Energy self-sufficiency through accelerated development of UK domestic fossil fuel resources:

Worthwhile opportunity or chimera?

Andy Wood

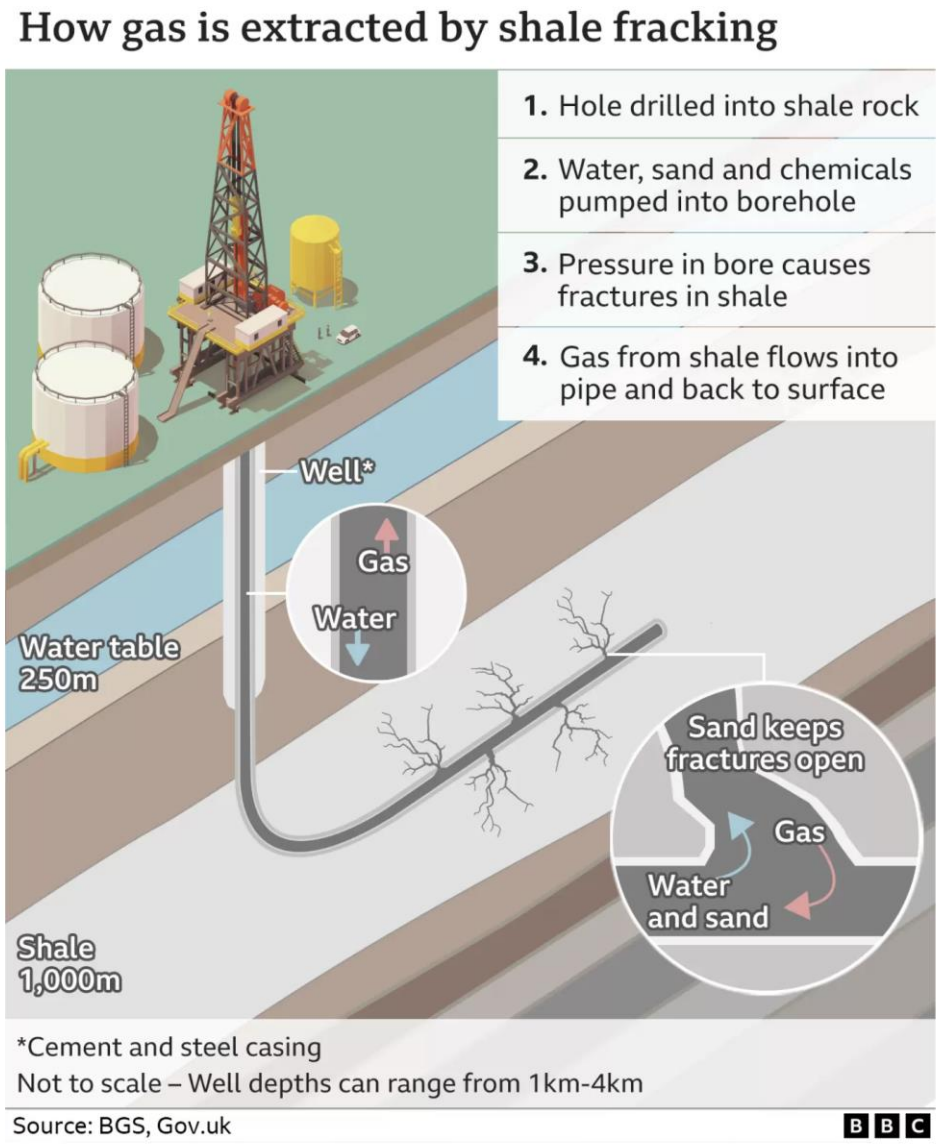
Farnham U3A Climate Change Group, 12th October 2022

- Brief review of conclusions and recommendations of of British Geological Survey Open Report OR/22/050 into induced seismicity of hydraulic fracturing of shales
  - What is shale gas and how is it extracted
  - Background to the report
  - Terms of reference
  - Main conclusions and recommendations
  - Responses in UK academia

- The future of shale gas extraction and conventional new oil and gas offshore developments in the context of the Government's recent announcements
  - What has the UK government announced?
  - What impact is the new strategy likely to have?
  - Is further development of domestic fossil fuels compatible with the UK's 2050 carbon neutral target?

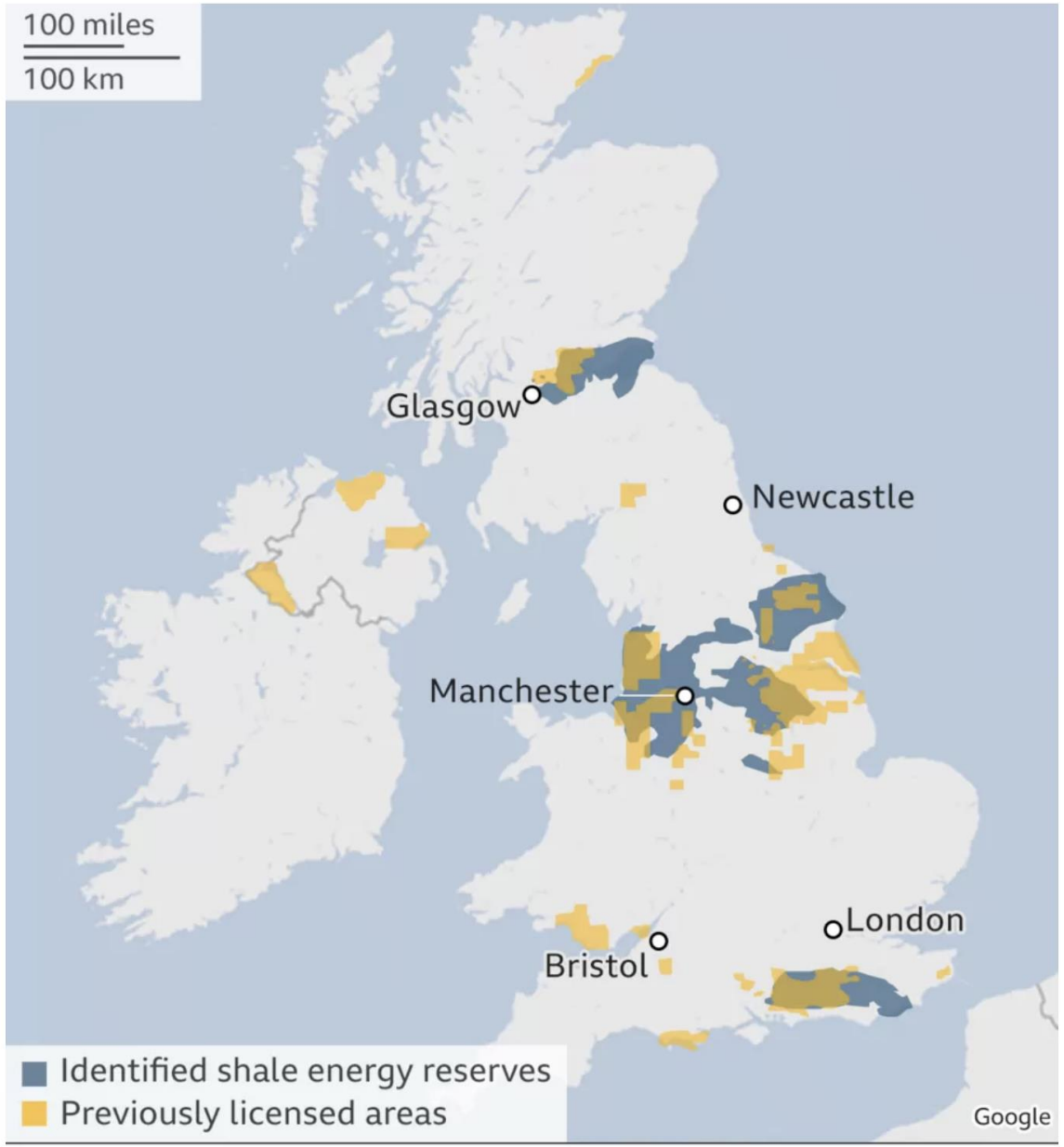
What is ‘fracking’?

- Hydraulic fracturing (HF) is a technique for recovering oil or gas from impermeable rocks, mainly shales.
- It involves pumping a mixture of water & sand under high pressure to open fractures in the rock.
- Can be used in vertical or horizontal wells.
- The technique is not new; extraction of oil and gas from shales, however, is novel.



BGS Report – background (I)

- Observations of induced earthquakes caused by hydraulic fracturing (HF) operations around the world has increased as the shale gas industry has developed.
- Data from the USA and Canada suggest that c.1% of HF wells can be linked to earthquakes with magnitudes of 3 or more, which are generally large enough to be felt by people.
  - In some areas the percentage of wells associated with induced earthquakes is much higher (>30%).
  - Variability is often explained in terms of geological factors such as proximity to existing faults or formation pore pressure.
- Hazard from earthquakes induced by HF might greatly exceed the natural earthquake hazard in regions of low to moderate seismicity.



Shale Gas – UK resource potential

- Activity has focused on the Bowland Shale Formation (350-320 my) and some older Carboniferous-aged shale beds in N. England.
- Bowland Shale:
  - 800-2,300 tcf (2013)
  - 140 tcf (2019)
- Midland Valley, Scotland
  - 50-135 tcf (2014)

Determining the proportion of these in-place volumes that could be economically recovered is not yet possible.

(For comparison, total UK gas consumption in 2018 was c. 3 tcf)

- UK exploration for shale gas started with award of the first onshore licenses in 2008.
- More than 100 exploration and drilling licences were awarded
- Cuadrilla was the only company to obtain consent to begin operations
- 3 wells in 2 sites drilled in Lancashire

BGS Report – background (II)

- HF of the first dedicated shale gas well in the UK, Preese Hall 1 near Blackpool, Lancashire, led to felt seismicity, suspension of HF operations, and studies into induced seismicity and risks.
- Regulatory roadmap published by BEIS in 2013 outlining regulations for onshore shale gas exploration included specific measures for mitigation of induced seismicity:
  - Avoiding faults during HF
  - Assessing baseline levels of earthquake activity
  - Monitoring seismic activity during and after fracturing
  - Using a ‘traffic light’ system that controls whether injection can proceed or not, based on that seismic activity.
- In July 2018, UK Research and Innovation (UKRI) funded the Unconventional Hydrocarbons in the UK Energy System programme consisting of 5 challenge areas of research:
  - The evolving shale gas landscape
  - shale resource potential, distribution, composition, mechanical and flow properties
  - coupled processes from reservoir to surface
  - contaminant pathways and receptor impacts
  - socio-economic impacts: the dynamics of public attitudes and community responses to shale gas; the social construction of unconventional gas extraction: and 'Fracking', framing and effective participation.
  - The programme is scheduled to conclude in Autumn 2022

BGS Report – background (III)

- In late 2018, HF of the Bowland Shale Formation was carried out in the Preston New Road-1 (PNR-1) well near Blackpool.
  - Operations were accompanied by seismicity
  - The largest event, with a magnitude of 1.6 ML, was felt by a small number of people near the epicentre.
- HF operations in the adjacent PNR-2 well started on 15 August 2019 and were also accompanied by seismicity.
  - Largest event had a magnitude of 2.9 ML
  - Occurred almost 72 hours after the last HF stage on 23 August.
  - The earthquake was strongly felt at distances of up to a few kilometres from the epicentre
  - This led to a premature end to operations only 7 of the planned 47 HF stages completed.
- Following a review of these events (Oil and Gas Authority, 2019), a moratorium on shale gas hydraulic fracturing was implemented on 2 November 2019.

BGS Report – background (IV)

- In March 2020, the Oil & Gas Authority (OGA, now the North Sea Transition Authority), commissioned four studies to investigate seismicity resulting from hydraulic fracturing operations in PNR-2.
- The OGA concluded that:
  - “It is not yet possible to accurately predict the seismic response to hydraulic fracturing, if any, in relation to variables such as site characteristics, fluid volume, rate or pressure.
  - “Where induced seismicity has occurred, mitigation measures have shown only limited success, and there can only be low confidence in their effectiveness currently”, and
  - “There remain significant uncertainties and challenges related to the prediction and management of induced seismicity from hydraulic fracturing”.

BGS Report – Terms of reference

- BEIS asked BGS to produce a short report on the “geological science of shale gas fracturing and the modelling of seismic activity in shale rocks in the UK”:
  - Have there been **new developments in the science** of fracturing? In particular, are there new techniques in use which could reduce the risk and magnitude of seismic events?
  - If there are new techniques, would they be **suitable** for use in fracturing in the UK, with its specific geology and high population density?
  - Given the new developments in these technologies, **how does the seismicity caused by fracturing compare** to other forms of underground energy production, such as geothermal and coal mining, or surface activities such as construction? Can you review the evidence on the different "safe" thresholds for activity, whether they remain the correct ones, and whether differences between them remain justified?
  - Has the **modelling of geologies** such as shale improved in the period since the pause was implemented in 2019? If so, do these improvements mean we could be confident about the modelling of seismic events and their predictability?
  - It is clear, from experience, that the shales drilled into in Lancashire have problematic geology. Are there **other sites**, outside of Lancashire, which might be at a substantially lower risk of seismic activity, and what level of confidence would we have in our assessment of seismic activity in these areas?
  - Noting our specific geology and population density, how does seismicity from fracturing in the UK **compare** to other countries e.g., the US?

BGS Report - Structure

1. Introduction
2. Background
3. Assessing earthquake hazard and mitigating risk (ToR Qs 1&2)
   - Recent Scientific Advances in Earthquake Monitoring and Forecasting
   - Advances in risk analysis and mitigation
4. Comparison of HFIS with induced seismicity from other industries (ToR Q 3)
   - Hydraulic fracturing of shales
   - Wastewater disposal
   - Mining
   - Conventional Oil and Gas Production
   - Geothermal Energy
5. Modelling of shales in relation to seismic activity (ToR Qs 4&5)
   - Recent advances in the modelling of shale successions in the UK
   - Geomechanics of HF operations: stress state in the UK and fault reactivation potential
   - Should we expect HFIS in other shales outside of Lancashire?
6. Global Experience of HFIS (ToR Q 6)
7. Conclusions

BGS Report – Key findings (I)
Assessing earthquake hazard and mitigating risk

- **Forecasting** the occurrence of large earthquakes and their expected magnitude remains a **significant challenge** for the geoscience community.
- Recent research describes **methods that may provide informative forecasts of HFIS in the near future**. These forecast models could use parameters from nearby sites in the very early stages of operations, which could then be refined during operations.
- The **applicability of such methods depends on high-resolution seismicity data** such as is available from operations at PNR. The applicability in near-real-time depends on rapid processing of data which is now possible using more advanced artificial intelligence workflows.
- Recent research demonstrates that **machine-learning can be applied** retrospectively, or in near-real-time, to provide the high-resolution data required to support these forecast models.
- **Probabilistic methods** to assess hazards and risks for tectonic earthquakes that combine models of seismicity with models of ground motion, exposure, and vulnerability, can also be applied to induced seismicity.
- **Red-light thresholds** for traffic light systems can be chosen to reduce the probability of the scenario to be avoided to a required level.

BGS Report – Key findings (II)
Comparison of HFIS with induced seismicity from other industries

- **Induced seismicity has been observed in other industries** that have been used for energy production in UK.
- In the absence of a seismic building code in the UK, consistent **risk targets**, i.e., scenarios to be avoided, could be considered for all energy related industries that present a risk of induced earthquakes.
- Adaptive traffic light systems to mitigate the risks of induced seismicity have been successfully used in the **geothermal industry**. Similar systems could be used during HF operations.

BGS Report – Key findings (III)
Modelling of shales in relation to seismic activity

- Recent research using **high quality exploration data that is available for some parts of the UK** reveals localised structural and stress heterogeneity that could influence fault reactivation. This is in keeping with findings in high-hazard natural seismicity settings.
- However, **limited exploration data from other parts of the UK** means that there are significant gaps in our knowledge of sub-surface structure of these places. When coupled with the uncertainties in predicting the magnitude, duration, timing and location of induced seismicity, it is not possible to discount the likelihood of HFIS in shale areas outside of Lancashire occurring.
- **It is not possible to identify all faults that could host earthquakes with magnitudes of up to 3 prior to operations, even with the best available data.**
- Recent research from the USA demonstrates the importance of **geomechanical modelling to identify faults that are most likely to rupture during operations**. This information can be used to assess risks prior to and during operations.
- However, **these models require accurate mapping** of sub-surface faults, robust estimates of stress state, formation pore pressures and the mechanical properties of sub-surface rocks. While this information is available in a few areas with unconventional hydrocarbon potential such as the Bowland Basin, more data is needed from other basins to allow robust geomechanical models to be applied more widely.

BGS Report – Key findings (IV)
Global experience of HFIS

- **The rates of HF-induced seismicity in other countries** where shale gas production has been ongoing for many years are observed to **vary widely**.
- Overall, given the large number of wells with HF operations, there are relatively **few published cases of HFIS**.
- However, **in some areas the percentage of wells associated with induced earthquakes can be as high as 30%.**
- **HF can trigger earthquakes large enough to cause structural damage**. These events were not predicted in advance of operations.
- The limited number of HF operations in the UK means that it is **difficult to make a valid comparison** of the rates of occurrence of induced seismicity with elsewhere.

BGS Report – BEIS reaction

- “The review recognised that we have **limited current understanding of UK geology and onshore shale resources**, and the challenges of modelling geological activity in relatively complex geology sometimes found in UK shale locations.”
- “There have only been 3 test wells which have been hydraulically fractured in the UK to date. It is clear that **we need more sites drilled in order to gather better data** and improve the evidence base and we are aware that some developers are keen to assist with this process.”
- **“Lifting the pause on shale gas extraction will enable drilling to gather this further data**, building an understanding of UK shale gas resources and how we can safely carry out shale gas extraction in the UK where there is local support.”

BGS Report – Reaction from academia (I)

Prof Geoffrey Maitland, Professor of Energy Engineering at Imperial College London, and Past President of IChemE:

- **Shale gas could provide 20% or more** of UK natural gas demand for 2025-50.
- It could be used in the medium term to **replace diminishing North Sea gas production and some gas imports** and as a bridge to 2050 as the country works towards accelerating sustainable low-carbon energy technologies and solutions.
- Well-established **engineering good practice and sound regulation can provide safe and environmentally acceptable solut**ions to concerns about shale gas extraction.
- **Local seismic disturbances arising from the fracturing process are usually very weak** and are of less power than the naturally occurring earth tremors that occur even in the UK (2-3) or the tremors arising from the passing of nearby trains or heavy goods vehicles (1-2), none of which cause significant structural damage.
- Full sub-surface analysis of potential sites required to **ensure that drilling and fracturing is not carried out in areas of potential seismic instabi**lity.
- **Monitor carefully** in real time all local seismic activity to ensure that fracturing is stopped as soon as seismic tremors reach potentially damaging levels for buildings or humans. In the UK could safely be set much higher than the current limit of 0.5.
- The current cost-of-living crisis emphasises the **need for more affordable and secure energy supplies in the short to medium term**, as well as in the long-term once sufficient affordable renewables and nuclear are in place.
- Until our economy can be entirely driven by renewable energy and renewable bio-feedstocks for zero-carbon materials, realistically by 2050, we **can continue to have the benefits of fossil fuels without exceeding the emissions limits that are needed to meet the 1.5C cap and still avoid catastrophic climate change**.
- **Shale gas is an essential and vital part of that journey**; gas and CCUS are the enablers and with them fossil fuels are a key part of the solution, not the enemy to be avoided at all cost."

Prof Quentin Fisher, Professor of Petroleum Geoengineering at the University of Leeds:

- **The government's statement on shale gas extraction seems entirely reasonable**. The UK will be relying on natural gas for many years to come and it seems sensible to produce our own wherever possible.
- The government's statement and the BGS report both correctly highlight the **need for more data**, which can only be acquired by drilling and testing more wells within shale. Such data is required to improve estimates of the amount of gas that could be produced.
- The BGS report correctly states that **seismicity may be generated by a wide range of activities** that make use of the subsurface to generate energy.
- **HF is a very safe, well-tested process** and reports of water contamination etc. have been vastly exaggerated by those opposed to shale gas extraction.

BGS Report – Reaction from academia (II)

Prof Ben Edwards, Professor of Engineering Seismology, University of Liverpool:

- A **thorough review** of state-of-the-art science.
- Given the complexity of the underlying science, there **still remain significant challenges** into predicting and mitigating induced seismicity.
- Since the moratorium was announced, there **has not been sufficient advance in scientific knowledge to demonstrate shale gas extraction as being unequivocally safe** when in close proximity to urban areas.
- The government decision therefore seems **at odds with their previous promise** to be 'guided by the science'.

Dr Salvador Acha, Senior Research Fellow, Department of Chemical Engineering, Imperial College London:

- Studies show the **potential for shale gas in the UK is low**, but if yields can even marginally alleviate energy security concerns it should help to mitigate the high prices we all are suffering.
- Need to put in place regulation that pushes the use of **CCUS** technologies so the use of this gas has a reduced environmental impact.
- **Fast-track heat demand reduction** policies across UK buildings to significantly reduce our fossil fuel import needs.

Prof John Loughhead, Industrial Chair in Clean Energy, University of Birmingham, said:

- Shows the **difficulty of predicting accurately any induced seismic activity**, but also **limited knowledge of UK geology** in the detail needed to realistically try.
- New computer analysis methods identified show there are probably **thousands of times more small magnitude events occurring naturally** than previous recorded.
- This highlights the **stringency of current controls** compared to natural background, to those applied by other countries, and even to UK regulation of geothermal energy.
- **Need more test data**, better analysis and monitoring capabilities, and a more refined regulatory approach than today's if we are to consider fracking objectively.
- It is regrettable that **developments in the technology of hydraulic fracturing are not considered** at all.

Prof Richard Davies, petroleum geologist at Newcastle University, said:

- The next question is whether there's **a place in the UK that is less likely to cause felt earthquakes** – and can we be sure?
- We cannot see the faults that are causing the earthquakes using modern methods – so **avoiding the faults is nigh on impossible right now**.
- Although **coal mining has caused many more earthquakes than fracking in the UK**, the inability to avoid similar magnitude events is the Achilles heel for onshore shale gas.

BGS Report – Reaction from academia (III)

Prof Jon Gluyas, Director Durham Energy Institute, Durham University:

- **It won't work** – societal objections aside, we have the **wrong kind of shale and geology** which is far too complex.
- **We can't forecast** if induced seismicity associated with fracking will occur and how big the Earth's response might be.
- **Some areas of the UK are critically stressed**, a part of our natural geology. Disturb these areas and you are likely to get more energy out in the form of seismicity than you put in to fracture the rock.
- As a nation we can deliver net zero (carbon) with **renewables and geoenergy** – geothermal in particular coupled with efficiency and insulation gains.

Alex Taylor, Head of Policy at the Institution of Engineering and Technology:

- Fracking is **unlikely to make any impact in the short to medium**. There are far more effective methods that would offer UK long term energy security, such as renewable energy, hydrogen, and focusing on energy efficiency like retrofitting.
- **How much accessible volume** of fracked gas is there, how long will it take to get into the gas network, how prices will be managed, how local support will be gained and ultimately how safe is it?
- There is no quick gain in any solution for decarbonisation – and if we are to meet net zero targets by 2050, **why encourage more carbon now**?

Dr Ajay Gambhir, Senior Policy Research Fellow, Grantham Institute:

- Fracking in the middle of a climate emergency seems particularly **inappropriate**.
- We have **next-to-nothing left in terms of our carbon budget**, so there's no more room for new fossil fuel sources.
- And that's before one considers the **length of time** (probably years) before the gas flows, the lack of popularity for fracking in the UK, and the potential tremors and local environmental impacts of it.

BGS Report – Reaction from academia (IV)

Prof Stuart Haszeldine FRSE, Professor of Geology at the University of Edinburgh:

- The review has shown **no new methods and no new science**; forecasting earthquakes remains a scientific challenge for many many years to come.
- **Predictions can be improved** if large quantities of data exist on fault locations and previous earthquakes. In the UK this information only exists in areas previously drilled for fracking.
- Drilling will be a **huge commercial risk** for companies who have already lost hundreds of millions pounds, and a huge reputation risk for government. Tweaking the danger settings on the present traffic light earthquake warning system is no substitute for good understanding.
- The best that can be expected is **a few months to a very few years** of local gas production after drilling tens to hundreds of boreholes.
- It would have been much better to have spent the lost hundreds of millions and government effort to develop secure **UK renewables, energy efficiency, and insulating consumers' houses.**

Prof Richard Green, Professor of Sustainable Energy Business, Imperial College London:

- Anyone thinking that this might have the same impact on prices that fracking had in the USA has forgotten that in energy terms, **North America is an island**, and the UK hasn't been one since we built pipelines to the Continent.
- North America only has low gas prices because they **haven't built enough infrastructure to export their surplus gas** to the rest of the world.

BGS Report – Reaction from academia (V)

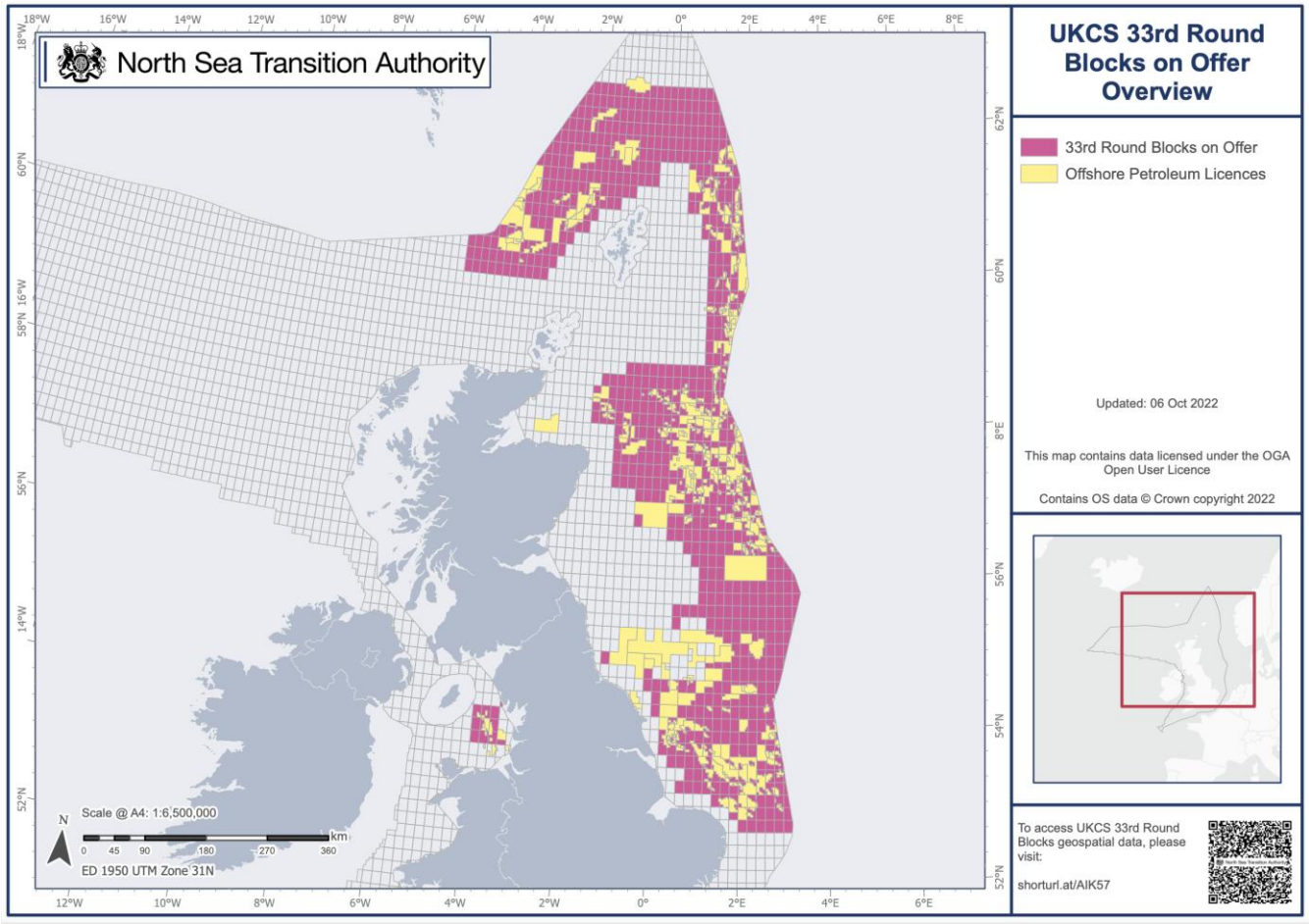
Honorary Professor Andrew Aplin, Department of Earth Sciences, Durham University:

- The BGS report indicates that in terms of the science, **little has changed** since the 2019 moratorium on fracking.
- **Estimates of commercial shale gas reserves are speculative**
- Our **ability to predict the magnitude of fracking-induced earth tremors has barely changed**.
- **Future drilling and fracking would gradually reduce uncertainties** around reserves and seismic risks.
- But even if the risks proved to be manageable and acceptable, shale gas would only make a significant impact to UK supply if, over the next decade, **thousands of successful wells** were to be drilled at hundreds of sites across northern England.
- **The price we pay for gas wouldn't change**, and new production would be inconsistent with the government's net zero strategy.
- The UK's **primary focus should be on reducing the demand for gas** rather than increasing supply.

UK Govt oil and gas strategy review

- Rapidly rising wholesale gas prices in the wake of the invasion of Ukraine has led to renewed scrutiny of the **UK's energy strategy** and systems.
- Previous Tory government resisted calls for lifting the shale gas moratorium.
- **HF moratorium lifted** on 22nd September following Tory leadership election.
  - increase home-grown sources of energy,
  - reduce the UK's reliance of foreign imports, and
  - explore all possible options to boost domestic energy security.
  - BEIS will consider future applications for Hydraulic Fracturing Consent with the domestic and global need for gas in mind and where there is local support .
- Also published UK gov response to the consultation on the UK Offshore Energy Strategic Environmental Assessment 4 (OESEA4) Environmental Report.
- 7th October North Sea Transition Authority launches **33rd Offshore Oil and Gas Licencing Round.**

33rd UK oil and gas licencing round



- **898 blocks and part-blocks** available
- Includes licensing the **Rough gas storage** facility.
- Net zero aims secured by **climate compatibility checkpoint** and NSTA rigorous full lifecycle stewardship and benchmarking
- Closes in **January 2023**
- 4 **priority cluster** areas identified in S North Sea

Cluster Rationale

North Sea Transition Authority

Context

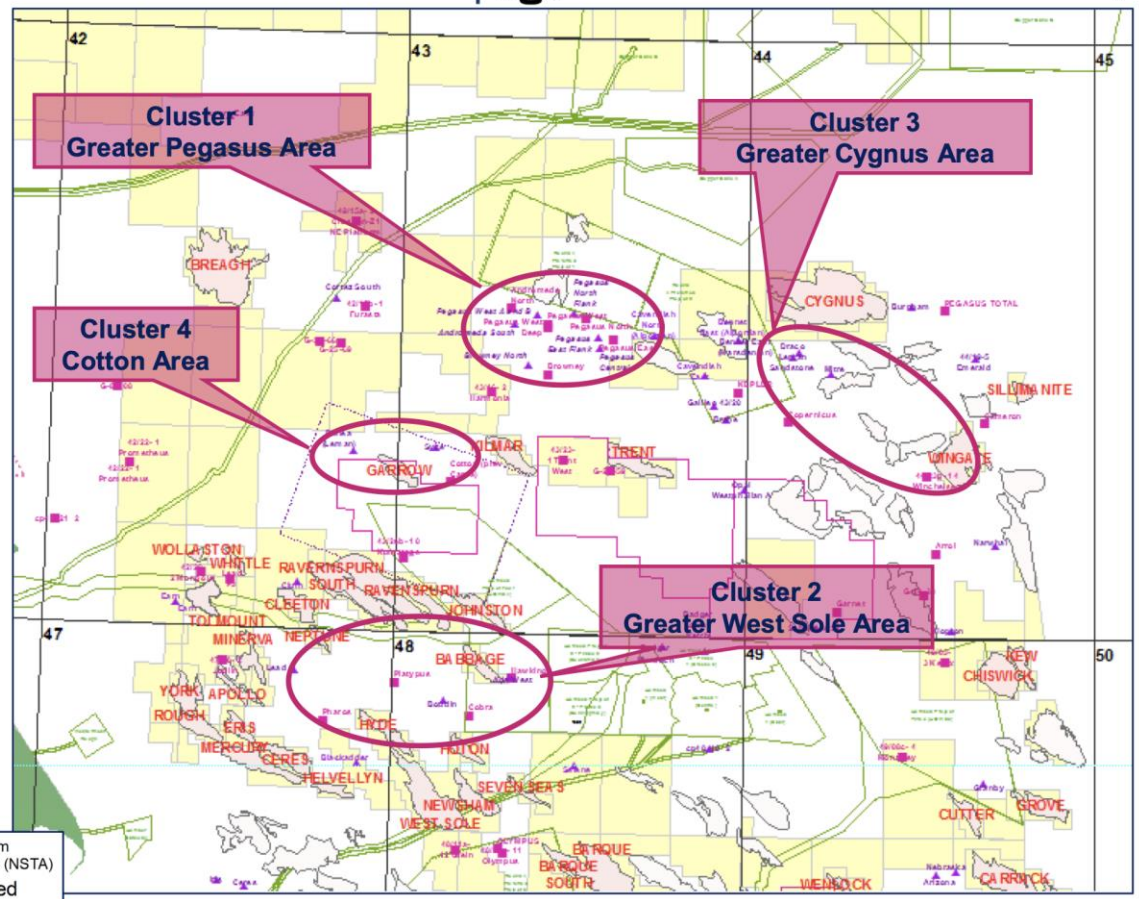
The Southern North Sea ("SNS") has a number of unlicenced, undeveloped hydrocarbon accumulations that include material hydrocarbon volumes that have historically been technically matured but have failed to progress to development. In addition there are associated prospects with a range of Geological Chance of Success ("GCOS").

Given the SNS is a region of ageing infrastructure, there is a risk of hydrocarbons becoming stranded and remaining unexploited. The SNS requires a strategic approach to deliver developments that can expedite hydrocarbon production in the near term as well as potentially enabling further exploration activity in the mid-term before the export routes reach Cessation of Production ("COP").

Commitment by licensees to strategic plans that will deliver hydrocarbon recovery at pace will be key for the SNS.

Licence Round Area of Focus

The SNS is largely well understood, but an historic piecemeal approach to development has proved unsuccessful. Four priority clusters in the SNS have been identified that offer an opportunity to strategically develop a critical mass of hydrocarbons to ensure timely development and optimal use of available infrastructure.



Terminal

Offshore Fields

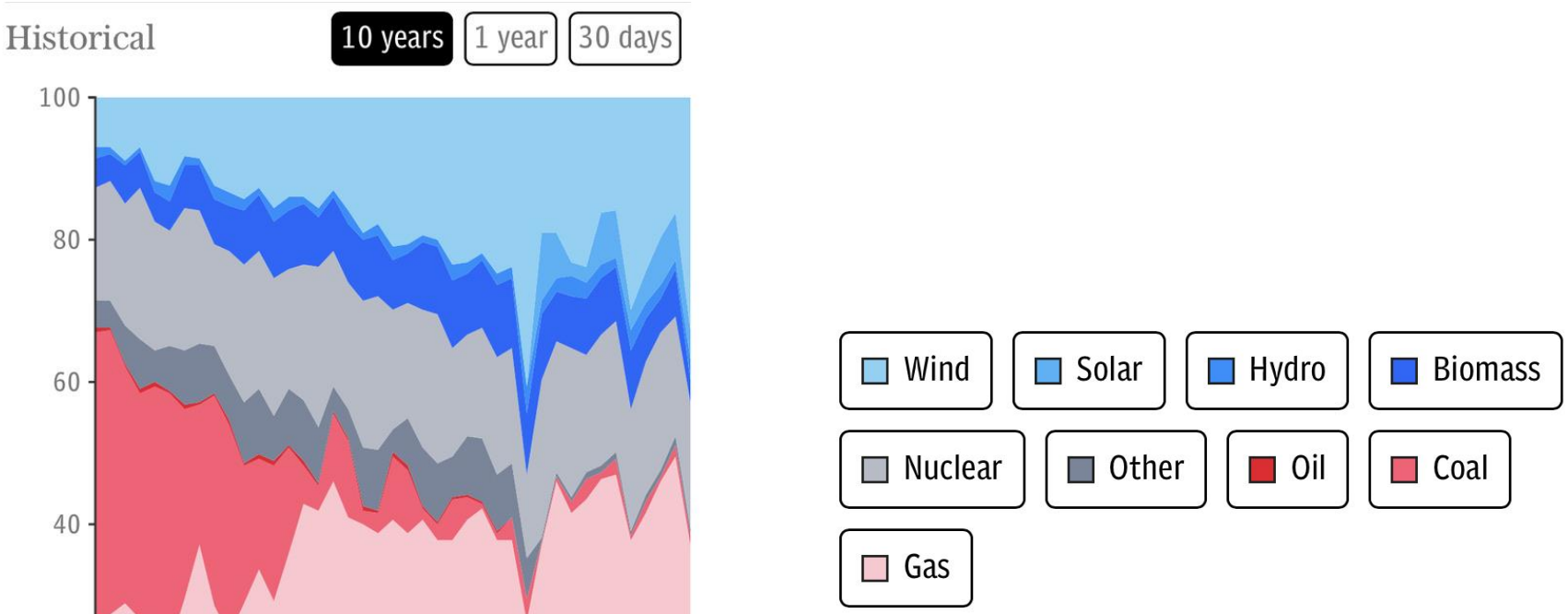
- Oil
- Condensate
- Gas
- Gas (producing)

- Wind Farm Leases (TCE)
- Wind Farm Export Cable Agreement (TCE)
- Wind Round 4 Preferred Projects (TCE)
- Offshore Minerals Evaporites Site Agreements (TCE)
- CCS Leases (TCE)
- CS Licences (NSTA)
- Petroleum Licences (NSTA)
- Selected Discoveries
- Selected Prospects

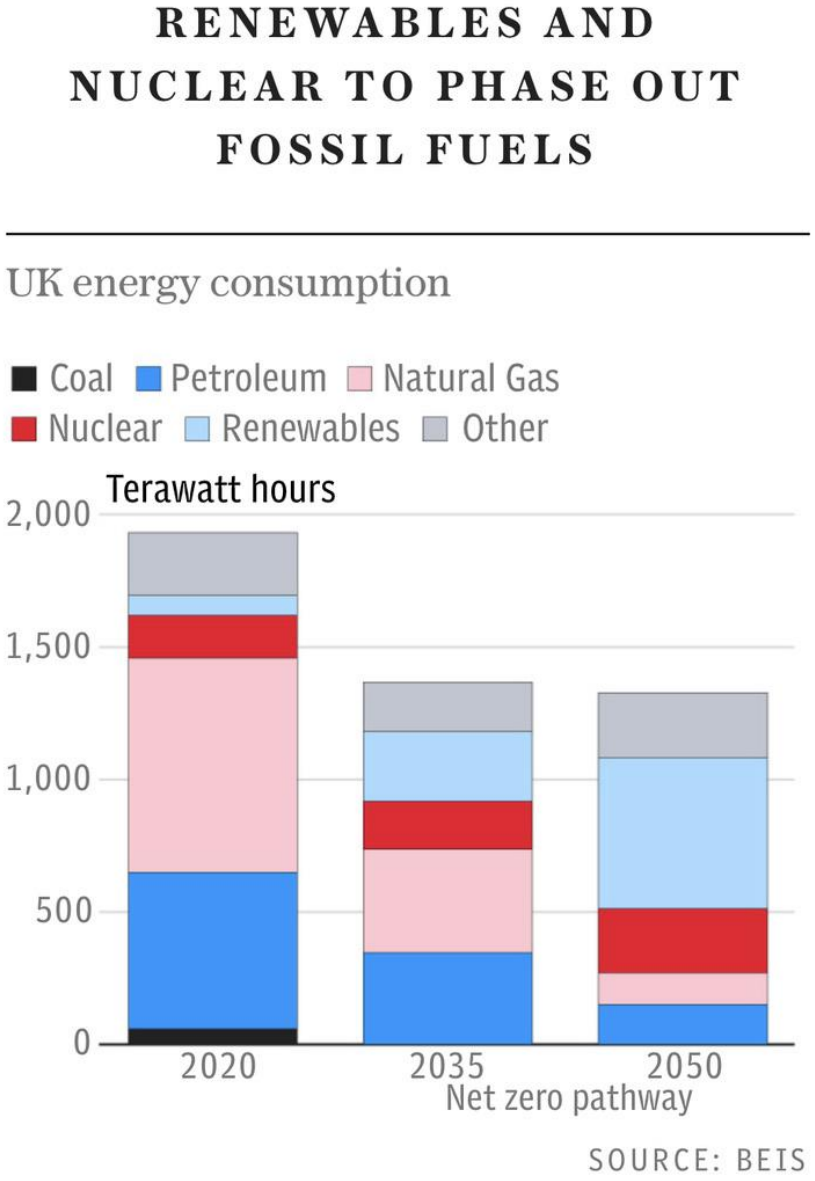
Map data as of 21 September 2022. May be subject to change.

Information compiled by the North Sea Transition Authority

The UK’s electricity mix

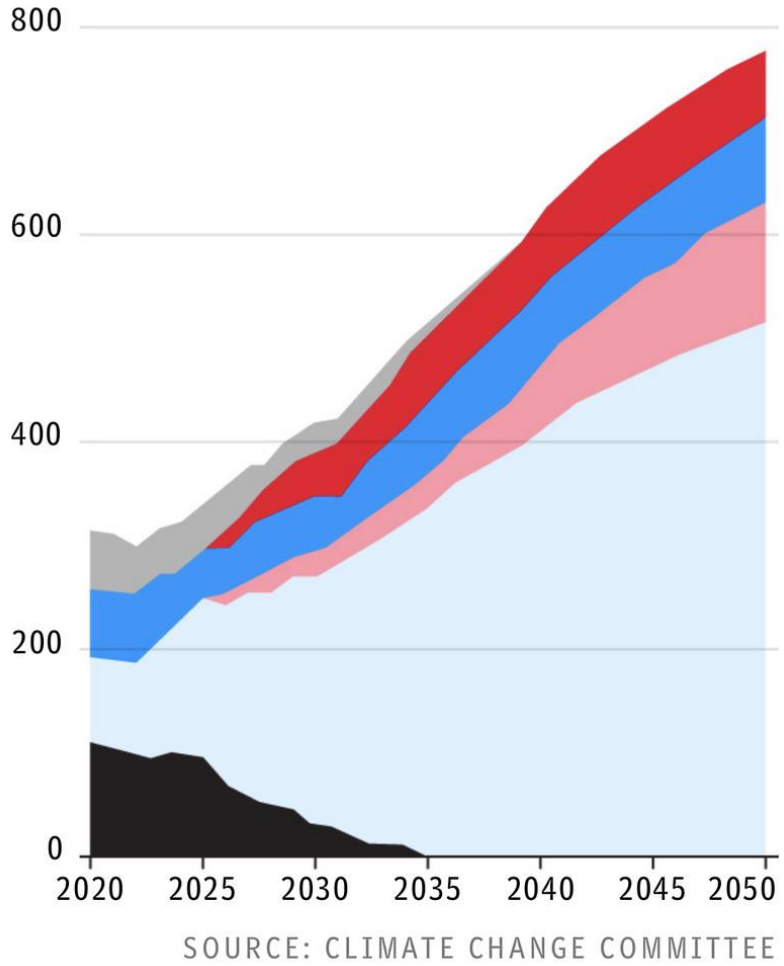


"Other" captures anything which is small volume and is not given its own category by the National Grid ESO. For example, batteries and energy from waste.



Renewable and nuclear to phase out fossil fuels

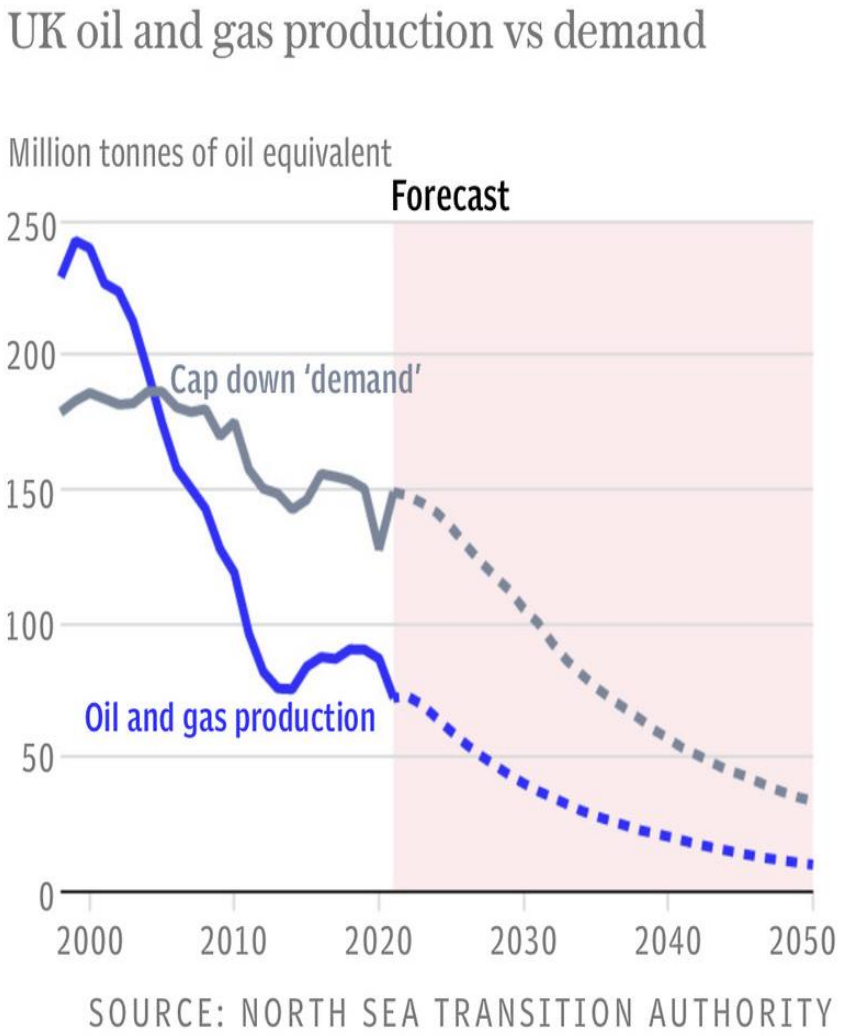
Britain will cut out carbon by 2050 under net zero plan



UK energy mix forecast, terawatt hours of electricity

- Electricity for hydrogen production
- Other
- Nuclear, hydroelectric, tidal power
- Renewables
- Unabated fossil fuel generation
- Guaranteed power plant output

North Sea production is in decline



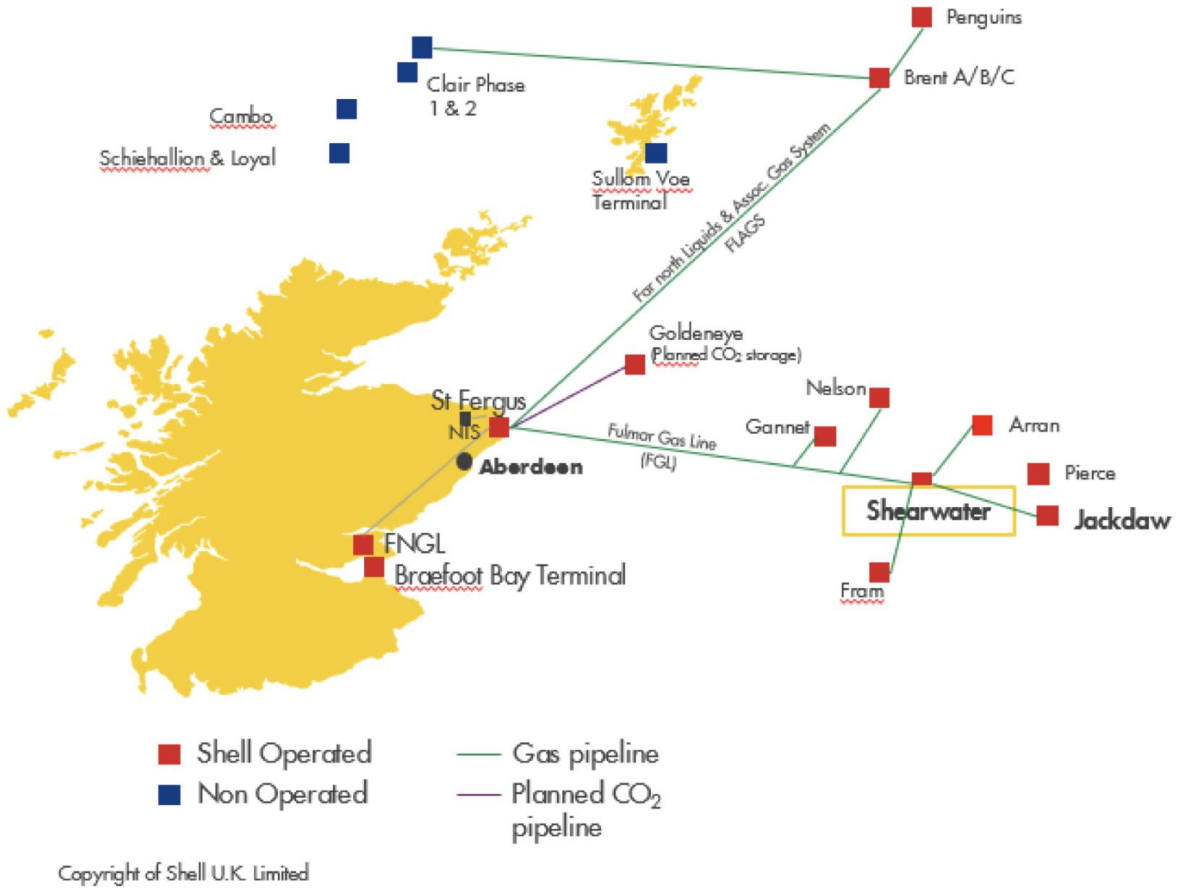
- Domestic production meets c. half of current UK oil and gas demand.
- Supply decline will be faster than the decline in demand.
- Total demand to 2050: 18.5 billion boe)
- Production to 2050: 9.25 billion boe

UK oil and gas reserves and resources as at end 2020 (end 2019) in billion boe

Reserves	2P
Reserves	4.4 (5.2)
Contingent resources	**2C**
Producing fields	1.8 (2.1)
Proposed new developments	1.8 (1.7)
Marginal discoveries	3.2 (3.5)
Prospective resources	**Mean**
Prospects and Leads	3.7 (4.1)
Plays	11.2 (11.2)

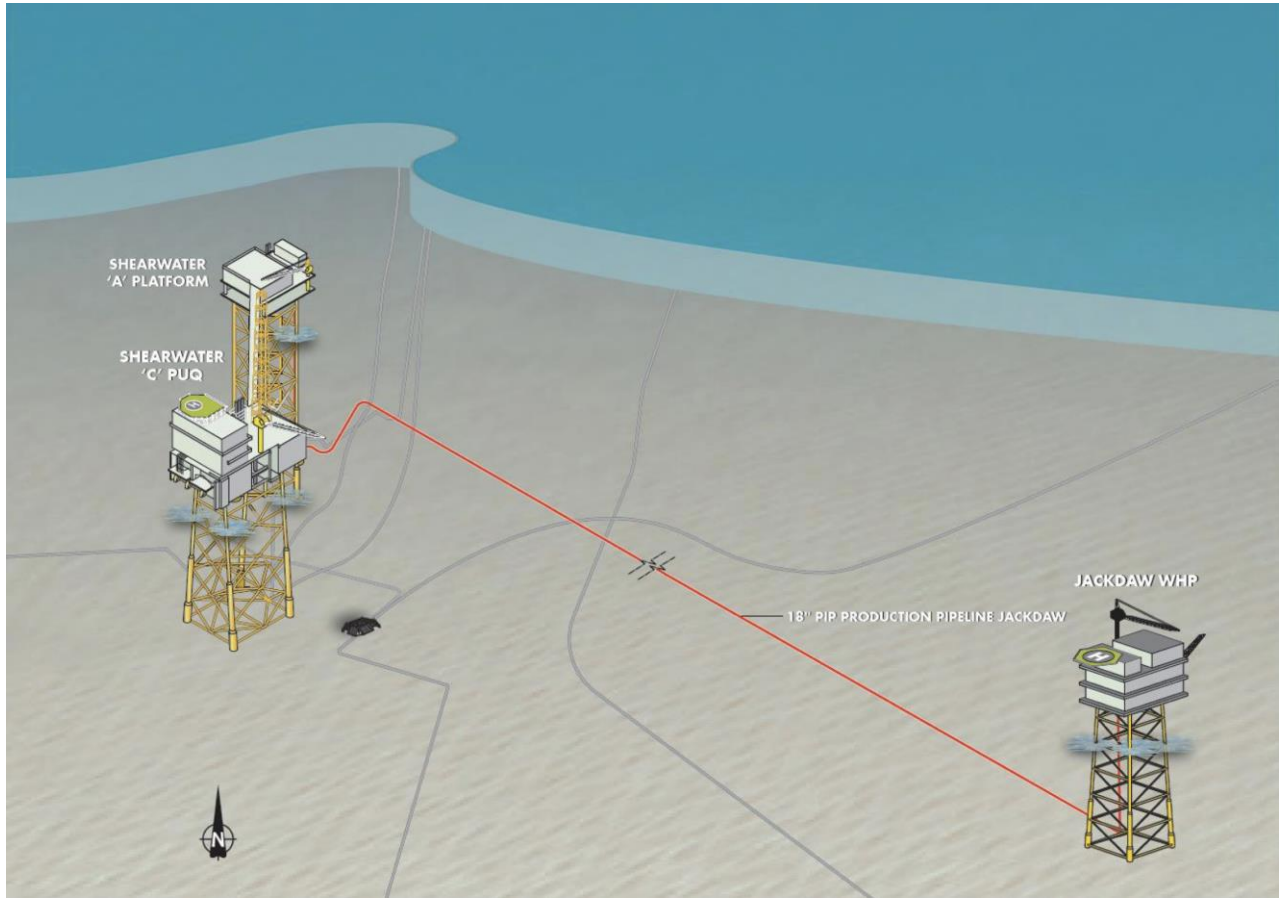
- Current 2P reserves only enough to sustain production to 2030
- 2020 production: 570 Mmboe
- 2020 reserves additions: 270 Mmboe
- Reserves replacement ratio of -33%
- Significant contingent resources (6.8 billion boe), much of it in mature developed areas
- 70/30% oil/gas
- Prospective resource estimates imply scope for further exploration.

Jackdaw Field Development



- First production expected between Q3 - Q4 2025
- Expected to deliver 6.5% of UKCS gas production for less than 1% of UKCS emissions
- Produce an amount of energy equivalent to heating over 1.4 million UK homes (75 Mmboe)
- Potential to form part of CNS electrification and Acorn CCUS projects

Jackdaw Development Concept



- Installation of a new Well Head Platform (WHP)
- Drilling of four production wells
- Installation of a new c. 31 km pipeline from the Jackdaw WHP to the Shearwater platform
- Processing and export of the Jackdaw hydrocarbons via the Shearwater host platform

Is further exploration and development of fossil fuels necessary or desirable?

- Fossil fuels will complement renewable energy for some time to come, still comprising a small part of the UK's energy mix even in 2050.
- It is doubtful whether shale gas could ever make a material contribution, even without societal objections.
- Current UK continental shelf reserves are declining and without development of discovered reserves (like Jackdaw), domestic production will contribute less and less, so more gas will need to be imported.
- Scope exists for further exploration to lessen the decline.
- If combined with Carbon Capture and Storage, finding and exploiting these additional reserves could still be valuably achieved without compromising the UK's COP commitments.
- More radical reform of the UK energy market is required to ensure that well-run energy producers are profitable and want to continue investing in the energy transition whilst reducing the impact of the energy crisis.

Reforming the UK Energy Market

WRITE TO LETTERS@THETIMES.CO.UK | Wednesday August 31 2022, 9.00pm BST, The Times

Sir, Today the energy market in our country is broken because our electricity is tied to global gas prices, even though imported gas makes up less than 20 per cent of our electricity generation. This energy crisis will be disastrous for consumers and businesses. The help being proposed is merely a short-term fix that falls far short of the country's actual needs; targeting handouts after the fact is far less effective than reducing energy prices at source in the first place. A more radical approach is needed to reform the way our energy markets work: reform that would show that new leadership was capable of taking the tough decisions.

We should immediately cap domestic electricity wholesale prices for non-gas generators (mainly, nuclear, wind and solar) and cap domestically produced gas prices too. These caps could be set at levels that reflect the investment risk and ensure that well-run energy producers are profitable and want to continue investing in the energy transition. We need security of supply as well as a move away from fossil fuels.

These caps would materially reduce the impact of the energy crisis and significantly reduce the compounding effect that energy costs have on inflation. The European gas market has been dominated by Russia for decades. Moscow's actions are now directly setting the astronomic prices of both gas and electricity, with truly disastrous economic and social consequences. This is likely to remain so throughout this decade unless we truly "take back control", not from Brussels but from Moscow.

Mark Carne, former CEO, Network Rail; **Malcolm Brinded**, former president, Energy Institute; **Sir Frank Chapman**, former CEO, BG Group; **Steve Holliday**, former CEO, National Grid; **Sir Mark Moody-Stuart**, former chairman, Royal Dutch Shell