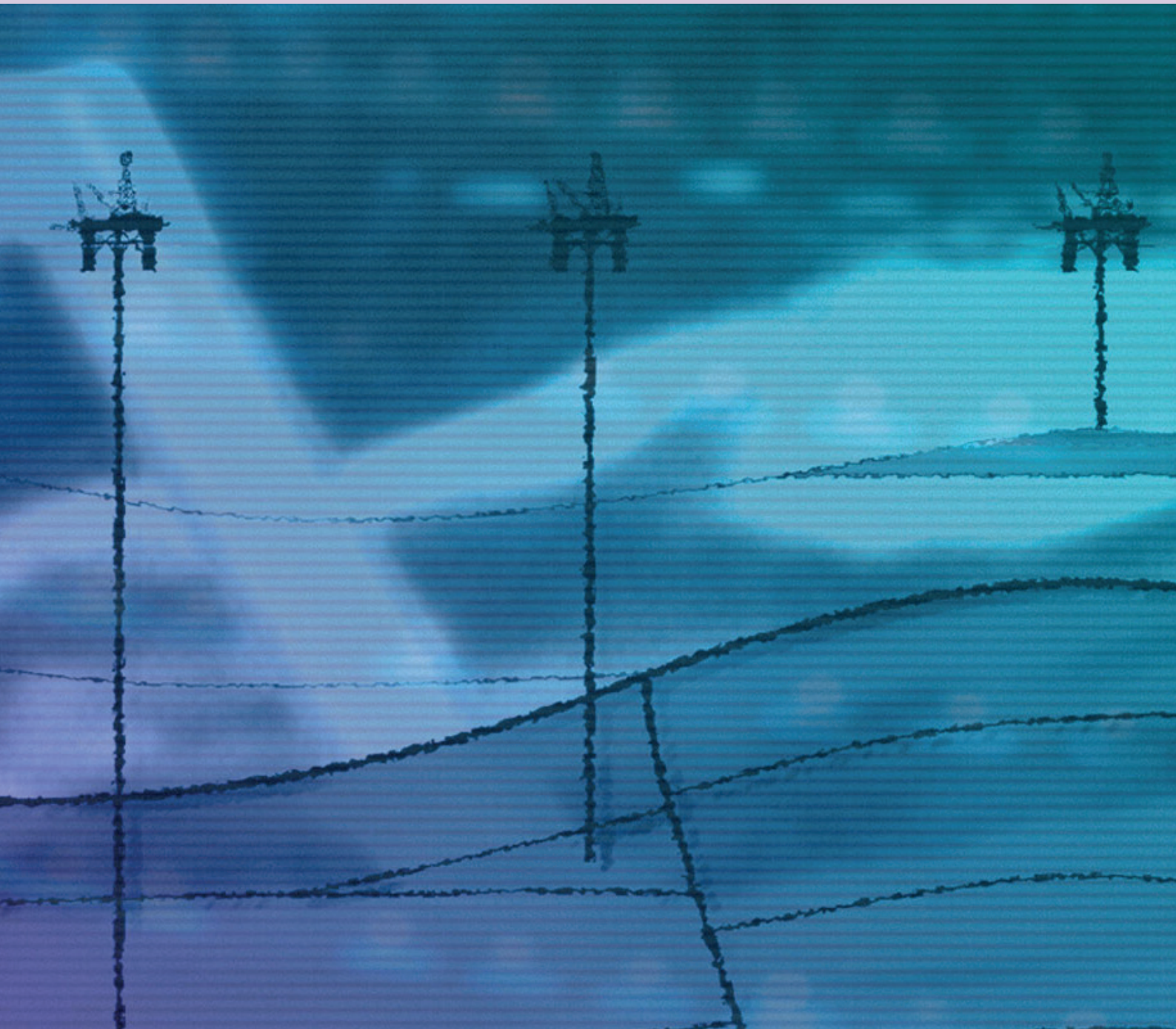
EXPLORATION INSIGHT 2022

OFFSHORE ENERGIES UK

The challenges and opportunities facing exploration in the UKCS



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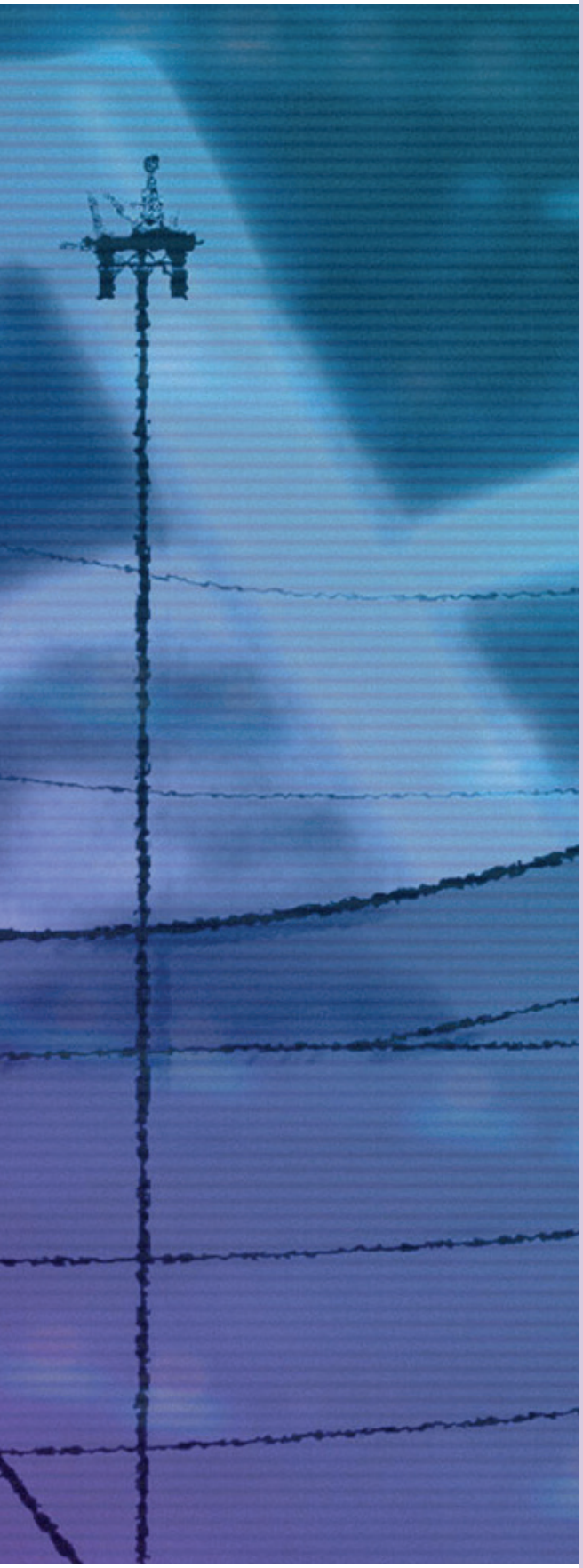

EXPLORATION REPORT 2022

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Foreword

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The UK continues to develop renewable energy resources, but access to reliable oil and gas resources remains critical to our energy security. To reduce our reliance on imported fossil fuels, the UK needs to continue to replenish its own resources through exploration for oil and gas.

In this insight, we outline what to expect in the years to come, identifying potential room for development within the basin. We also reflect on the opportunities presented by the 33rd offshore licensing round and the inaugural carbon storage licensing round. These could significantly extend the life of the basin, helping to strengthen the supply chain, and ensure the UK retains the essential skills needed to deliver and underpin its low carbon energy transition ambitions.

The 33rd exploration licence round is underway following the completion of the new climate compatibility framework for oil and gas production. As noted by the Committee for Climate Change, UK production of oil and gas has lower carbon intensity than many other countries.In conjunction we have seen 26 licence applications in the UK's inaugural carbon capture and storage licensing round. Industry has worked hard to create a more positive outlook for UK exploration. However, a large caveat to medium-long term investment would be the impact on investor confidence deriving from Energy Profit Levy (EPL)."

The UK's oil and gas basin boasts access to high-quality seismic data and advanced reprocessing capability. It has a track record of world class industry collaboration to realise discoveries. With high technical and commercial success rates (around 60% and 30% respectively) and 6.1bn barrels of oil equivalent (boe) within 30 kilometres of existing infrastructure, the UK offers a comparatively low-risk investment option close to existing infrastructure. Pursuing these resources is critical to a managed and homegrown transition to cleaner energies, preventing a rapid increase in the nation's reliance on imports and prioritising domestic resources.

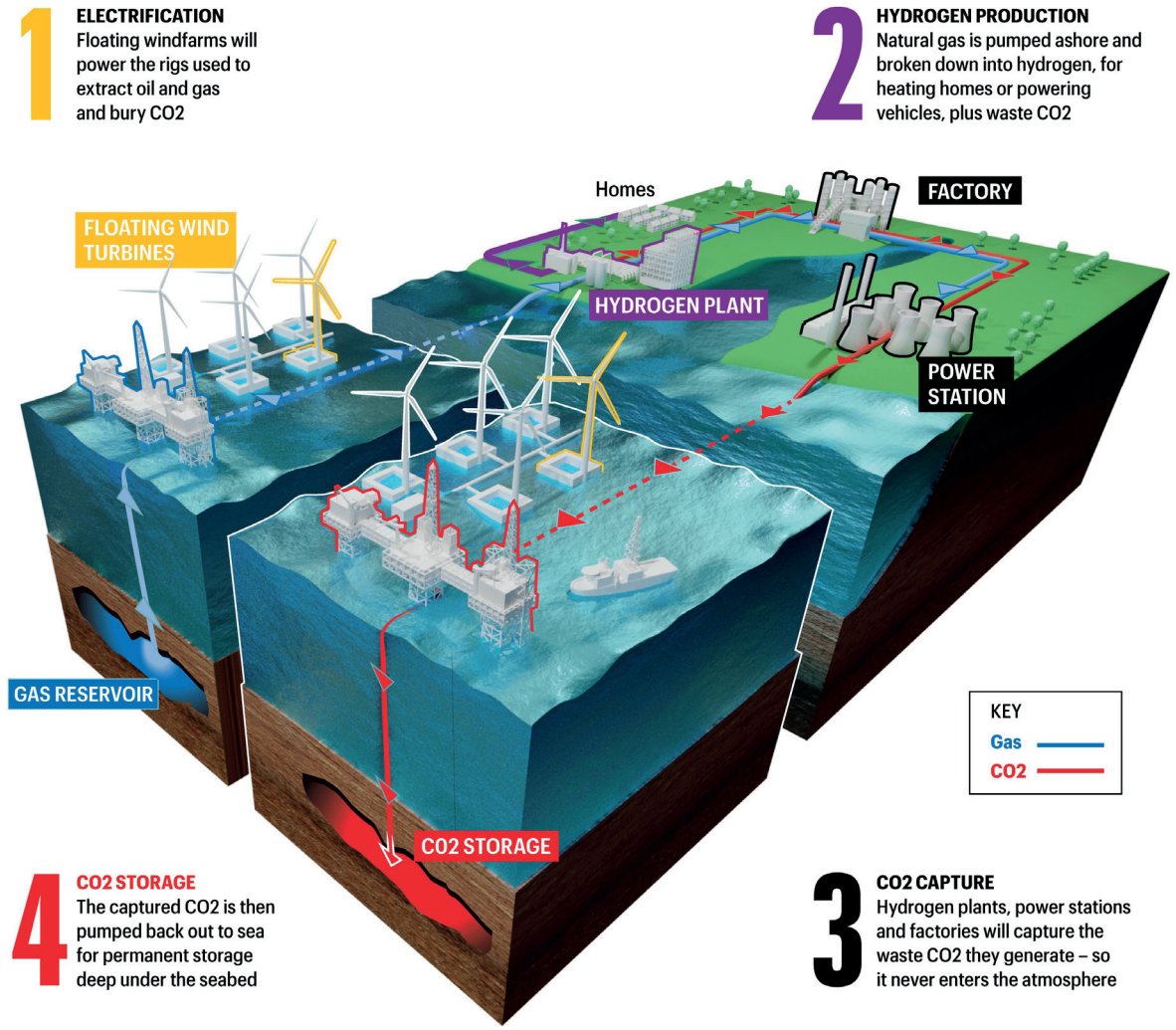
Last year saw the UK rely on oil and gas for nearly three-quarters of its total energy needs, of which 56% was met by domestic production: it accounted for 75% of oil demand and 38% of gas demand. Thus far in 2022, the UKCS has managed to supply 68% and 40% of respective domestic oil and gas demand. While oil and gas will provide a diminishing share of the UK's energy over time, even in 2050 they will still be needed.

Continued investment into domestic exploration is essential to secure our oil and gas supply and provide the nation with a reliable source of energy throughout the transition. Industry must continue to ensure and demonstrate these energy requirements are produced and used in an increasingly low carbon way.

Furthermore, many of the skills and technologies needed for oil and gas exploration are also required to explore for CO2 storage. Carbon capture utilisation and storage (CCUS) is a critical technology

Offshore Energies

The UK's offshore operators are developing four key new technologies to help the UK achieve carbon neutrality



for the decarbonisation of power generation and hard-to-decarbonise industries, and an enabler for hydrogen production. There are six active carbon storage licences on the UKCS and in June our regulator, the NSTA, launched the UK's first-ever carbon storage licensing round. The synergies with conventional exploration are important. A steady level of exploration activity in the basin maintains the extensive subsurface knowledge and expertise, services and technologies, that are vital to support exploration of CO_2 storage sites.

Recent exploration activity levels in the UKCS are lower than necessary to sustain reserves and meet UK demand. Against this backdrop of skills, knowledge capability and geology, ongoing political and fiscal uncertainty risk undermining the ability of UK oil and gas industry to meet its full potential as a partner to the UK. With the right support, exploration activity in the UK can play a critical role, ensuring the UK can meet domestic demand, deliver energy security and become an enabler for the energy transition.

Mark Wilson

1. Exploration outlook

While the NSTA's 2021 reserves and resources report estimates there are 4.0bn barrels of oil equivalent (boe) in prospective reserves in mapped prospects and leads, along with a further 6.4bn boe in contingent resources, a recent study conducted for OEUK indicates there could be as much as 6.1bn boe in undeveloped resources within 30 km of existing infrastructure, with up to half of this being gas. With high technical and commercial success rates, access to high quality seismic data, advanced reprocessing capability and a track record of world class industry collaboration to realise discoveries, the UK offers a comparatively low risk investment option. Subject to a fiscal regime that is stable, competitive, attractive to investors.

The purpose of this insight is to shine a light on the significant exploration opportunities remaining in the basin and support industry efforts to rekindle exploration activity.

Exploration is vital for energy security

The UK relies on oil and gas for nearly three-quarters of its total energy needs. Of that, last year, UK oil production met 75% of national demand and gas production met 38%, or 56% on a boe basis. While the UK has significant oil and gas deposits, they are spread across hundreds of smaller reservoirs which are becoming depleted. The next ten years, for example, will see 1,600 oil and gas wells being decommissioned. These closures could see UK production of oil and gas reduce by 75%, unless we are able to discover new resources for appraisal into reserves. That decline would be far sharper than any demand reduction that could be achieved - so imports of oil and gas would increase with households and businesses facing further potential rising costs.

This is why the UK needs to revitalise exploration activity. Finding new reserves will help to maintain the flow of energy needed in the decades to come.

Exploration activity levels and the impact of UK tax changes

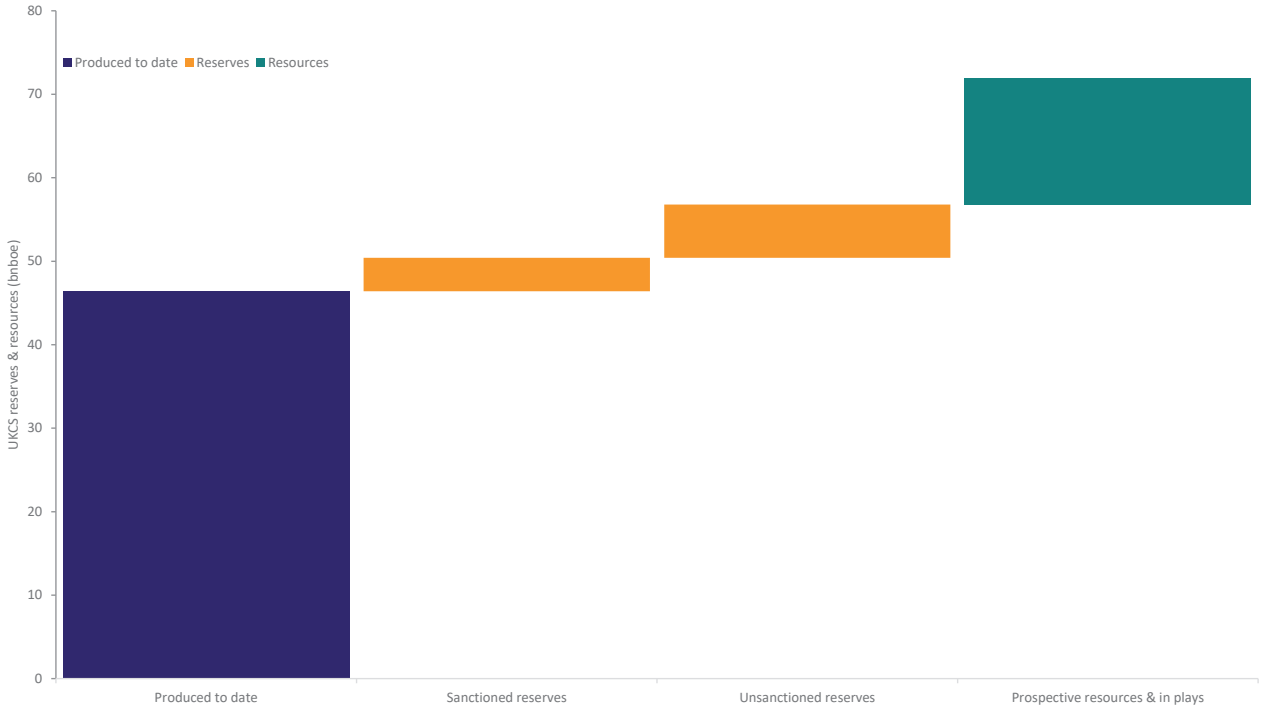
There has been a marked decline in exploration since 2011, which can be partly attributed to the tax revision at the time which dented investor confidence in the basin. Exploration rates had just started to recover in 2019, when the Covid-19 pandemic resulted in activity plummeting as companies revised investment decisions following the heavy financial losses incurred. There is a real risk that the new Energy Profits Levy (EPL) will have a similar impact to the 2011's tax changes as investment decisions are re-evaluated.

2020 and 2021 saw just 12 exploration wells drilled: seven in 2020 and five in 2021. Four exploration wells were drilled in the first seven months of 2022. The NSTA forecasts that at least a further two exploration wells will be drilled in 2022, taking the total up to six exploration wells and three appraisal. By comparison 2019 (the most recent pre-pandemic year) saw 16 exploration and 13 appraisal wells, illustrating the level of decline in recent years.

Figure 1:

UKCS: Total reserves and resources (bn boe)

Source: NSTA, OEUK

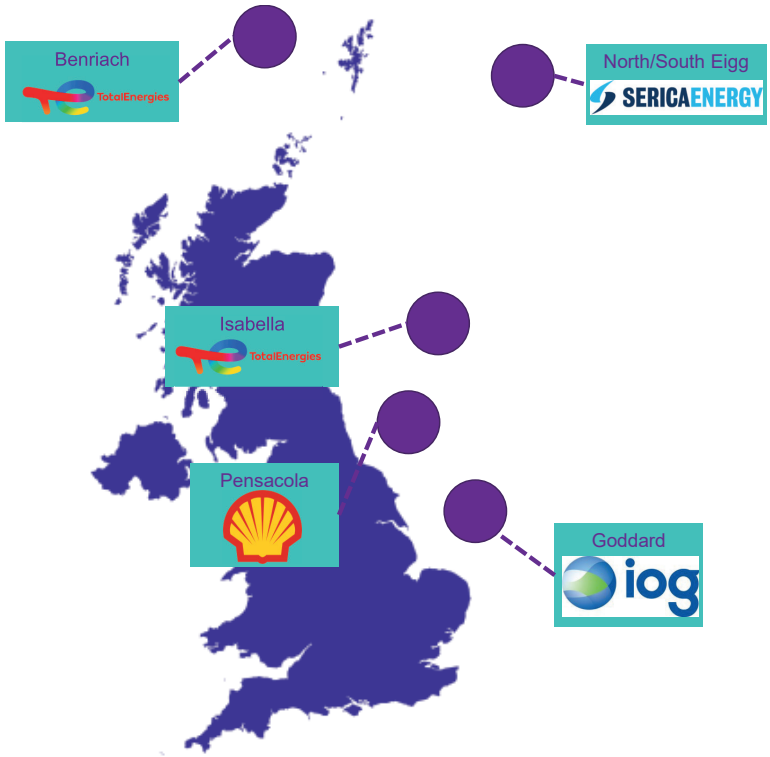


Source: OEUK, NSTA

Figure 2:

Map of top exploration & appraisal prospects

Source: OEUK



Resources & reserves replacement

Avoiding further reliance on imports requires effective management of UKCS production levels, with the continued replacement of reserves key to this. The reserves replacement ratio provides an indication of how current production levels are being replenished through new resources being discovered and then developed into reserves.

In 2020, the NSTA reported a net reserves replacement ratio of negative 33%, due to low development of reserves and adjustment of reserves. Over the past 10 years, the UKCS has produced roughly 6bn boe, while an estimated 600mn boe of commercial liquids and gas resources were discovered.

Last year's approvals added only 80mn boe in reserves, divided between four new fields and field redevelopments. Reserves of this size would only be able to sustain the UK's oil and gas needs for two months. The capital expenditure associated with developing 2021's approved reserves will near £750mn.

OEUK's *Business Outlook 2022* showed that the potential for total approved new reserves could hit 300mn boe across 10 new fields/field developments this year. However approval rates have been slower than initially expected, with just two UK fields approved so far. Despite this, the number of fields going through the environmental assessment process is encouraging, with a further 500mn boe currently in regulatory processing, equivalent to one year's domestic production. This rise has been aided by a multitude of factors, namely sustained high commodity prices, the lifting of Covid-19 restrictions and the approval of projects pushed back

Figure 3:

Exploration & appraisal wells drilled 2010-2022

Source: NSTA, OEUK

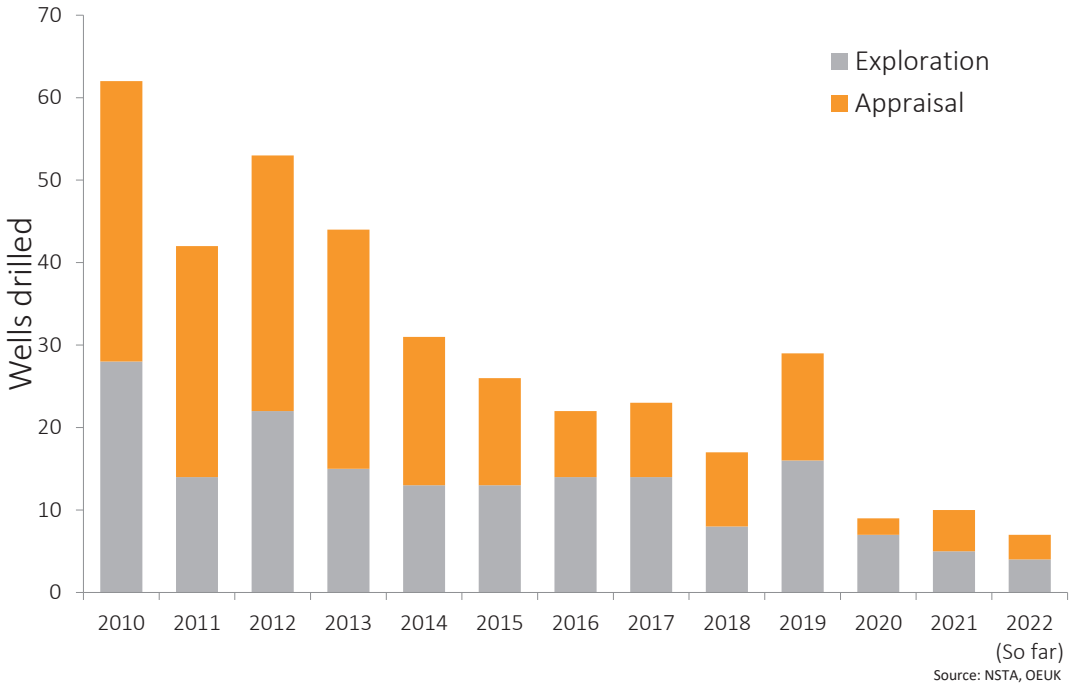


Figure 4:

Total approved new reserves

Source: NSTA, OEUK

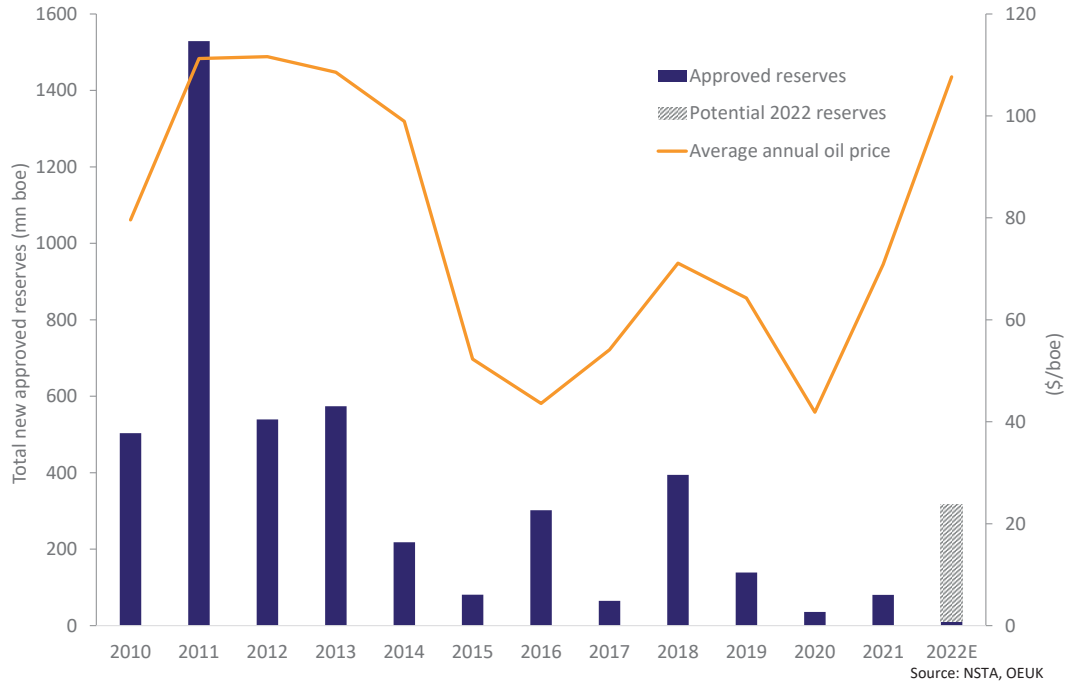
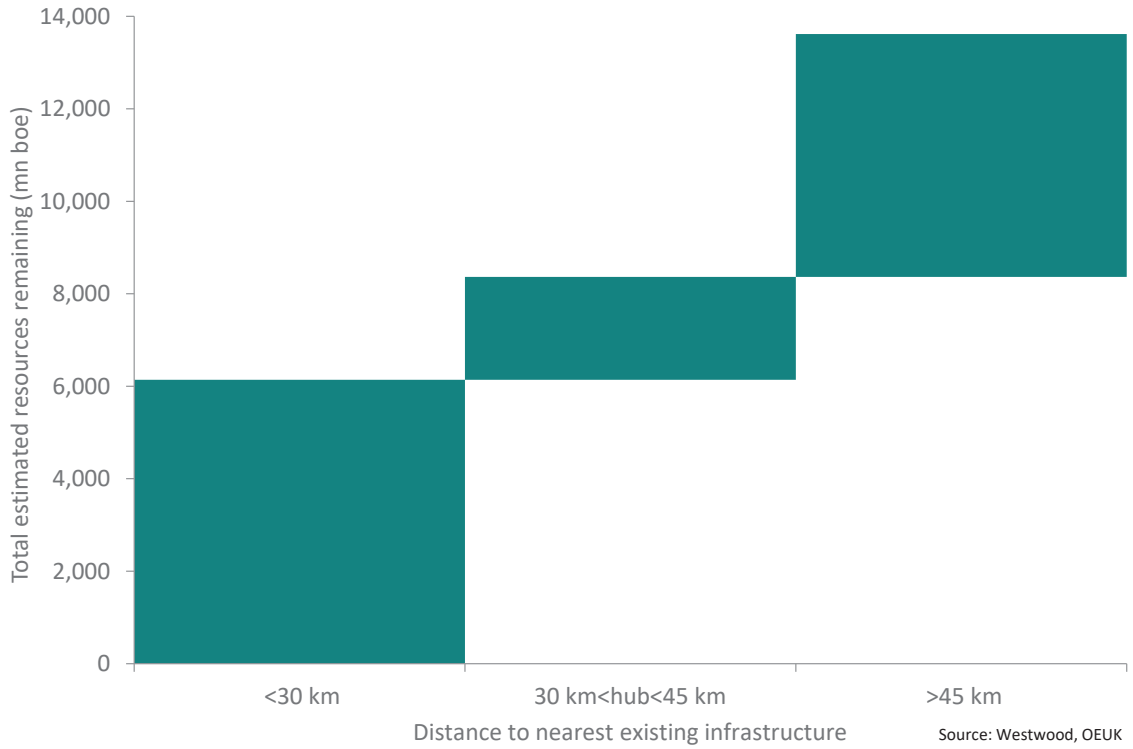


Figure 5:

Total resources

Source: Westwood, OEUK



from 2021. Peak production from fields planned to come online in 2022 could be as high as 250,000 boe/d, resources split roughly 50/50 between liquids and natural gas. While this could offset the decline in production from existing assets and ensure that total production from the basin remains stable throughout the next 12 months, the UK remains a net importer and continued exploration activity is needed to replenish reserves. The full extent of the impact of the EPL on exploration remains to be seen as exploration is particularly vulnerable to fiscal change.

In 2019 the NSTA set a five-year rolling average key performance indicator target of 200mn boe discovered resources. Since then a rolling average of 120mn boe has been recorded.

In terms of resources remaining in the basin these estimates can vary however. OEUK's study with Westwood estimates there over 6.1bn boe remaining to be discovered within 30 km of existing infrastructure, with a further 7.5bn boe greater than 30 km of existing infrastructure as illustrated in Figure 5. We expand further on these opportunities in later sections.

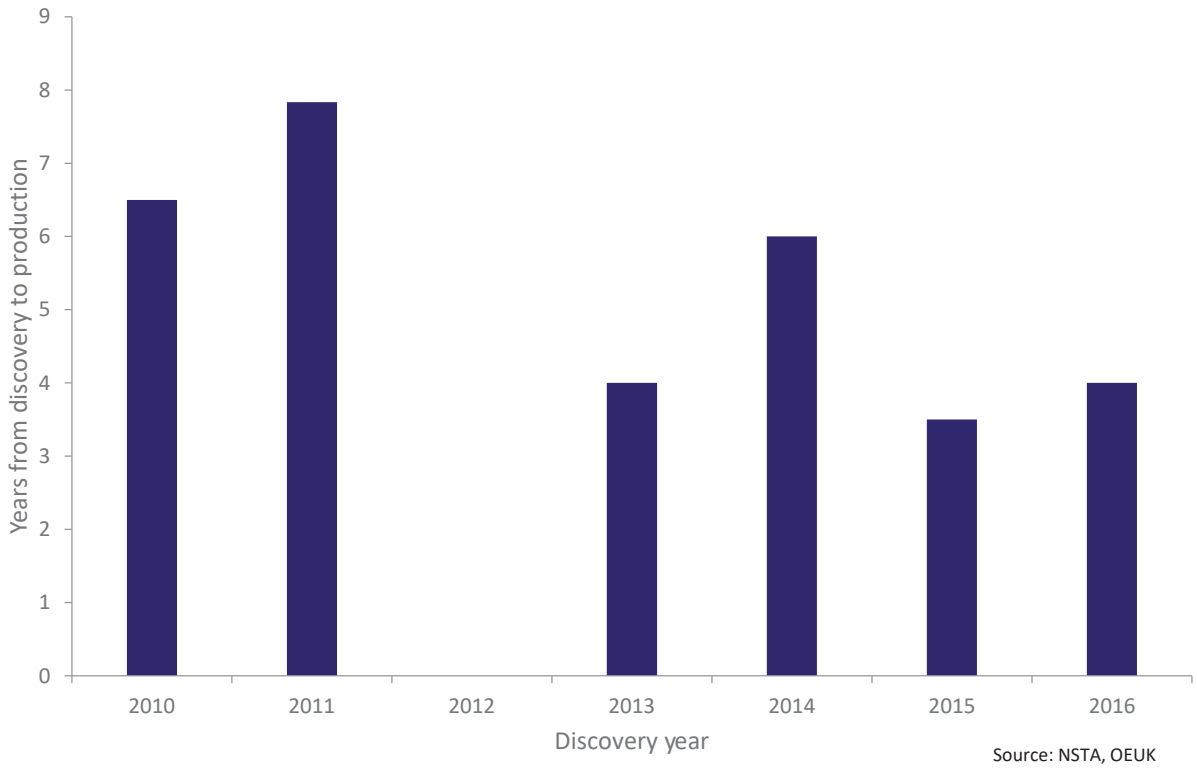
These opportunities offer a comparatively low risk exploration investment option and should provide confidence in the UK's ability to quickly replenish reserves of oil and gas.

Discoveries that have been made in the last decade, which have then gone on to be developed have done so in an average time of four years and eight months.

Figure 6:

Time taken from discovery to production

Source: NSTA, OEUK



Source: NSTA, OEUK

The UKCS's progressive licensing regime, new technology, better subsurface understanding, and improvements to infrastructure access mean that older finds, previously thought to be uneconomic, can sometimes quickly be made commercial. Furthermore, the expected production timeframe for new exploration finds, near existing infrastructure, can be less than twelve months. For example, Harbour Energy's Jade South was a small exploration discovery made in 2021 and has already started producing. As another example, Apache's Garten was discovered in March 2018, and produced its first oil in November 2018 – just eight months later. Increased exploration of prospects that tie back to existing infrastructure will only reduce this time to develop.

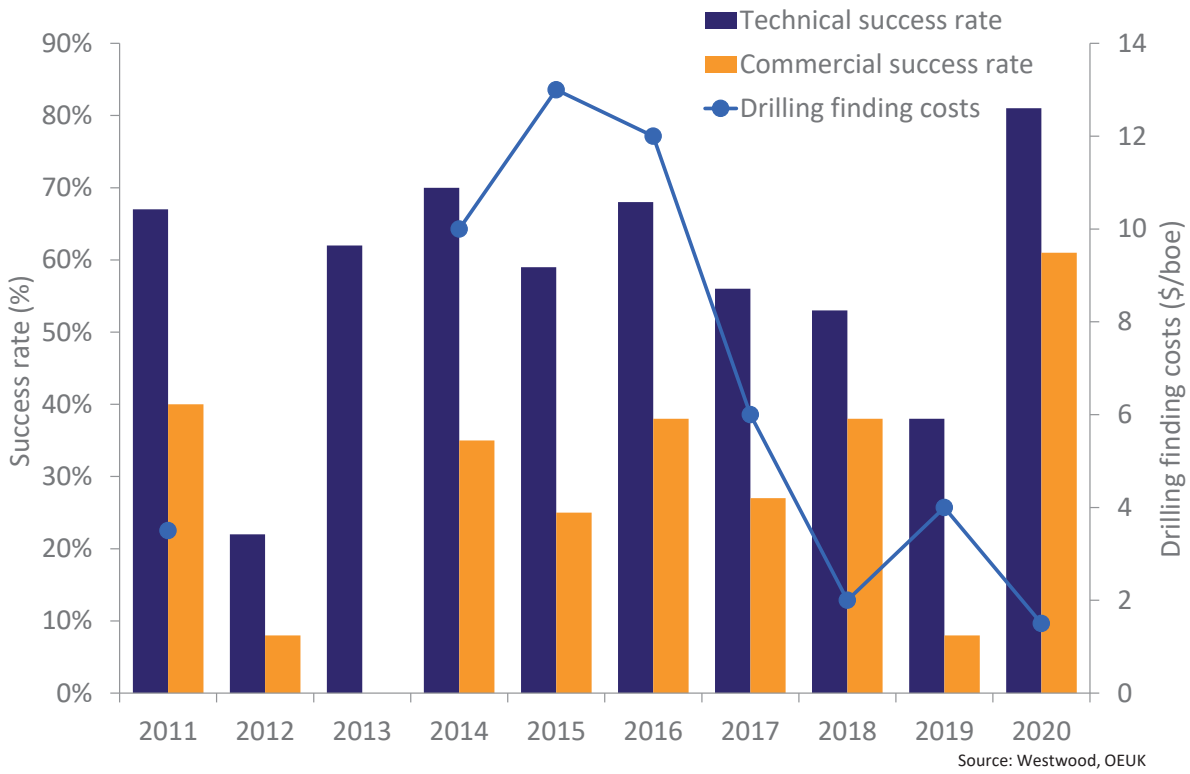
Performance trends

Over the past 10 years, the technical success rate (TSR) in the UKCS has fluctuated between 30% and 80%, relying heavily on the number of exploration wells drilled. over the course of the decade the UK has averaged a TSR of 60%. The commercial success rate (CSR) of the UKCS, while lower at 20%-35%, mirrored the fluctuation periods seen in the TSR. Both rates are on par if not marginally higher than on the Norwegian Continental Shelf (NCS). Our industry has made significant advances in drilling finding costs over the past decade with the average since 2017 sitting around £3/boe, dipping as low as £1.35/boe in 2018. By comparison, the average drilling finding costs at the start of the decade were around £8-£10/boe.

Figure 7:

UKCS historic TSR, CSR, drilling finding costs

Source: Westwood, OEUK



UKCS investment forecast

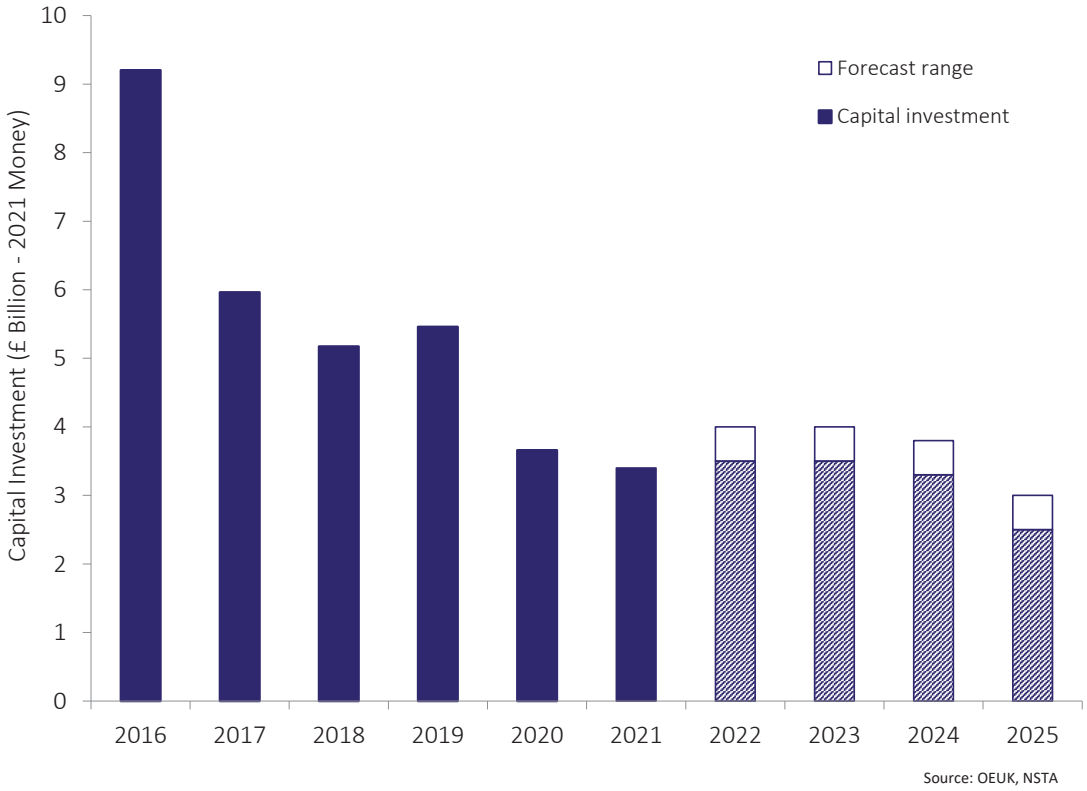
The forecast capital investment for 2022-23 of £3.5-£4bn/year is marginally higher than seen in 2020 and 2021 (£3.6bn and £3.4bn respectively), with this in part being driven by anticipated increases in new field approvals. Declining capital expenditure could see future production dip beyond expectations, increasing the UK's future reliance on imported energy and susceptibility to external supply shocks.

The introduction of the EPL in May 2022 has impacted projects and company plans to varying degrees. OEUK continues to quantify the impact of the measure on both short-term and long-term investment plans. Industry needs long-term, stable and predictable fiscal and regulatory regimes to secure capital. The addition of the EPL is out of step with the "Driving Investment" plan introduced in 2014 that was a key step to rebuild confidence in the UKCS following several tax changes in previous years. Without a stable and predictable environment UK investment will become hampered and could curtail exploration activity further. OEUK and industry are concerned that the detrimental impact of tax revisions such as those from 2011 onwards contributed to declining exploration activity.

Figure 8:

Oil and gas capital investment

Source: OEUK, NSTA



There is significant potential left in the UKCS

The UKCS, a mature basin, still contains significant prospective resources, a large proportion of which are within the tie-back range of infrastructure (30-45 km). Such prospects have the dual benefit of an increased chance of commercial success while potentially extending the life of existing hubs. OEUK's Westwood study identified about 6.1bn boe risked prospective resources within 30 km of existing infrastructure, with 3.6bn boe and 2.6bn boe licensed and unlicensed, respectively. If the distance is expanded out to 45 km beyond existing infrastructure, then the total resources rise to 8.4bn boe - roughly eight times the UK's annual consumption of oil and gas.

Extending existing infrastructure life

As previously mentioned the UKCS has significant opportunities to access resources through tie-backs to existing infrastructure, not only increasing the chance of success of the opportunities but also helping to extend the life of the infrastructure. Indeed, without these nearfield opportunities, significant parts of the UKCS infrastructure will cease production. Figure 10 shows the number of hubs set to cease production between 2025 and 2030, along with the prospective resources within 30 km of these hubs. It is evident that the central North Sea (CNS) holds the greatest opportunity for extending the lifecycle of existing infrastructure with roughly 1.4bn boe in prospective resources within tie-back range. The average commercial success rate of prospects over

Figure 9:

Sanctioned, probable and possible reserves within existing company plans

Source: NSTA, OEUK

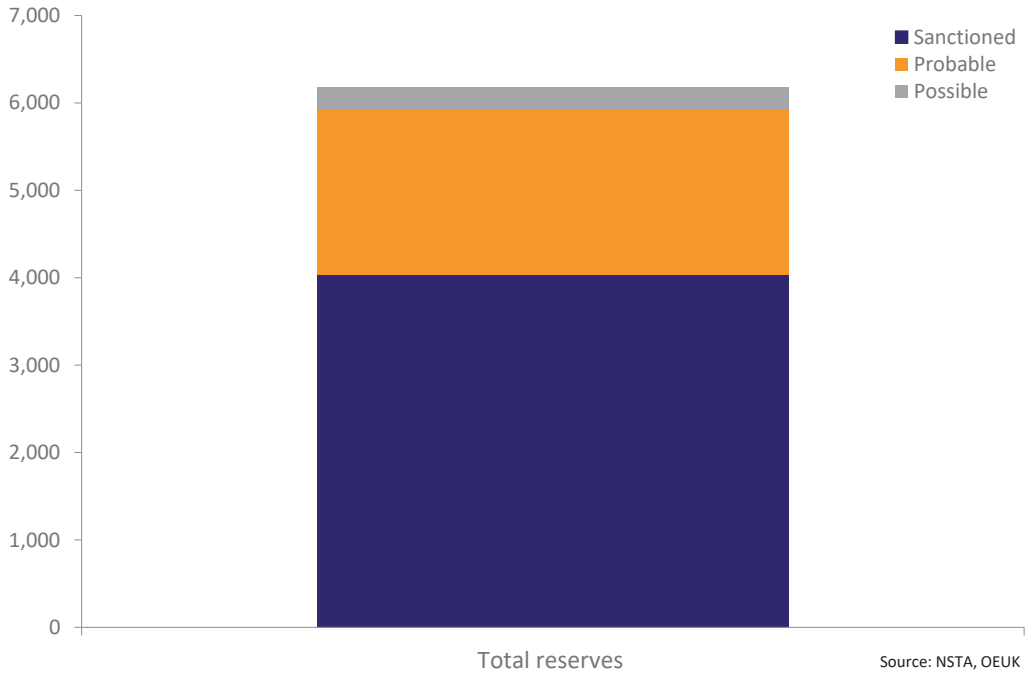
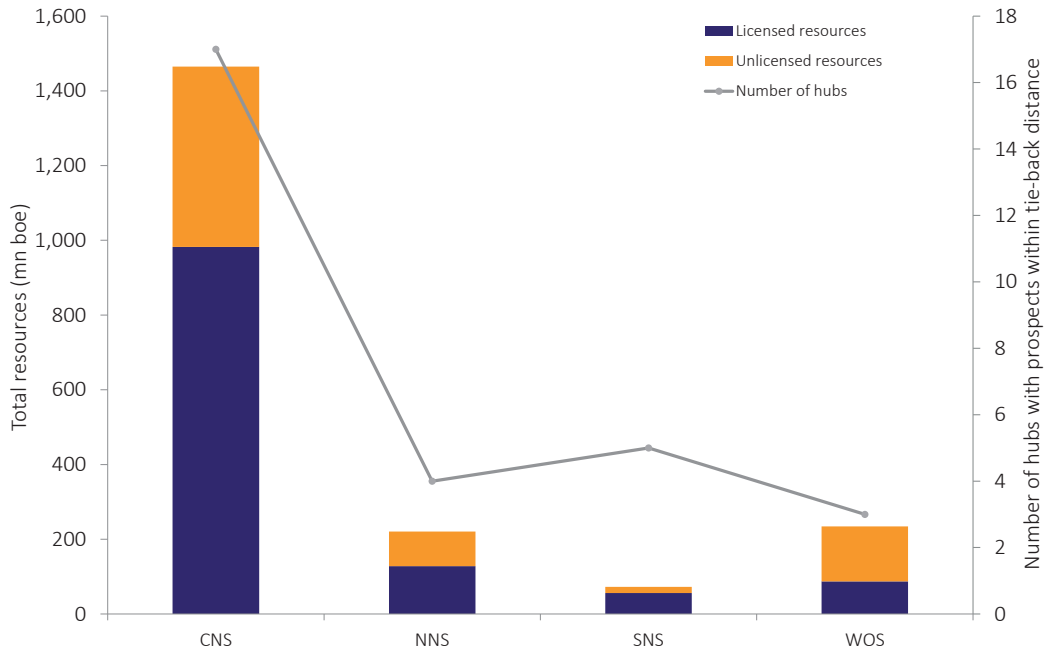


Figure 10:

Resources within tie-back distance of hubs (cessation of production 2025-2030)

Source: Westwood, OEUK



the past 10 years was between 20% and 25%, a realistic figure for prospect tie-backs in this basin alone could be in the region of 350-600mn boe. This is the equivalent to one year of domestic oil and gas production.

Energy forecasts

After a relatively stable period between 2015 and 2020, the gradual decline in production is likely to resume post 2023. The rate at which this happens will depend upon investment in exploration and asset development from 2022/2023 onwards. If all proposed greenfield and brownfield projects were to go ahead, the annual rate of decline could be at least halved, meaning greater energy security. Also ensuring the UK retains the footprint of integrating operator and supply chain companies needed to support a homegrown energy transition. Exploration is required to curtail the drop in sanctioned reserves as these assets move towards development.

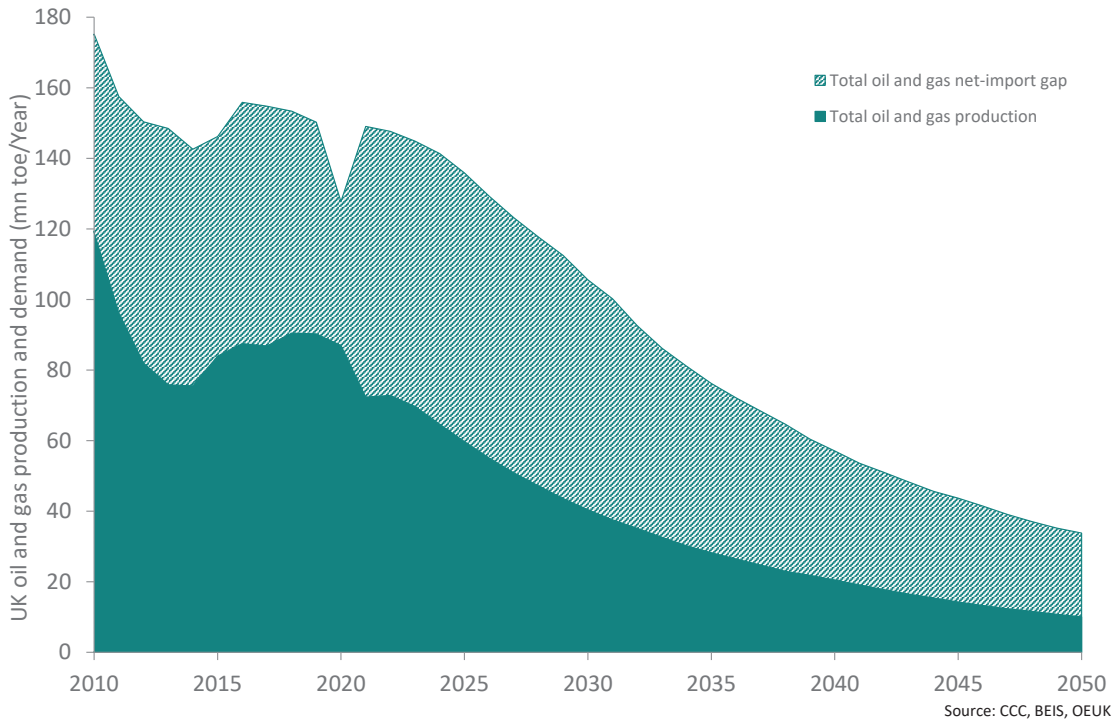
Since 2011 resources discovered in the UKCS have totalled 600mn boe, 10% of production during this period. Without continued investment into exploration, this decline in this resource replacement rate will continue. 2020 was a relatively positive year for resource replacement, with 212mn boe discovered: 35% of production.

The NSTA forecast six exploration and two appraisal wells in 2022, and so far the UK

Figure 11:

UK net import gap

Source: Climate Change Committee, BEIS, OEUK



has seen four exploration and two appraisal wells spudded. The UK is still some way off the 29 exploration and appraisal wells drilled in 2019. OEUK can attribute a large proportion of this decline to project delivery lag caused by the pandemic. However, without sustained or increased investment into exploration, OEUK could see a cycle whereby declining exploration leads to a wider production gap and increased reliance on imported oil and gas. This would put the UK at a higher risk of external energy supply shocks and more volatile domestic fuel prices. The current rate of exploration activity will not meet the recovery required of reserves and the production gap. Therefore, only if there is an upturn through upcoming licensing rounds will the UK see a recovery in reserves replacement rates in future.

UKCS emissions overview

As noted by the Committee for Climate Change, UK production of oil and gas has lower carbon intensity than many other countries. The UK can still meet its carbon budget and develop new fields if it accelerates efforts to cut emissions from production. New assets brought on stream because of successful exploration and appraisal will replace high emitting assets, naturally leading to reduced emissions, please refer to *OEUK 2022 Emissions Report* (see appendix for further reading).

The accompanying graphic (*Figure 12*) shows that newer and smaller facilities tend to be the least carbon intensive. The primary differentiator is the hub's age rather than its size. The UKCS could reduce emissions over time as new hub developments have a lower carbon intensity. The opportunity for exploration will likely be focused upon expanding cleaner existing hubs or utilising latest technology to develop new low emission developments such as those proposed at Rosebank and Avalon.

UK hub emissions profiles

In 2020, the NSTA identified that the UKCS' average emissions intensity of 22 kg CO_2/boe was roughly three times lower than imported LNG, 59 kg CO_2e/boe. At present, the UK's least carbon-intensive form of natural gas is imported pipeline gas from Norway at 18 kg CO_2e/boe. However, with the EU's increased reliance on Norway for gas, the UK's imports face competition. As a whole gas imports (LNG and pipeline) have a carbon intensity of 35 kg CO_2/boe - around 60% higher than domestically produced gas.

Early cessation of domestic exploration would result in declining production, a wider production gap and an increased reliance on imported gas. With pipeline gas from Norway constrained by capacity and increasing demand for gas from EU member

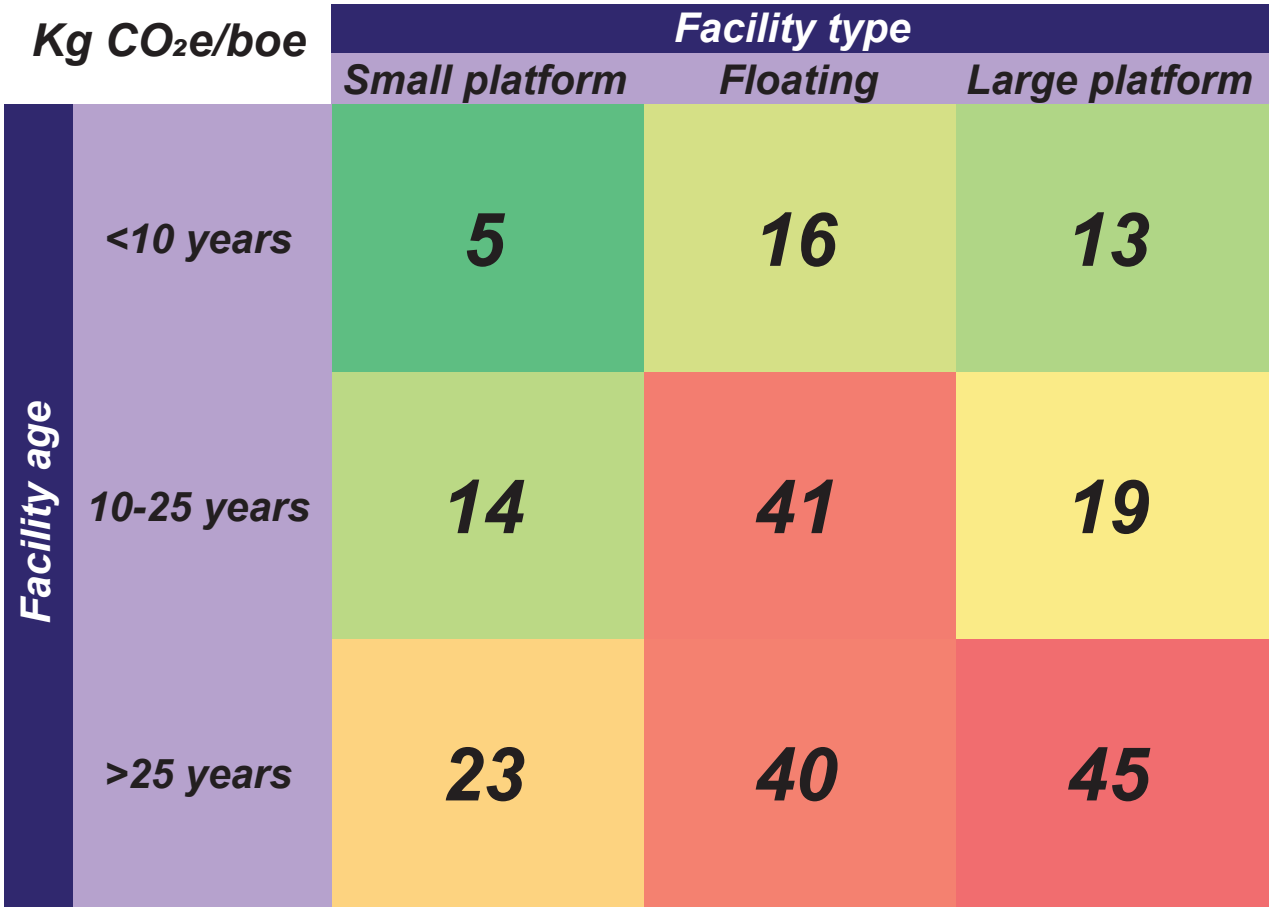
states, the margin would likely be taken up by greater LNG imports. That means that each cubic metre of additional UK output would help to avoid upstream emissions that would be three times greater. UKCS gas is, therefore, cleaner and strengthens our energy security. A reliance on LNG would increase the UK's emissions, damage our balance of payments and leave us more vulnerable to external supply shocks.

It is the industry's contention that key policy considerations should be focused upon promotion of the lowest emissions, throughout the exploration and production cycle.

Figure 12:

Emissions intensity by platform type and age

Source: NERA, NSTA



2. Exploration opportunities

Key enablers & constraints

The table below (*Figure 13*) outlines the key enablers and constraints to future potential exploration within the UKCS. The shading red (constraint) to green (enabler) provides subjective considerations respectively. The table is reflective of the significant enablers that remain in the UKCS and serves to illustrate the continued opportunities for future exploration. These enablers and constraints are dynamic and will vary by operator but are intended to be indicative of the overall basin.

Exploration activity levels and future impact on resources

Between 2011 and 2020, 136 exploration wells were drilled on the UKCS. In total these wells discovered a total of 600mn boe, comprising 30 individual discoveries. Looking to the future, together with OEUK, Westwood has identified 31 exploration opportunities as potential future wells, the majority of which are ILX (infrastructure led exploration). These wells could target up to 1.87bn boe reserves, the equivalent to roughly two years of pre-pandemic UK

Figure 13:

Enablers and constraints

Source: OEUK

Key enablers & constraints overview of UKCS exploration

Consideration	Overview	Consideration	Overview
Exploration Licensing	• NSTA poised to hold 33rd license round. (Refer to Deltic case study for further insight) • New Energy Profits Levy (EPL) may constrain bidding for acreage • Balance required frequent licence rounds and progressing or relinquishing current licence.	Government & Regulatory	• Regulatory excellence good practice collaboration • Uncertainty over long term government support for exploration, vital to ensure longer term support. • Period of validity of the climate compatibly checkpoint must create longer term stability.
Farm Outs	• Active ecosystem of prospects being worked up / derisked and then farmed out. (Please refer to Deltic & Athena case studies for further insight) • Exploration drilling is becoming dominated by farm-in wells • Refresh of UK farmin prospect portfolio needed	Rig Market Access	• Rig dry rates have fallen by 35-45% between 2015-2020, utilisation is expected is expected to grow in 2022-23 onwards retain active assets in the basin. • Rig-sharing may enable exploration drilling • Potential competition from other activities in coming years, eg Decommissioning, CCUS and overseas could constrain rig supply
Access to Infrastructure	• The UK has 76 production hubs, and associated ullage, making near-field exploration a viable proposition. • The number of active hubs is expected to drop to 39 by 2030 • Exploration activity needs to recover rapidly in order for discovered resources to access existing infrastructure.	Access to Capital	• Exploration has to compete for capital in the UK with investors balancing financial, regulatory and reputational risk
Energy Transition	• Oil and Gas will remain a key part of the energy system. (Refer to case studies for further insights) • Exploration expertise and personnel could be reutilised within the CCS industry. (Refer to Schlumberger case study for further insight) • "hearts and minds" battle needs to be won – energy transition/climate change	Security of Supply	• Need for domestic production is in the public conversation and energy security policy. • Ability to control our own scope 1 & 2 emissions footprint. • Rise in commodity prices has meant that imports are becoming more expensive, sustained domestic production will reduce the reliance on imports
Access to Data	• Culture of sharing lessons learned & industry collaboration through OEUK Exploration Conference. • 60% of licences covered by 3D data shot in the last 10 years • World class industry collaboration to realise discoveries. (Refer to PGS case study for further insight) • Data quality crucial for derisking investment decisions		

Figure 14: Total resources added per annum

Source: OEUK

Cumulative discovered resources added (mn boe)						
Exploration wells drilled per annum	Average discovered resources per exploration well 2011-2020	By 2022	By 2026	By 2031	By 2036	By 2041
5	4.3	22	109	217	326	435
10	4.3	43	217	435	652	870
10 year average - 13.6	4.3	60	300	600	900	1,200
15	4.3	65	326	652	978	1,304

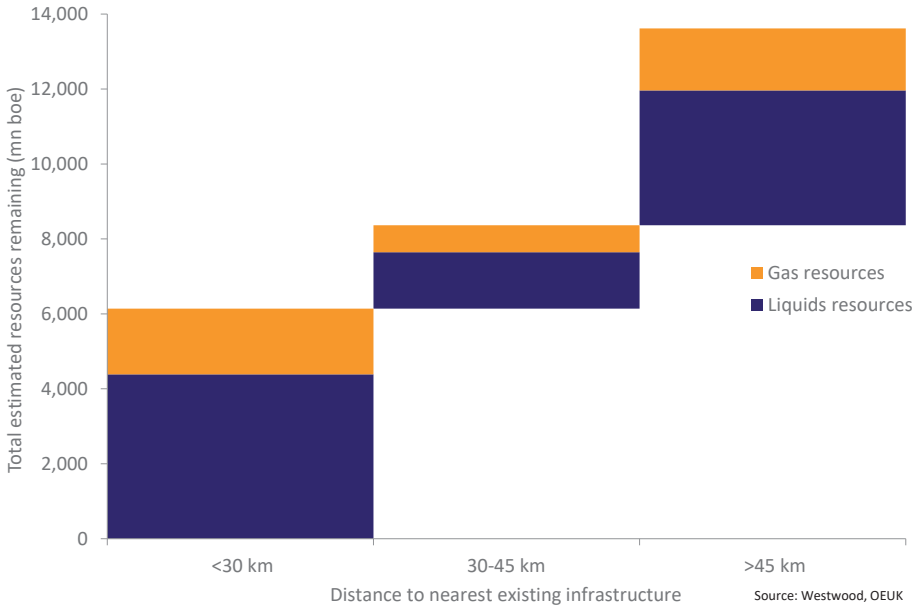
oil and gas consumption. In a successful case, these wells could be drilled to support declining production at nearby operated hubs, both increasing the longevity of the infrastructure and reducing the costs for exploration of new prospects.

Over the past 10 years, the average resources added per exploration well has been 4.3mn boe. The accompanying table (*Figure 14*) highlights the impact that varying annual drilling rates would have on the UKCS's total resources, based on the average discoveries per exploration well over the past 10 years. If exploration were to occur at the same rate as it did in 2011-2020 then an additional 1.2bn boe could be added between 2022 and 2041. This would meet just over 15 months of UK oil and gas requirements. This serves to further illustrate the need to re-invigorate a fundamental step change in the level of UK exploration activity.

Figure 15:

Total resources left: oil – gas split

Source: Westwood, OEUK



Non-catchment prospectivity

In total, the Westwood study indicates that 5.3bn boe prospective resources lie 45 km beyond an existing hub, spread over 210 prospects. At present, only 1.3bn boe of these prospective resources are licensed. In other words, over three quarters of prospects beyond 45 km tie back distance are unlicensed. The average size of these unlicensed prospects is 27mn boe, greater than that of recent developments. Of the 210 prospects 10 are estimated to have prospective resources greater than 100mn boe, offering opportunities for future hub installations. Given the distance to existing hubs and terminals, any prospects within the West of Shetland (WoS) region would need to prove to be large or situated in a cluster of similarly large prospects considered commercially viable.

Previous licensing rounds

The two most recent licence rounds offered significant opportunities within the basin.

The 32nd Licensing Round, was launched in 2019 and in 2020 the NSTA offered for award 113 licence areas, across 260 blocks or part-blocks to 65 companies. The round offered blocks in mature, producing areas close to existing infrastructure, under the flexible terms of the Innovate Licence. 'This type of licence enables applicants to define a licence duration and phasing that will allow them to execute the optimal

Figure 16:

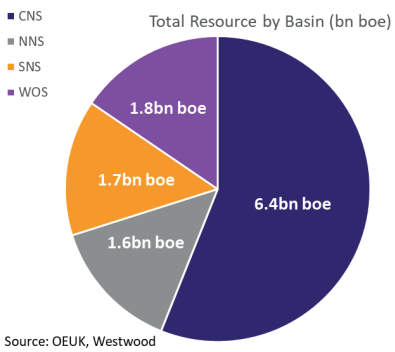
UKCS basin SWOT analysis

Source: OEUK, Westwood

WoS	
Strengths	• Lower emissions associated with new technology • High level of prospective resources remaining
Weaknesses	• Limited number of production hubs • Few tie-in opportunities
Opportunities	• Largest remaining prospects • Highest average prospect size in the UKCS • Introduction of new technology to new build hubs
Threats	• Opposition from anti-industry NGOs

NNS	
Strengths	• Opportunities for tie-ins, high infrastructure density
Weaknesses	• High number of farm-in required to move area volumes
Opportunities	• Later CoP result in more ILX projects • Secondary area to benefit from electrification after CNS
Threats	• Non ILX developments cost challenged

CNS	
Strengths	• Likely to be the first basin to electrify • HPHT play • High number of ILX opportunities • Higher volumes in remaining prospects
Weaknesses	• HPHT development costs
Opportunities	• Extending the lifecycle of existing infrastructure • Realisation of electrification benefits first
Threats	• EPL cools investment volumes / benefits • Competition for seabed coverage



Source: OEUK, Westwood

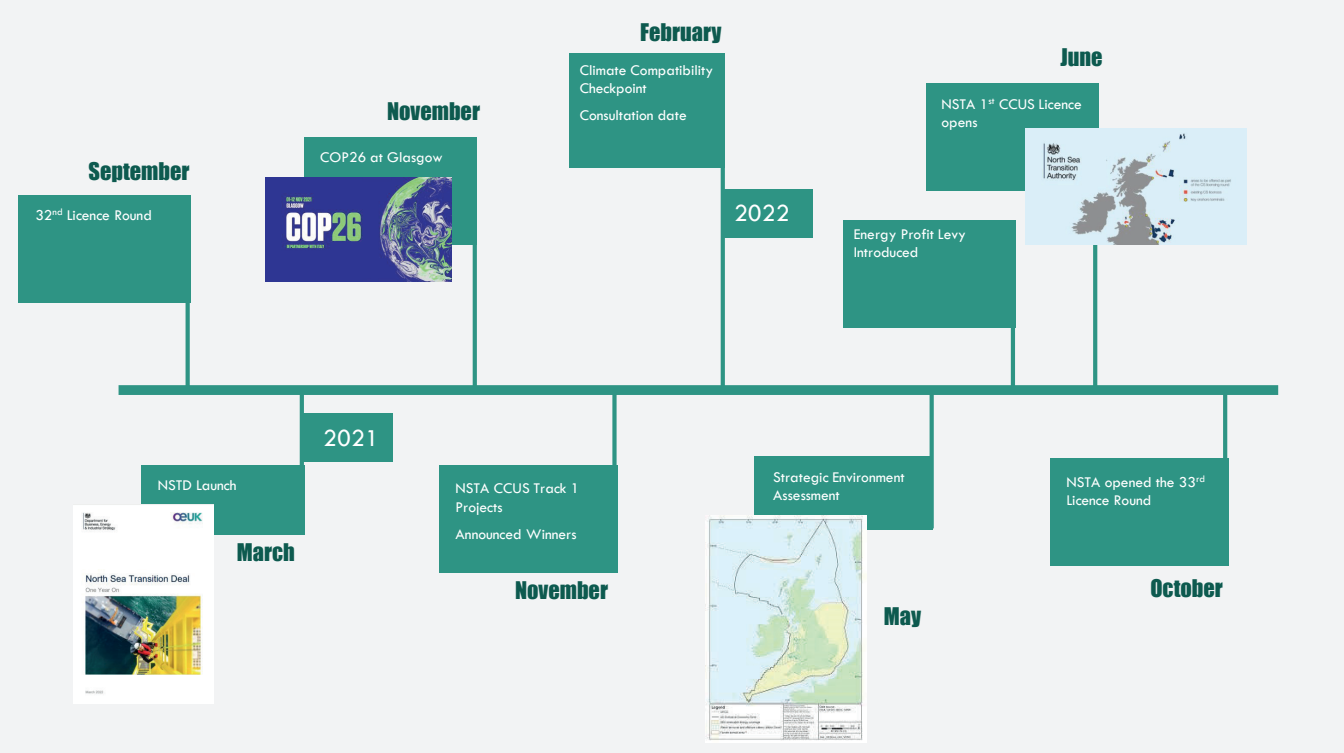
SNS	
Strengths	• Gas-led area • Lower finding costs • Data rich • Cross border synergy
Weaknesses	• Limited high-impact opportunities • Hubs are closer to COP • Smallest average prospect size in the UKCS
Opportunities	• Alleviate energy security concerns • Opportunity for net zero developments
Threats	• Loss of infrastructure reducing prospectivity of farm-ins • Competition for seabed coverage

Licensing activity overview

Figure 17:

UKCS timeline

Source: OEUK



work programme. The majority of the licences entered the initial term (Phase A or Phase B exploration stage), and 16 of the awards were for licences that proceeded straight to second term, either for potential developments, or re-developments of fields where production had ceased and the acreage had been relinquished.

The 31st Licensing Round was launched in 2018 and in 2019 the NSTA offered for award 37 licence areas across 141 blocks or part-blocks to 30 companies. These awards acted as a strong platform for future exploration and production in frontier areas of the UKCS. A number of the proposed new work programmes secured included new shoot seismic acquisition, with two licences progressing straight to field development planning (second term licences).

These rounds have produced minimal success thus far with just 15mn boe progressing to development. The 32nd round was heavily affected by the Covid-19 pandemic, forcing operators to adjust their portfolio plans. However, it should be noted that the UK's average time from licence award to first production is six years, and four years eight months exploration to production. It is too early to make any assessment of whether these opportunities are on track to be realised within this average time window.

33rd licensing round

The 33rd licensing round was held in autumn 2022 and and it focused on acreage where data has already shown that hydrocarbons exist. The licence round was linked to the government's work on a climate compatibility checkpoint for new oil and gas production, for which the consultation with industry closed February 28, 2022. A copy of OEUK's Climate Compatibility Checkpoint Consultation response on behalf of our members, can be found here:

https://oeuk.org.uk/consultation-international-support-copy/

CCUS licensing round

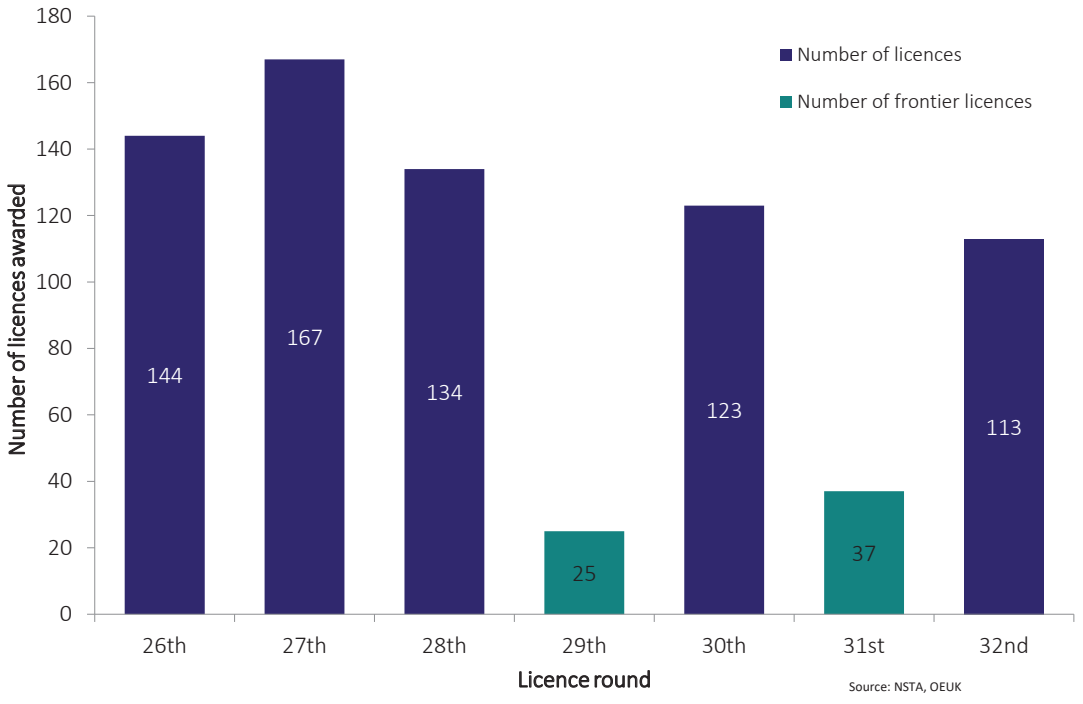
In addition to the 33rd licensing round, which was still ongoing as this report went to press, the UKCS has seen an exciting evolution through the North Sea's first carbon storage licensing round. At present, six carbon storage licences are operating on the UKCS. These could meet up to one fifth of storage needs, if they reach their maximum proposed potential of up to 40mn tonnes/yr injection rates by the mid-2030s.

The new 90-day licensing round opened in June 2022. It attracted bids for licences in 13 areas from 19

Figure 18:

Number of licences awarded in previous licence rounds

Source: NSTA, OEUK



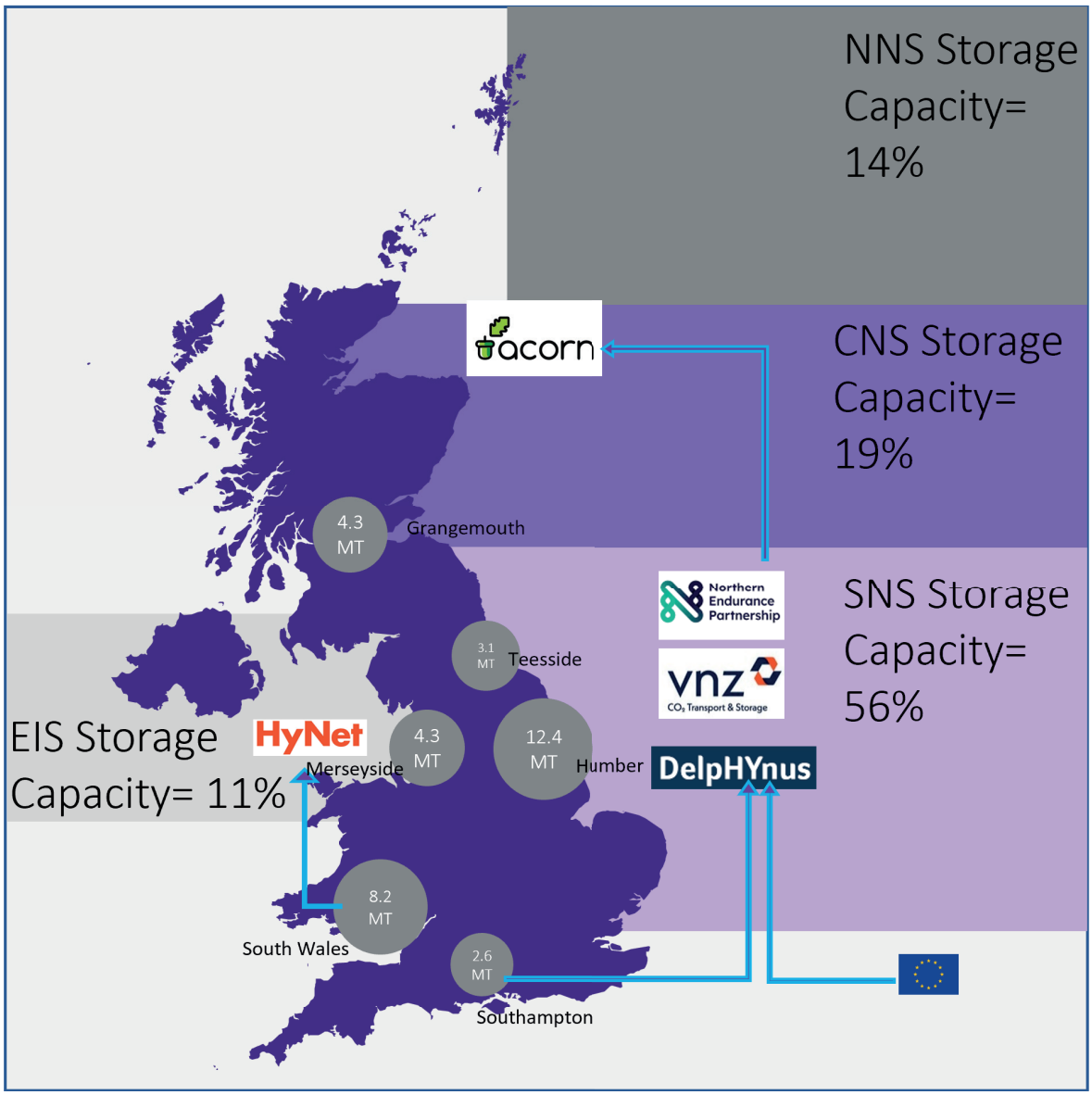
companies. This development provides a new avenue for exploration within the basin, with our skills and expertise being applied to identifying new saline aquifers for carbon storage.

According to first-pass estimates, the number of wells required to meet the 2050 CCUS injection requirements is significant, implying a continued and sustained need for UKCS exploration. Assuming that a CO_2 injection well can inject on average 1mn tonnes/yr, 180 CO_2 storage wells will have to be in operation by the mid-century.

Figure 19:

CCUS activity

Source: OEUK



3. Summary

UK energy security and gas opportunities

Putin's war in Ukraine has had a tragic toll and caused wider geopolitical as the EU implemented sanctions against its primary energy supplier, Russia. The impact of this conflict has sent shockwaves across the world. The subsequent energy supply crisis also comes after some years of under investment in oil and gas resources by European nations. This has led to a sustained rise in gas prices in northwest Europe. In the UK, gas prices have hit record highs, peaking at 512 p/therm and consistently sitting above 150 p/therm throughout 2022. For context in 2019, the average UK gas price at the National Balancing Point was just 34.73 p/therm.

An increase in domestic gas supply - so far this is up this year by 27% compared with the first half of 2021 - will aid energy security concerns. Continued investment by UK energy producing companies into exploration, and the subsequent speed of development of prospects will be critical in helping the UK to reduce the energy import gap and achieve greater energy security

The industry, regulator and government all have a critical part to play in rekindling exploration activity and attracting investment into the basin. OEUK seeks strong alignment between industry and government that can support UK energy supply through the energy transition while maintaining energy security and protecting skills and jobs without risking higher UK carbon emissions or the closure of heavy industry.

4. Case studies

Deltic Energy: strategic overview of Southern North Sea

Deltic Energy, with its partners, is about to launch an exploration drilling programme in the UK southern North Sea (SNS), beginning with a potentially play-opening well at Pensacola in the autumn. This will be the first exploration well in the SNS since 2019 and only one of a handful of wells since the Pegasus discovery in 2014.

A renewed focus on domestic gas production has resulted in a visible increase in support for the sector from UK government which includes a number of important policy statements and fiscal changes which will ultimately support future exploration activity. Like Deltic, the government now understands the importance of this domestic gas resource for jobs, Treasury receipts, energy security and for emissions reduction.

A supportive government is one part of the story and the SNS, as a mature basin itself, has a number of key advantages which support exploration activity. Despite the maturity of the basin, its geological setting continues to provide a diverse range of targets. The utilisation of extensive seismic and well datasets allows the rapid evaluation and maturation of prospects. Sixty years of exploration and production in this world-class gas basin have resulted in a network of production hubs, pipelines and processing plants that enhance the likelihood of a discovery being commercialised.

Deltic's success is based on the identification of material prospects in overlooked [and less well understood] plays and recognising prospects where technological advances in seismic processing, depth conversion or production well design can unlock prospects which were previously seen as too risky or commercially marginal. Acreage is secured at low cost through regular licensing rounds feeding a 'conveyor belt' of opportunities which are matured and presented to organisations which see strategic value in the area for their own business. Deltic prides itself on producing high-quality geological evaluations and this deep commitment to maintaining technical standards results in prospects which can withstand the scrutiny of the world's top E&P companies.

With its operating partner Shell, Deltic plans to spud the Pensacola well in the emerging Zechstein Reef play in the SNS. The Deltic-Shell JV has also recently committed to drilling the Selene prospect in the traditional Leman Sandstone play. In parallel, the Deltic-Capricorn joint venture is busy interpreting newly acquired 3D seismic data, maturing various prospects to feed the next phase of drilling activity. At time of press, the team at Deltic had been sifting through data in order to make fresh applications in the UK's 33rd offshore licensing round with the aim of replenishing the hopper of opportunities.

There is plenty of potential remaining in the SNS. With the UK bill for imported oil and gas reaching an average of £143mn/day in 2021, there is clearly a hard commercial reality supporting domestic UK gas production. Deltic's business model will continue to produce high quality prospects, supporting increased exploration drilling activity which is the first step to match this demand with fresh domestic supply.

Athena Exploration – West of Shetland Tuskar gas prospect

The West of Shetland (WoS) is a proven basin, rich in both oil and gas infrastructure, with about 3bn boe discovered resources and 5.5bn boe yet-to-find. Drilling density is only around 20-25% of the mature basins and the mean lead size is three to four times larger. WoS is the primary area of the UKCS where large (100mn+ boe) lower risk prospects can be matured. Elsewhere on the UKCS only small (or high risk) prospects remain.

Recent success rates in the WoS have been mixed. The plays that have been tested have given generally poor results. Subsequent to the successes of Foinaven and Schiehallion the industry has struggled to pursue or replicate the key elements for success. This has been compounded in recent years by a massive loss of exploration capability from the industry and so some of these earlier lessons have been forgotten. However, exploration potential remains in the region in key plays such as the Palaeocene.

The Tuskar prospect is a Palaeocene pinch out and fault closure on Block 208/14 in the northern gas province. Athena is the sole licensee and Tuskar's P50 prospective resources are put at 1.1 trillion ft^3. What initially drew Athena to Tuskar was a previous operator's work. It recognised an amplitude and amplitude variation with offset (AVO) anomaly at the Palaeocene level on a TGS-NOPEC Geophysical Company (TGS) spec 3D seismic dataset. Unfortunately, the seismic did not cover the whole of the feature and there was a data gap with no angle stacks available over the southern part. The operator could not, therefore, complete the prospect definition. In particular, the trap geometry and amplitude and AVO response and decided to relinquish.

Many of the play elements for Tuskar have been de-risked by adjacent wells. 208/19-1 lies immediately adjacent and penetrated 273 m of Palaeocene reservoir with a 35 m gas column (Ledaig) at the top. Downdip lies the Cragganmore gas discovery penetrated by wells 208/17-3 & 4 which has 55-71 m of gas bearing Palaeocene reservoir. Athena decided to acquire the licence to the acreage as Tuskar has many of the key characteristics needed for a successful prospect. All that was needed was additional data to complete the seismic coverage and provide full prospect definition. Athena undertook to reprocess the legacy 3D seismic which together with the TGS data provides complete coverage of Tuskar.

These new volumes will allow all the outstanding prospect elements to be addressed. This reprocessing has just been completed by Petrotrace and will be interpreted in Q4 2022. Key in the evaluation will be confirming the trap geometry and in particular the separation from the Ledaig gas discovery and the conformance between the trap and the amplitude and AVO response. Further reprocessing is then planned over Athena's other licences to assist in delivering drillable prospects from the large remaining potential that exists in the WoS.

Schlumberger - supporting carbon storage screening and domestic energy on the UKCS

Since 2021 Schlumberger has completed several seismic reprocessing and carbon storage screening projects across the North Sea to support both the growing carbon storage and domestic oil and gas industry through relevant subsurface data and insights. As a result of basin structure and geography and the extensive network of subsea gas lines that are now used at below nameplate capacity, the southern North Sea is a key sub-basin for carbon storage and gas exploration and production. It offers depleted field and aquifer opportunities for carbon storage sites while also offering infrastructure-led gas exploration continuing to exploit the Rotliegend.

Greater Cavendish reimaging

In December 2020 Schlumberger completed the Greater Cavendish reprocessing project – a 2,736 km^2 pre-stack depth migration project over the Cavendish area combining Schlumberger and adjacent public data. Situated on the northern fringes of the SNS, the project area sits in shallow water with pre-salt exploration targets and images. Triassic Bunter domes are key targets for UK carbon storage. The data has been processed through an optimised broadband workflow including data-adaptive de-ghosting and advanced surface and interbed multiple attenuation. Full-waveform inversion (FWI) is used to produce a high-resolution velocity model to reduce uncertainties within the Zechstein salt and improve pre-salt imaging.

Sole Pit carbon storage review

To validate and expand UK CO_2 storage sites, during H2 2021 a regional subsurface screening investigation was undertaken using 3D seismic data, calibrated by well data, located offshore over the Sole Pit Basin and East Midlands Shelf in the SNS. Following seismic interpretation, numerous structural closures were identified within the Lower Triassic Bunter Sandstone Formation. Each site was critically ranked based upon volumetric storage capacity estimates and risk evaluation.

Results have built upon earlier projects by identifying numerous saline aquifer storage sites while ruling out Bunter closures previously interpreted as prospective, owing to critical risks and uncertainties. Project results highlighted previously identified risks in the area, principally overburden faulting, and the structural interaction with local fault zones, particularly the Dowsing Fault Zone. Calculated storage capacity in the study area totals 2.7bn tonnes offering standalone storage potential and ancillary sites close to the Endurance structure.

Southern North Sea reimaging 2022

This year saw the NSTA launch the first carbon storage licensing round as the UK drives towards net-zero emissions by 2050. Eight carbon storage areas have been offered within the SNS to add to the four licences already awarded. After a three-year hiatus, the 33rd UKCS licensing round launched in September. It included available acreage in the SNS. This round is anticipated to be followed by the 2nd UK carbon storage licence round at some point in 2023 to continue the momentum of UK CCS deployment. Schlumberger has embarked on a SNS basin-spanning reprocessing project to support the industry across both domains. The project will combine Schlumberger and public access 3D seismic datasets totalling 60 surveys to provide 20,000 km^2 of broadband, depth imaged contiguous coverage of core areas for ongoing and future carbon storage and E&P licence rounds in the basin. The reprocessing project features workflows and techniques to specifically target the Bunter as a carbon storage option using high-resolution imaging and the impact on overburden assessment in addition to pre-salt-focused imaging.

PGS – UKCS: West of Shetland vision

The project started with the first of four phases in early 2021 followed by phase 2 and phase 3. The fourth and final phase is due to complete at the end of 2023.

The project aims to provide enhanced images of the subsurface and to improve the depth uncertainty at the target, using data collected from the West of Shetland on the UKCS. To achieve this, PGS has initiated a rejuvenation project, using legacy seismic data acquired between 1995 and 2013. By using high-end processing, model building and imaging techniques, we plan to produce a seamless and high-quality dataset and depth image over the basin. In all, 38 legacy surveys, covering more than 20,000 km², are processed in four stages over three years. The enhanced demultiple full waveform inversion (FWI) techniques and geologically constrained tomography updates have allowed PGS to achieve improved data and images.

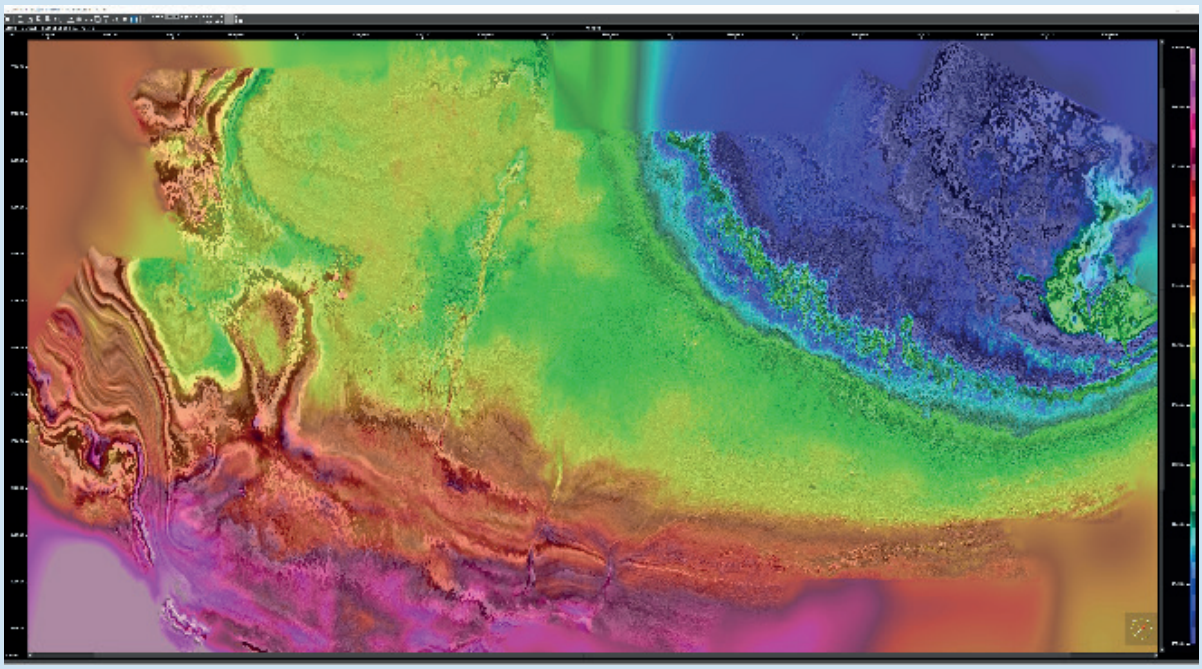
The UKCS has long been an active site for petroleum exploration and over the years a large library of seismic data has been compiled. However, many of these datasets have not been processed for years and fewer have been processed together. PGS is looking to add value to this data and improve basin understanding by rejuvenating this data into a single entity, using high-end processing and imaging techniques to join multiple vintages of data together.

The robust processing flow includes multi-model demultiple and several stages of survey matching and merging, while the velocity model build (VMB) includes FWI, geo-body picking and constrained tomographic updates. The vast number of wells available allowed for thorough QC and derivation of anisotropic parameters. Final imaging is via Kirchhoff pre-stack depth migration, followed by a robust post-processing flow.

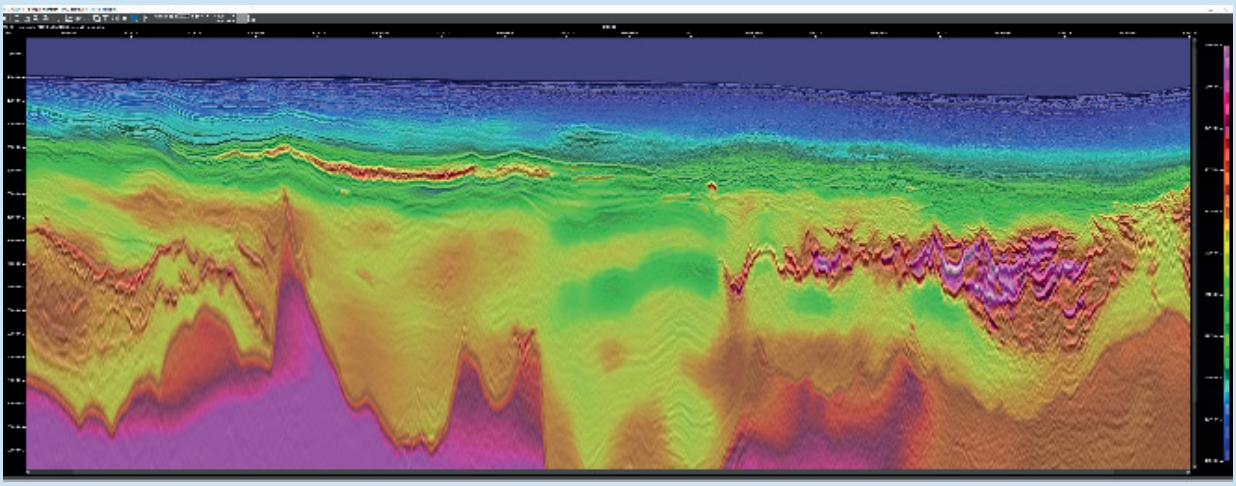
The pre-processing flow led to much of the residual multiple, present in legacy projects being eliminated, while iterative rounds of matching and merging produced a seamless blend of the surveys, even when acquisition styles vastly differed. The FWI solution, implemented during the VMB, uses a unique gradient that uses diving waves, refractions and reflections to simultaneously and effectively update the model beyond the depth of “conventional FWI”. Not only is FWI able to insert velocity detail in the smaller shallow features, such as injectites, turbidites and polygonal faulting, but it is also updated within and below the extrusive volcanics.

Refined interpretation, as well as auto-picking the volcanics to produce a geobody, allowed for further refinement of the velocity within and below the intrusive volcanics without the risk of bleeding into the background sediments.

Wells were used to constrain the data, and constant comparison with legacy images allowed for evaluation of the data throughout the processing and gave confidence that value was being added to the data as the phases evolved. Regular meetings with stakeholders, who have long been active in the area also allowed for in-depth discussion, ensuring progress. Feedback suggests that stakeholders have been satisfied with the results and they have met or exceeded expectations. To date, the high-end processing flow, coupled with geological knowledge and know-how has led to unprecedented results, with a highly resolved model, constrained heavily by the well data and interpretive knowledge to produce high-quality images and data sets, providing a superior image of the subsurface of the WoS.



Z-slice: Phases 1 & 2 – full stack with velocity overlay



Inline: Phases 1 & 2 – full stack with velocity overlay

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