The Shale Gas Endgame?

A Review of the United Kingdom's Short-Lived Revival of Shale Gas Exploration, 2021-2022

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UKUH Unconventional Hydrocarbons in the UK Energy System

UKSGL Shale Gas Landscape

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Introduction

In November 2019, after a series of earthquakes at Cuadrilla's well pad in Lancashire culminated in a 2.9 magnitude event, the Johnson administration imposed a moratorium on hydraulic fracturing (or 'fracking', as it is more commonly known). In its written ministerial statement to Parliament, the government was clear that this was *not* a ban, but a stay of consent until such time that scientific evidence emerged that induced earthquakes could be reliably forecast and controlled.

Yet, at the time, it was widely seen as a death knell for the shale industry in the United Kingdom (UK). For one thing, it did not seem likely that any new evidence would emerge that 'unacceptable levels' of seismicity could be prevented. Indeed, Kwasi Kwarteng, the Minister for the Department of Business, Energy and Industrial Strategy (BEIS)[1] – the principal department responsible for the regulation of shale development – said in 2020 that the government "will not support fracking unless the science shows categorically that it can be done safely and without inconvenience. As I have said, this is extremely unlikely to happen".[2]

Perhaps more importantly, the moratorium also came eight years into the industry, a period of time marked by a great deal of noise, but little by way of achievement. There is 12,700km^2 of land held under onshore petroleum licences in the UK, and the three largest shale companies – INEOS, IGas and Cuadrilla – each hold more than 2,000 square kilometres.[3] What has been accomplished across this vast tract of territory? A grand total of 8 wells have been drilled prospecting for shale gas,[4] and only three wells have even been *partially* hydraulically fractured. In fact, following the abandonment of Cuadrilla's sites at Preese Hall, Grange Hill, Becconsall and Anna's Road in 2013, only 4 wells have been drilled, and one well partially fractured – and that was the Cuadrilla site at Preston New Road (PNR) whose earthquakes led to the moratorium.

By way of comparison, the U.S. Environmental Protection Agency has estimated that between 2000 and 2014, a third of a million wells were hydraulically fractured in the country.[5] That equates to ~22,000 wells fracked a year. If we assume that this occurred at a constant rate, then the United States hydraulically fractured roughly the same number of wells as the UK did (partially) in 8 years, every hour, for 15 years non-stop.

1 On 7th February 2023, BEIS was disaggregated into three separate departments: the Department for Energy Security and Net Zero, the Department for Science, Innovation and Technology and the Department for Business and Trade. We stay with BEIS in our analysis, as this was the structure in place through 2021-22.

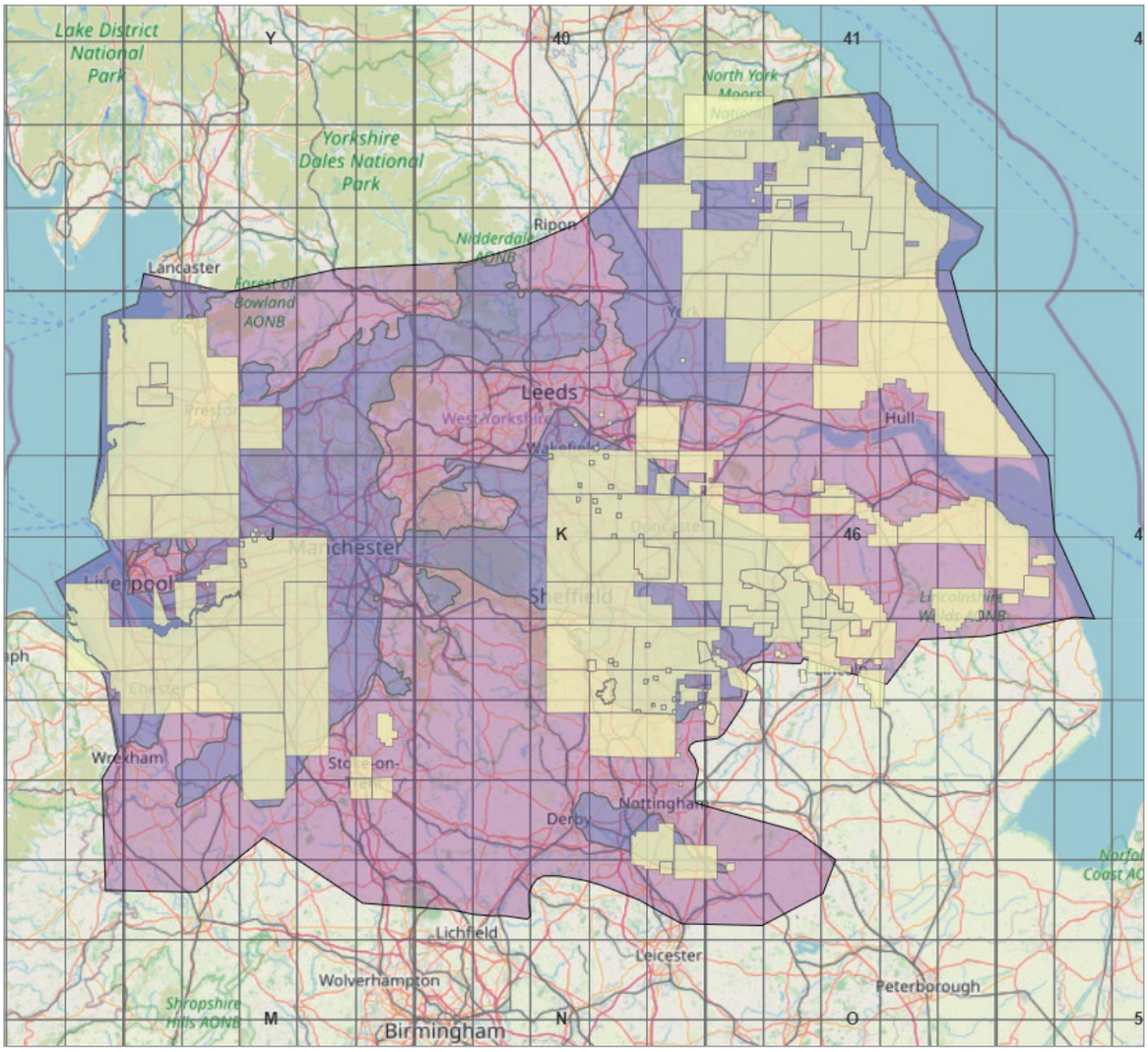
2 HC Deb, September 28th 2020, Vol. 681, Col. 128-134.

3 Our analysis of North Sea Transition Authority licence data.

4 This figure was reached by cross-referencing the North Sea Transition Authority's data on wellbores and shale licence blocks, though given that a single well can target multiple formations, it involves some judgement.

5 EPA (2016) *Hydraulic Fracturing for Oil and Gas: Executive Summary*, p.4.

Figure 1: Onshore petroleum licence blocks covering the Bowland Shale



Note: North Sea Transition Authority (NSTA) onshore interactive map.
Purple shows the shale prospect across the Bowland, yellow existing licence blocks.

Why then, despite all this, did shale gas return to the political agenda in late 2022, only to sink into prohibition again within the span of a month? In this report, we suggest that that shale development could only be revived on terms that *almost fated it to failure*. But in order to grasp this story, we need to stand back. Although it took the Truss administration to lift the moratorium in September 2022, the debate was reignited a whole year beforehand, at the outset of the energy price crisis, as the global economy began to emerge from the shutdown of the pandemic. Our narrative thus runs through 2021-2022 and stands as a punctual account of this well delineated political episode.

What was fundamentally at stake in this political struggle can be easily summarised – should the moratorium on hydraulic fracturing be continued or lifted? The moratorium continued for the entire period up to September 2022, at which time it was lifted for all of a month, too short a time to lead even to planning applications for drilling, or any local reaction to industry movements. For the simple reason that it never got any further, then, the debate over this question largely revolved around the House of Commons

Our argument in Part 1 of the report takes the form of a narrative history, anchored around an analysis of the consolidation of the idea that shale development ought only to take place upon meeting three tests: on emissions, on seismicity, and on local consent.[6] These tests emerged from the interaction of regulatory developments, political constraints and pressures, and parliamentary debate. We build this narrative with the help of a quantitative skeleton, a coding of every shale gas argument – pro and contra – in the House of Commons between 2016 and 2022. This allows us to map in numerical form where the key turning points were in the parliamentary debate.

To pre-empt our argument, in capsule, the three tests to development run as follows.

Climate test - The UK incorporated net zero into law in June 2019 and, by the time that the shale debate resurfaced in 2021, this had filtered through to the latest advice of the Climate Change Committee (CCC) and Oil and Gas Authority (OGA).[7] The OGA trailed the introduction of a 'climate compatibility checkpoint' for the development of new offshore fields. The CCC refocused the question of shale development upon its effects on *global* aggregate emissions, overriding the territorial logic of the UK's net zero legislation, and concluded that an independent review into the shale industry's 'climate impact' should precede any decision on whether or not to support exploration. Together, this helped formalise the expectation that the development of new petroleum fields should only take place where it passes a review adjudging its compatibility with net zero. It was also in 2019 that climate change moved to the foreground of parliamentary debate about shale gas, a prominence from which it never then retreated. A new bipartisan consensus emerged on 'greening' the country.

Seismicity test - Surprisingly, induced seismicity did not much animate MPs until *after* the imposition of the moratorium. Even after the spate of earthquakes culminating in a 2.9 local magnitude (ML) event at Preston New Road in August 2019, just one argument in the House of Commons cited seismicity in the lead up to the moratorium. But precisely because the government itself made the prohibition of shale development contingent on the emergence of evidence that induced seismicity could be effectively forecast and controlled, this suddenly became central to the terms of the shale debate. Both the government – as we saw in Kwasi Kwarteng's statement quoted above – and opponents of shale development clung to this standard. 'Local disturbance', and *not* material damage, had been ingrained as the standard of acceptable seismicity upon the introduction of the traffic light system in the wake of the quakes at Preese Hall in 2011. In the light of popular apprehension as to the safety of hydraulic fracturing, and the robustness of its regulation, it proved politically untenable to revise this standard. Thus, a test to development was consolidated – the effective forecast of seismicity liable to disturb local residents – that it was not at all clear the industry could ever pass.

Social test - Even before the ballot among Conservative MPs had winnowed the party's candidates to succeed Boris Johnson down to two, in order that they could be put to the membership, Liz Truss had voiced her support for shale development. But from the first moment she attached a qualification to this support: she would support shale extraction *only* where it met local consent. In both respects, political considerations were paramount. Her support for the shale industry was a transparent bid for support from the party's new caucus of net zero sceptics. But the Conservative Party had ridden to a landslide victory in 2019 on a crest of support across the 'red wall' in the north of England. A sizable share of Conservative MPs now sat on constituencies stretching across the Bowland shale play, where opposition to 'fracking' was often palpably felt. Supporting shale development where it met local consent was an attempt to square this political circle, but it made Liz Truss dangerously exposed to the reality that shale gas extraction was *not* widely popular.

But if these tests piled up, and ultimately buried shale development, how did it re-emerge into the light of day in the first place? It is for this reason that, in our chronological narrative, while the first section of this report corresponds to the climate test, the third to the seismicity test, and the fourth to the social test, the second section of the report breaks from this mould. It is there that we trace how a *reaction* to net zero, given momentum by the energy price crisis, led to successive campaigns to lift the moratorium. Midway through, in January 2022, it coalesced around the 'Net Zero Scrutiny Group', a cluster in the Conservative Party modelled on the European Research Group. It brought the political repertoire seen in the Brexit campaign to bear on shale gas, centring net zero in a mirror-image of the role climate had come to play in the anti-fracking cause.

6 On the relationship between history and narrative, Hayden White remains authoritative. See White, H. (1984) 'The Question of Narrative in Contemporary Historical Theory', History and Theory, 23(1), pp.1-33.

7 The Oil and Gas Authority was renamed the North Sea Transition Authority (NSTA) in March 2022.

Events then broke in their favour. The leadership of Boris Johnson was weakened by scandal and desperate to court support from the backbenches, and Russia's invasion of Ukraine gave new force to those suing for energy independence. Johnson soon set in motion a 'review' of the moratorium on hydraulic fracturing.

In Part 2 of the report, we reflect on whether the demise of the shale industry is final. Could it repeat its improbable comeback in 2022? We think not, and comprehensively set out the political and economic reasons why. Its problems begin in the nation's several parliaments. It is proscribed in Scotland and Wales, and the Labour, SNP and Liberal Democrats all support an outright ban in Westminster. Shale gas' only redoubt is the Conservative Party. But opposition across the Bowland means that a caucus of its own MPs – stretched across the electorally vulnerable 'red wall' – are also fiercely resistant to shale development. Liz Truss' revivalism led to raucous party infighting, and it was a bill to ban hydraulic fracturing that ultimately precipitated her resignation. Rishi Sunak, like Boris Johnson before him, saw the political expedience of imposing a moratorium. Even here then, in the Conservative Party, the future of shale gas is perilous at best.

But, even if shale gas exploration in England surmounted this parliamentary hurdle, it would find itself in no better a position that it did before the 2019 moratorium. Indeed, it would be in a worse position. The industry's petroleum licences are expiring, it has no planning permissions in place to drill, the UK's carbon budget is shrinking, and the whole industry would have been in deepfreeze for years. It would still face three, consolidated barriers to development: on seismic hazard, on emissions, and on local consent. It would also have to prove its commercial viability. After more than a decade, the industry still has yet to complete the basic exploratory drilling on the strength of the results of which estimates of production could be gauged. The means at the centre of the industry stands an enormous question mark, *even now.* These compounding uncertainties mean that the industry faces a prohibitive cost of capital and has been unable to stitch together a coherent industrial strategy to bring down costs.

In short, shale development faces three major barriers: parliamentary support, political legitimacy, in the form of the three tests, and economic viability. We believe that, taken together, they pose an insuperable barrier to the UK shale industry succeeding at any significant scale. The industry is, for all intents and purposes, dead.

Before we proceed with the narrative, a few methodological words are necessary on our survey of the shale gas debate in the House of Commons. The most common register in the now considerable literature on shale development in the UK has been discourse analysis. Scholars have looked at how shale gas and 'fracking' is interpreted and represented across a wide range of domains, from broadsheet newspapers[8], to parliamentary committee inquiries[9], to local planning regulations[10], to social media[11], to local focus groups[12], to the whole cross-section of actors on both sides of the shale debate.[13]

But, most relevant for our purposes, is the work of Laurence Williams, Benjamin Sovacool and Abigail Martin, as part of Theme 5 of the Unconventional Hydrocarbons in the UK Energy System (UKUH) programme.[14] Together, they have written both a lean overview of the official parliamentary debate over shale development from 2009 to 2019, and a comprehensive assessment of the way shale development was framed in parliamentary discourse from 2010 through to 2018. In a sense, this report can be thought of as a chronological extension of both strands of work. But there are important differences, too.

Unlike much of this literature, our aim is not to understand the broad-based social construction of shale gas through an analysis of how it has been 'framed'. Rather, we trace the balance of opinion in the House of Commons *for the specific purpose* of understanding the unfolding political struggle over shale gas exploration. For this same reason, the unit of our quantitative analysis is not 'frames' but arguments –

8 Mattfeldt, A. (2022) 'Risk in discourses around fracking: a discourse linguistic perspective on the UK, the USA and Germany', *Journal of Risk Research*, 25(3), pp.317-330.

9 Nyberg, D. and Wright, C. and Kirk, K. (2018) 'Fracking the future: the temporal portability of frames in political contests', *Organization Studies*, 41(2), pp.175-196.

10 Hilson, C. (2015) 'Framing fracking: Which frames are heard in English planning and environmental policy and practice', *Journal of Environmental Law*, 27(2), pp.177-202.

11 Jaspal, R. and Turner, A. and Nerlich, B. (2014), 'Fracking on YouTube: Exploring risks, benefits and human values', *Environmental Values*, 23(5), pp.501-527.

12 Williams, L. and Macnaghten, P. and Davies, R. and Curtis, S. (2017) 'Framing 'fracking': Exploring public perceptions of hydraulic fracturing in the United Kingdom', *Public Understanding of Science*, 26(1), pp.89-104.

13 Bomberg, E. (2017) 'Shall we drill? Discourse dynamics in UK fracking debates', *Journal of Environmental Policy & Planning*, 19(1), pp.72-88.

14 Williams, L. and Martin, A. and Sovacool, B. (July 2020) *A brief history of the UK's political debate over shale gas, 2009-2019*, UKUH Briefing; Williams, L. & Sovacool, B. (2019) 'The discursive politics of 'fracking': Frames, storylines, and the anticipatory contestation of shale gas development in the United Kingdom', *Global Environmental Change*, 58, 101935.

reasoned claims for or against shale gas exploration – and we use this only as a skeleton on which to build a wider interpretive account of the 2021-2022 saga. We do not treat discourse as a delimited plane of analysis but interleave it with the wider political dynamic of which it is a part.

Timeline of key events

- **2020/2:** AJ Lucas increases its stake in Cuadrilla to 93%
- **2020/7:** Spirit Energy exits from its interest in Cuadrilla's Bowland exploration
- **2020/12:** The OGA publishes its PNR seismicity study, concluding that "it is not yet possible to accurately predict the seismic response to hydraulic fracturing"
- **2021/3:** BEIS publishes the North Sea Transition Deal
- **2021/5**: Labour proposes an amendment to the Environment Bill to ban 'fracking'
- **2021/7:** IGas' application refused at its "world-class" Misson Springs site
- **2021/9:** After wholesale gas prices reach 3x April prices, the first campaign to lift the moratorium on shale development begins across the right-wing press
- **2021/12:** Shell pulls out of its stake in the Cambo oil field, pausing the project
- **2022/1:** Launch of the Net Zero Scrutiny Group (NZSG)
- **2022/2/9:** The OGA orders Cuadrilla to plug and abandon its PNR site
- **2022/2/9:** Cuadrilla publishes a press release with the NZSG
- **2022/2/12:** The NZSG sends a letter signed by 29 Conservative MPs to the PM, calling for a reversal of the OGA decision, and for a lifting of the moratorium
- **2022/2/24:** Russia invades Ukraine
- **2022/2/28:** Kwasi Kwarteng writes that UK shale will make no material difference to wholesale prices, and suggests that the UK "move away from gas"
- **2022/3/5:** The NZSG sends a letter from 40 MPs calling for the MP to reverse the OGA decision on PNR, and for the lifting of the moratorium
- **2022/3/5:** Nigel Farage launches his 'Vote Power not Poverty' campaign
- **2022/3/8:** The UK government announces plans to phaseout Russian oil imports
- **2022/3/9:** Kwasi Kwarteng says in the Commons that "in conversation with the Prime Minister, we were clear that it did not necessarily make any sense to concrete over the wells" at PNR
- **2022/3/9:** A Downing Street spokesman, when asked about shale gas, says that "everyone would expect the prime Minister to look at all our options".
- **2022/3/31:** The OGA withdraws notice to Cuadrilla to plug and abandon PNR site
- **2022/4/5:** Ahead of the Energy Security Strategy, the government commissions the British Geological Survey (BGS) to report on any scientific advances in forecasting induced seismicity
- **2022/4/10:** INEOS challenges the government to let it drill a test well
- **2022/6:** Spirit Energy re-enters into agreement with Cuadrilla
- **2022/6:** Government secretary (Michael Gove) finally refuses IGas' application at Ellesmere Port and INEOS' application at Woodsetts
- **2022/7/6:** The BGS submits its scientific report to the government
- **2022/7/7:** Boris Johnson resigns as Prime Minister
- **2022/7/27:** Liz Truss and Rishi Sunak voice support for shale development with 'local support'
- **2022/8/25:** Liz Truss writes an op-ed announcing her intention to lift the moratorium
- **2022/9/5:** The NZSG writes to the *Telegraph* calling for the lifting of the moratorium
- **2022/9/6:** Liz Truss' premiership begins
- **2022/9/8:** In her first address to Parliament, Liz Truss declares that "We will end the moratorium on extracting our huge reserves of shale, which could get gas flowing as soon as six months from now where there is local support for it"
- **2022/9/22:** The BGS report is published
- **2022/9/22:** Jacob Rees-Mogg's ministerial statement lifting the moratorium

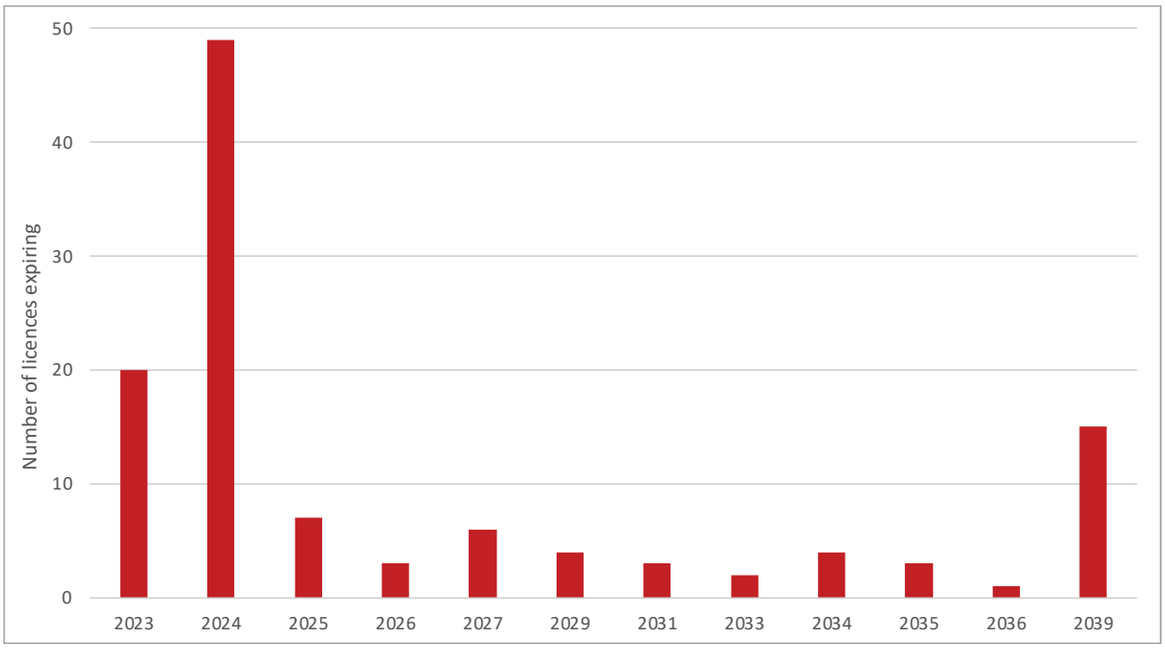
- **2022/9/23:** Kwasi Kwarteng sets out a 'mini-budget' announcing £45bn in tax cuts, precipitating weeks of market turmoil
- **2022/9/29:** AJ Lucas issues shares worth $19.7m to fund Cuadrilla
- **2022/10/19:** Labour table a bill to ban 'fracking'. Jacob Rees-Mogg concedes that any 'consultation mechanism' will have to be put to the Commons
- **2022/10/20:** Liz Truss' premiership ends
- **2022/10/26:** Rishi Sunak says he will reimpose the moratorium
- **2022/10/27:** Grant Shapps makes a statement confirming the reimposition of the moratorium

The state of the shale gas industry entering 2021-2022

The shale industry entered into 2021-2022 in a weak condition. Three data points give expression to this atrophy: petroleum licences over shale plays, the financial health of leading shale companies, and planning permissions for exploratory drilling.

First, analysing data from the NSTA, we find that there are currently 117 active onshore petroleum licences covering English shale plays. Of the total 12,700km^2 of licenced territory, 87% falls in the Bowland shale basin stretching up from Derbyshire in the south, to York and Lancashire in the north. Significantly, some 53 of these licences were allocated in 2016 in the 14th onshore licensing round. Under UK regulations, new licences are effectively provisional: their first term lasts for 6 years, at which point the company either shows proof of agreed activity, or surrenders the licence.[15] But, in light of the moratorium in 2019, the government was forced to roll-over the initial term of these 53 licences to 2023-2024. This means a sizable fraction of licences are effectively *up in the air* and, absent new activity, are liable to expire in the coming years.

Figure 2: Active onshore shale licences: When do their current terms expire?



Note: Data sourced from the NSTA

Second, a good index of the *financial* straits of the industry is the fate of its most prominent company, Cuadrilla. In the months before the moratorium was even imposed, Cuadrilla's major investors – Riverstone and AJ Lucas (held by Kerogen Capital) – were reportedly looking to cash out.[16] In the end, in February 2020,

15 For an overview, see Oil and Gas Authority (September 7th 2015) *Oil and Gas: Petroleum Licensing Guidance.*

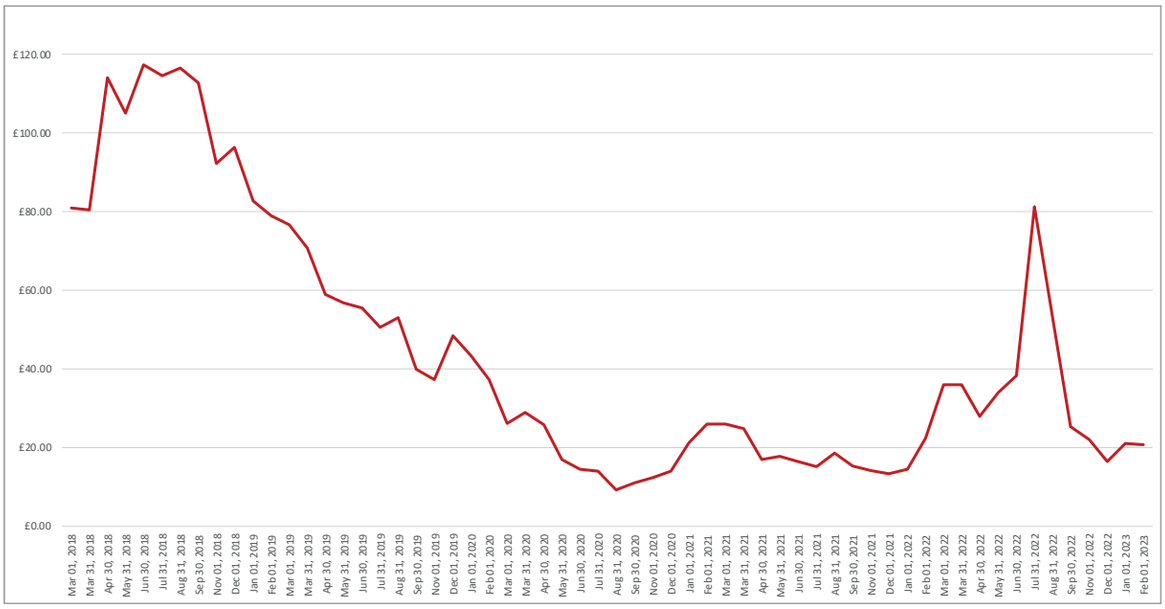
16 Gilblom, K. and Nair, D. (September 6th 2019) '*Cuadrilla Owners Said to Mull Options Including Sale of Company*', Bloomberg.

Riverstone sold its 45% stake to AJ Lucas for a nominal same-day payment, and the promise of a fraction of future revenues in the succeeding three years *if* their shale assets turned good.[17] This was spelt out in two ways.

On the one hand, if within three years, AJ Lucas sold 25% or more of its stake in UK shale assets for a sum which gave its *full* stake (the equity share at the time of signing) a valuation of over US$100m, then Riverstone would receive US$5 million. On the other hand, if Spirit Energy, a subsidiary of Centrica, fulfilled their next carry payment to Cuadrilla of £46.7m in the next three years, Riverstone would receive a US$2m share. Although Cuadrilla's full contract with Spirit Energy is undisclosed, it seems that this carry payment was conditional on Cuadrilla entering into a development phase.

To put this in context, Cuadrilla's 2018 annual report put the company's total equity value at £47.5m.[18] Selling a 45% stake in the company for a nominal amount, and the unlikely prospect of a later payment of $2-5m, shows a precipitous devaluation in the space of two years. IGas, one of the other two major onshore licence holders, saw a similar market swing. At the start of 2019 its shares traded for ~£95, but by the end of 2021 its share price was just ~£14 (see Figure 3).

Figure 3: IGas 5-year share price chart



Note: Share price data sourced from Yahoo Finance.

With Riverstone's exit, Cuadrilla effectively became a subsidiary of AJ Lucas, itself held by Kerogen Capital. Cuadrilla's board of directors now consists of its CEO, Francis Egin, Andrew Purcell of AJ Lucas, and Julian Ball of Kerogen. This is especially significant because Kerogen is the largest external shareholder in one of the two other major licence holders, IGas, in which it has a 27% stake.[19] In other words, the industry shrank to the point at which a single private equity fund, Kerogen, indirectly owns a large fraction of licensed shale acreage (around a quarter of the Bowland shale).
In another significant blow, in July 2020, Spirit Energy voided its carry agreement with Cuadrilla – including the conditional promise of £46.7m to fund the development phase of extraction – by exiting its 25% stake in Cuadrilla's Bowland exploration.[20]

Third, it is instructive to place the fate of the industry's planning applications alongside its precarious licensing, and financial straits. From 2020 onwards, it was only bad news.[21]

17 AJ Lucas (February 5th 2020) *AJ Lucas to Acquire Riverstone's Interest in Cuadrilla Resources.*

18 Cuadrilla (2018) *Annual Report & Accounts 2018*, p.19.

19 See IGas' listing of major shareholders.

20 AJ Lucas (July 3rd 2020) *Bowland Joint Venture Update.*

21 The bulk of this information was gleaned from the excellent website, *Drill or Drop*. Note that Egdon received permission to carry out a proppant squeeze at Wressle in January 2020, which is sometimes considered a small scale frack, though it does not meet the legal definition of 'hydraulic fracturing' underlying the moratorium.

- Aurora withdrew its planning application for shale exploration at Altcar Moss (PEDL164) in July 2020.
- Cuadrilla surrendered its environmental permits for PNR (PEDL165) in 2020.
- IGas' planning application at Springs Road (PEDL139) – which it had canvased as a "world-class" asset, and a key part of the company's value – was rejected in July 2021, and IGas declined to appeal.
- INEOS' planning permission at Marshal Lane (PEDL300) lapsed in August 2021.
- Finally, two appeals that were recovered by the government's Levelling Up Secretary in 2019 – IGas at Ellesmere Port (PEDL184) and INEOS at Woodsetts (PEDL304) – were refused in June 2022.

Nottingham Council Council's explanation for rejecting IGas' planning application at Springs Road is suggestive of what stood behind this uniform refusal.[22] "Given the ongoing uncertainty surrounding the Government's moratorium on hydraulic fracturing originally enacted in 2019, the proposal would lead to the retention of the site and its associated boreholes in their present condition until November 2023 which is considered to be an unacceptable length of time, continuing to adversely impact the amenity of the local community and the sensitive local environment". Councillors were reluctant to countenance extending the prospect at Springs Road when, on the one hand, it was a cause of great anxiety and uncertainty to some residents, and on the other hand, it was far from clear that shale gas exploration could ever be legally pursued.

By the end of this saga, *no* site in the country had planning permission to drill shale gas wells. Given that the planning process often took years to reach a decision, embroiled companies in polarising local debates, and more often than not resulted in a negative verdict, this was an enormous roadblock to future development.

Part 1: Shale gas' aborted revival

Early 2021: Leave it in the ground

The start of 2021 was marked by two reports from UK regulatory bodies on the climate credibility of new domestic petroleum extraction, and an amendment submitted by Labour to ban hydraulic fracturing outright, a case which they rested by and large on its incongruence with the 'climate emergency'. We argue that, together, this amounted to the emergence of the expectation that shale gas development required a *climate licence*. Should the pivotal role of climate in this episode surprise us?

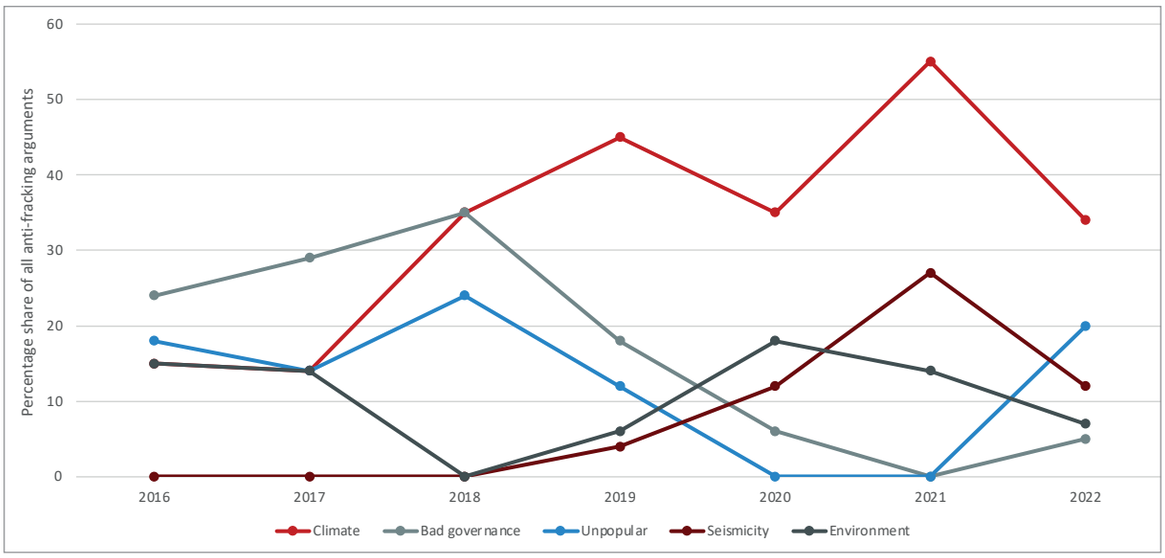
Our most comprehensive assessment of the 'frames' that enclosed the parliamentary debate about shale gas extraction suggests so. Sovacool and Williams conducted 30 original interviews and reviewed 1557 documents, largely parliamentary testimony, and found that four frames dominated the anti-fracking case in the official record: aesthetic spoilation of the landscape; giving short thrift to local democracy; locking in fossil fuel production; and the poor regulation of an industry threatening the local environment and public health.[23] Sovacool and Williams found that, roughly, these frames were equally important, and that they waxed and waned together. But, for our purposes, there is a crucial caveat. Their study covers the period August 2010 through to November 2018. It omits the all-important year leading up to the moratorium.

In order to fill this gap and determine whether climate change's conspicuous role over the last two years was novel, we analysed every use of the terms 'fracking' and 'shale gas' in the House of Commons from 2016 to 2022, recording the frequency of popular anti-shale gas arguments. We find, to an extent that has been unappreciated, that climate change *dominated* the debate in the year leading up to the introduction of the moratorium in November 2019.

22 Nottinghamshire County Council (August 3rd 2021) *IGas: Notice of Planning Decision*.

23 Williams, L. & Sovacool, B. (2019) 'The discursive politics of 'fracking': Frames, storylines, and the anticipatory contestation of shale gas development in the United Kingdom', *Global Environmental Change*, 58, 101935.

Figure 4: *Key anti-fracking arguments in the Commons, 2016-2022*



It is worth breaking these results down in some detail (see Figure 4). From the start of 2016 up until the moratorium, we found that three arguments – that shale gas lacks public support (unpopular), that it is badly regulated (bad governance), and that it is high-carbon (emissions) – made up 74% of *all* anti-fracking arguments in the House of Commons. But their use was far from equal across the period.

Over the period 2016 through 2017, the *bad governance* argument made up 25% of all anti-shale arguments, followed by arguments opposing 'fracking' because it was locally or nationally *unpopular*. By 2019, however, climate made up 42% of all anti-shale arguments, while the bad governance and unpopular arguments trailed at 17% and 11% respectively. This is especially significant because the parliamentary debate mushroomed in 2019. We identified more anti-shale arguments in that one year than in 2016, 2017 and 2018 combined – it was, clearly, a pivotal year. It is also worth noting that, while induced seismicity began to find mention in 2019, it never moved to the heart of debate in the Commons. This was true even following the 2.9 ML seismic event at Preston New Road in August.

The movement of climate change to the centre of the parliamentary debate on shale exploration from 2019 is easily explained. It dovetails with the soaring salience of climate change in general over the period. Late 2018 saw the first Extinction Rebellion protests, followed in early 2019 by global school strikes for the climate. Images of extreme weather events were widely circulated as spectres of the dawning climate crisis – epitomised by the surreal images to emerge from the 2019-2020 bushfire season in Australia. It was also a turning point for net zero targets.[24] In 2018, only 20 countries had, in some way, committed to net zero.[25] In 2019 that more than doubled, soaring past 50. Similarly, the Science-Based Targets initiative reported a doubling in the number of companies with approved net zero targets in 2019.[26] At the end of the year, Oxford University Press announced that the use of the phrase 'net zero' had multiplied tenfold in 2019, and 'climate emergency' a hundredfold.[27]

In June 2019, the UK brought net zero into law, amending the 2008 Climate Change Act to increase the government's commitment from an 80% fall in emissions to 100%. It was this which, in 2019, gave impetus to the idea that an entirely new petroleum industry might not be compatible with the UK's climate commitments, and which led to a raft of parliamentary business in which this tension played out. In turn, the Labour and Conservative parties vied to seize this emerging political territory. Labour's 2019 election manifesto hinged on a programme for a 'green industrial revolution'.[28] In November 2020 the Johnson

24 Net zero targets have been plagued by a lack of implementation and, in no few cases, incoherence. But the very fact of their adoption evidences the climbing salience of climate change.

25 Coppenolle, H. and Blondeel, M. and Graaf, T. (2022) 'Reframing the Climate Debate: The Origins and Diffusion of Net Zero Pledges', *Global Policy* [online pre-publication].

26 Science Based Targets Initiative (January 2021) *From Ambition to Impact: How Companies are Reducing Emissions at Scale with Science-Based Targets*, p.11.

27 Oxford Languages (2019) *Oxford Word of the Year 2019*.

28 Labour Party (2019) *It's Time for Real Change*, pp.9-25.

administration published its own 'ten-point plan for a green industrial revolution', followed in 2021 by *Net Zero Strategy: Build Back Better.*[29] At the same time, net zero began to feed through the UK's regulatory bodies – bringing us full circle to the two reports published in early 2021 with which we began.

In March 2021, the CCC updated its 2016 advice on onshore petroleum extraction, in fulfilment of its statutory obligation under the Infrastructure Act to provide this advice every five years.[30] In 2016, it had effectively given the generic advice that any shale gas production and consumption would have to fit within the UK's carbon budget.[31] In its 2021 update, it added two key things.

First of all, given that net zero had been brought into UK law during the intervening period, redefining the CCC's mandate, the carbon budget within which to accommodate shale gas was significantly tighter. Further, given that even within this budget, petroleum production on the UK continental shelf is projected to lag behind consumption, the fundamental question is the relative emissions of the two possible sources that could supplement it: domestic shale or imported liquid natural gas (LNG).[32] By way of an answer, the CCC notes two countervailing considerations. On the one hand, the lifecycle emissions of imported LNG could be higher than "strongly regulated" UK shale gas by 2-to-63 grams of CO2e per kWh of energy. On the other hand, the creation of a new UK shale industry would increase global aggregate gas production and consumption. Given that the net effect of this trade-off on emissions is highly uncertain, the committee concludes with one definitive recommendation. To wit, "the moratorium on UK shale production should not be lifted without an in-depth independent review of the evidence on the climate impact".

The committee's new stance was especially important because it looked beyond the letter of its mandate to its spirit. The UK's climate targets have always been indexed against territorial emissions. It therefore discounts the emissions generated in the production of imported fossil fuels, and the effect domestic fossil fuel production would have on the global energy system. In other words, if held to, it makes nonsense of any analysis of the climate impact of UK shale development. By asserting that the relevant standard for the evaluation of the climate credibility of onshore petroleum is its net effect on global emissions, the CCC established a vital precedent. It recentred the debate on what matters most – whether global emissions go up or down.

In the same month, BEIS published the 'North Sea Transition Deal'.[33] While it concerned offshore petroleum, it is indicative of the incorporation of climate change into the heart of fossil fuel governance in the UK *writ* large. It committed offshore production to a 50% fall in its *operational* emissions by 2030, as well as to new investments in electrification, CCUS and hydrogen capacity. Of greater significance is that it was accompanied by the announcement that the government would, in the future, introduce a 'climate compatibility checkpoint' for all new offshore petroleum licences. In doing so, it formalised the growing norm that new petroleum fields should only be tapped if it can clearly be shown to be compatible with the UK's climate commitments.

Just two months later, in May 2021, the International Energy Agency published its *Net Zero by 2050* report, a landmark analysis with enormous agenda-setting power across received institutions, from boardrooms, to academia, to policy-making.[34] It included the crucial finding that existing oil and gas reserves are sufficient to meet the declining curve of fossil fuel consumption in a net zero trajectory. This grounded the tectonic recommendation that "no new oil and gas fields" *whatsoever* should be developed.[35] In this context, a 'climate compatibility checkpoint' threatened to tip into an outright prohibition.

In that same month, this was put to the test. Siccar Point Energy applied to the OGA to develop production at the Cambo oil and gas field, a large prospect north of the Shetlands with estimated reserves of 800 million barrels of oil. Crucially, the field fell within an area already licenced to Siccar, meaning that it would not have to pass through any climate compatibility checkpoint. Nevertheless, the project met with wide

29 BEIS (October 2021) *Net Zero Strategy: Build Back Greener.*

30 CCC (31st March 2021) *Advice to the UK government on compatibility of onshore petroleum with UK carbon budgets.*

31 CCC (March 2016) *The compatibility of onshore petroleum with meeting the UK's carbon budget.*

32 See also Stamford, L. (June 2020) *Shale Gas and the UK's Low Carbon Transition*, UKUH Briefing. We return to this subject in Part 2 of the report.

33 BEIS (March 2021) *North Sea Transition Deal.*

34 IEA (May 2021) *Net Zero by 2050*

35 IEA (May 2021) *Net Zero by 2050*, p.21.

opposition on climate grounds, and became a bellwether for the future of petroleum production in the UK.[36] Significantly, both the government and the financial backers of the development were threatened with legal action, to the effect that tapping Cambo was incompatible with their net zero commitments.[37] By the end of the year, Shell pulled out of its 30% non-operator stake, forcing Siccar to 'pause' the development.

What the full arc of this series of events shows is that climate change moved to the centre of the debate on shale gas in 2019 and began to be formalised as a regulatory condition of development in 2021. That the UK introduced net zero into law shrank the carbon budget in which to accommodate a homegrown shale industry and raised the spectre of legal challenges to government support for the exploitation of new oil and gas fields. More generally, net zero was now both central to popular and political debate, and had become a subject of bipartisan consensus, with *both* Labour and Conservative governments touting programmes for a green industrial revolution. The centre-ground of debate on climate change, and thus fossil fuels, had shifted.

It is in this light that we can understand why, in May 2021, the Labour Party submitted an amendment to the Environment Bill proposing to ban hydraulic fracturing, and why the majority of interventions in favour of the amendment were staked on grounds of climate.[38] It was a strategic gambit to simultaneously capitalise on the popularity of climate action and unpopularity of hydraulic fracturing.

The debate also spoke to the atrophied condition of the shale industry. Curiously, the principal objection in the Commons debate to Clause 12, by Conservative MP Lee Rowley, was not a *positive* case in favour of 'fracking'. Rather, it was that the amendment was an unserious piece of political theatre, advancing a proposal that was unnecessary because the industry "is effectively already dead... Fracking is over. The battle is won. The industry has packed up. It is done. And I will not support an amendment that pretends otherwise". The other objection from the Conservative Party, advanced by the Under-Secretary of State for Environment, Food and Rural Affairs, was more guarded, saying simply that "on current evidence, fracking will not be taken forward in England", and that the opposition were therefore playing a "game".

September 2021 to March 2022: A pro-shale gas coalition emerges

By the Autumn of 2021, that certitude had begun to crack. Between April and September, wholesale gas prices at the National Balancing Point *tripled*, at which point there emerged the sudden, alarming realisation that the UK had been swept into a global energy crisis.

This led to the *first* campaign to lift the moratorium on shale development, one that largely played out across the right-wing press in September and October of 2021. Skyrocketing prices were portrayed as the inevitable result of a naïve environmental push by "eco-warriors" and "eco-bullies" to throttle domestic petroleum production, a delusory campaign that found its apogee in shale gas.[39] Anguished headlines ran, like 'Fracking could have saved us from this energy crisis', and 'We were fracking idiots to ignore the energy on our doorstep'.[40] Unflattering comparisons were drawn with the United States, whose shale gas industry had "insulated" the country from the price shock.[41] Tory MP Nigel Mills lamented that "we appear to have bet the whole farm on green energy, and overlooked whether it is affordable or offers a secure supply", while David Davis described the UK's climate policies as "over-hasty". Mark Littlewood, Director of the Institute of Economic Affairs, described the government's stance on shale gas as "craven caution", prioritising minor local disturbances and "over-blown environmental claims" over national energy security.[42]

By the start of 2022, a pro-shale gas coalition had begun to coalesce on these terms. It brought together

36 Reed, S. (5th November 2021) '*In Fate of Oil Field, Climate Activists and Energy Executives see Future*, *New York Times*.

37 Client Earth (13th September) *Letter: Your net-zero commitments and the Cambo oil field*; Ambrose, J. (23rd July 2021) '*UK faces legal action over North Sea oilfield explorations plans*', *Guardian*.

38 HC Debate, 26th May 2021, Vol. 696, Col. 375-482.

39 Ridley, M. (20th September 2021) '*Visions of an eco-apocalypse have been used to justify a headlong charge to carbon zero for years... but this current crisis is a mere harbinger of the candle-lit future that awaits us if we do not change course*', *Daily Mail*; The Spectator (25th September 2021) *How the Tories have fuelled Britain's energy crisis*.

40 Lyons, R. (23rd September 2021) '*Fracking could have saved us from this energy crisis*', *Spiked*; Littlewood, M. (24th September) '*We were fracking idiots to ignore the energy on our doorstep*', *Telegraph*.

41 Shapland, M. and Line, H. (8th October 2021) '*Britain should reconsider its ban on fracking and exploit North Sea oil to help end reliance on foreign energy imports, MPs urge*', *Daily Mail*.

42 Littlewood, M. (24th September) '*We were fracking idiots to ignore the energy on our doorstep*', *Telegraph*.

Conservative MPs, right-wing commentators, and the shale industry. Its central node was the 'Net Zero Scrutiny Group' (NZSG), a caucus of Conservative parliamentarians launched in January 2022. Modelled on the influential European Research Group (ERG), it offered a new lodestar to replace the – now played out – cause of Brexit. Its two chairs bridge the causes. Steve Baker was previously head of the ERG, and Craig Mackinlay was originally leader of the UK Independence Party. There are also indications that the NZSG tapped into the same funding ecology.[43] It was the NZSG that drove the campaign that would culminate in the lifting of the moratorium, and it is therefore worth pausing to reflect upon its starting coordinates. Three stand out.

First, the imposition of the moratorium upturned the argumentative landscape. Proponents of shale gas now found themselves cast into an oppositional role, one in which they faced an enormous rhetorical challenge. They could no longer just rely on a familiar list of the industry's putative benefits – for the economy, for security, as a bridge fuel. Rather, they also had to offer some *retrospective* account that explained the most conspicuous feature of shale development in the UK: its failure. Why had the government – a Tory government, no less – seen fit to proscribe hydraulic fracturing? The claim that *if* only the moratorium were lifted, we would witness a new, revolutionary industry across the north of England, was rather less plausible a decade into the shale debate. How was this scale of failure possible if shale gas held such promise?

Second, the answer had shades of 'populism'.[44] As a concept, populism has well-known difficulties. It is highly geographically and historically variable, it evolved as a pejorative foisted on others rather than a sincere self-description, and it does not describe any substantive first-order beliefs but spans the entire gamut of the political spectrum. But it is not derelict and can be conceived in a way that preserves its kernel of insight, while accommodating its many-headed challenges.[45] It is best understood as a flexible political tactic for articulating citizens into a 'people' in an age where parties are no longer embedded in society, no longer enjoy mass memberships rooted in stable categories of class, occupation, religion and status, and thus can no longer act as effective mediators between society and the state. Populism is therefore a tactic for appealing *over the heads of established parties* and directly to society with a schematic political logic: it constructs a 'people' defined negatively against an incumbent 'elite', and often enough, a nefarious 'minority' responsible for the corruption of public life. Thus conceived, it is an invaluable interpretive category, not a term of denigration.

It is in this light that we can understand the appeal of populism to many proponents of shale development. Its gloss runs as follows. Net zero was invented by well-to-do metropolitan elites – "green virtue-signalling" (Andrew Neil), "well-heeled" (Steve Baker), "dreamt up in the kitchen diners of Notting Hill" (Julian Knight)[46] – and injected into policy-making by the "green blob", an unelected coterie of journalists, civil servants, academics, and campaigners. In consequence, its winners are those same elites, and its losers are ordinary citizens, a cost transmitted via soaring taxes, and multiplying energy bills. In the words of Andrew Neil, the veteran broadcaster, "the posh folk are doing very nicely out of greenery and the plain folk are picking up the tab".[47] Or, as Craig Mackinlay put it: "it's fine for the super-rich to buy their Tesla, but that's not the case for the just-about-managing majority".[48] Playing out in the right-wing press, this populist narrative helped fuel a polarisation of debate, dragging shale gas – and fossil fuel development more generally – into a roiling 'culture war'. Indeed, a longitudinal UKUH survey over 2019-2022 found that, over the period, political beliefs and newspaper readership increasingly predicted attitudes on natural gas.[49]

But populism in the UK is inflected by its majoritarian electoral system, which forces populist currents to append themselves to the Labour and Conservative Parties – as witnessed with Corbyn and Momentum, and the Brexit wing of the Tory Party and UKIP. For this reason, the formation around the NZSG was

43 Geoghegan, P. (30th October 2021) '*The Brexit dark money lobby has a new target – climate change action*', *openDemocracy*.

44 Atkins, E. (2022) 'Bigger than Brexit: Exploring right-wing populism and net-zero policies in the United Kingdom', *Energy Research & Social Science*, 90, 102681.

45 See especially Jager, A. and Borriello, A. (2020) 'Making Sense of Populism', *Catalyst*, 3(4); Laclau, E. (2005) *On Populist Reason*. London: Verso, pp.117-123; Mair P. (2013) *Ruling the Void: The Hollowing of Western Democracy*. London: Verso.

46 Neil, A. (8th October 2021) '*Still keen on green now that your bill's arrived? Carbon zero is a glorious goal. But as our leaders use it to burnish their halos, the true cost is finally hitting home*', *Daily Mail*; The All-Party Parliamentary Group for Fair Fuel (August 2021) *What does the 2030 fossil fuelled new vehicle sales ban really mean to the economy, environment, and UK's 37m drivers?*, pp.3-4. This unofficial parliamentary group, chaired Craig Mackinlay, was an important predecessor to the NZSG.

47 Neil, A. (8th October 2021) 'Still keen on green now that your bill's arrived? Carbon zero is a glorious goal. But as our leaders use it to burnish their halos, the true cost is finally hitting home', *Daily Mail*

48 The All-Party Parliamentary Group for Fair Fuel (August 2021) *What does the 2030 fossil fuelled new vehicle sales ban really mean to the economy, environment, and UK's 37m drivers?*, p.7.

49 Evensen, D. *et al.* (2nd March 2023) *Growing importance of climate change beliefs for attitudes towards gas*, *Nature Climate Change*.

fundamentally Janus-faced. While it criticised the Conservative government for a lack of "gumption" in staring down the "green blob", it also saw Boris Johnson and the 'Vote Leave' contingent around him as fellow travellers, as latent populists that could be *won* over to their cause. After all, both the Johnson government and the NZSG emerged from the same side of the Brexit campaign. We see this play out clearly in an early, agenda-setting opinion piece in the pages of the *Telegraph* by Allister Heath.[50] He criticises how "a government of Brexiteers, in power only because they led a populist rebellion", can have any truck with a technocratic, top-down initiative like net zero. In the same breath, he calls for *Johnson* to seize the moment, "call a referendum on net zero", and establish himself as the face of "Vote Leave II".

This populist narrative also offered a convenient retrospective explanation for why the shale gas industry had stumbled through the past decade, falling finally into the ditch of the moratorium. This was not due to any inherent problem with hydraulic fracturing, so much as an extraneous imposition of the ideological agenda of net zero. What is more, this was tied together with the energy crisis in an elegant and powerful parable. Soaring prices would have been avoided had common sense prevailed, and shale gas development been supported rather than quashed, and was manifest vindication of the fact that net zero *did* come at the expense of ordinary bill and taxpayers. It was a historic comeuppance.

Third, at the time, Boris Johnson's support was teetering on the back of a series of personal scandals. Allegations that he flagrantly broke social distancing rules at Christmas parties, and financed renovations of his Downing Street flat with funds from a Tory donor, saw his popularity ratings slip. YouGov polls found that, whereas 89% of canvassed Tory party members thought Boris Johnson should be Prime Minister in July 2020, by January 2021 that figure had fallen to 59%.[51] The upshot was an empowered backbench, especially those like the NZSG who appealed over the head of the party, directly to the right-wing press and grassroots members.

It is significant that the *second* campaign to lift the moratorium began before the Russian invasion of Ukraine. It was not the war that was the catalyst, so much as a populist reaction against net zero in the context of an energy price crisis beginning September 2021.

The rallying cause of the second campaign was the OGA's order to Cuadrilla to plug and abandon its two wells at Preston New Road by March 15th. Cuadrilla released a press statement relating that it had been given this order on February 9th, which included long quotes not only from its CEO Francis Egan, but also from the two Chairs of the NZSG: Craig Mackinlay and Steve Baker.[52] On February 10th, Net Zero Watch, a campaign group with close links to the NZSG, published a short article announcing that it "had called on ministers to overrule the fracking regulator" on Preston New Road, complaining that "regulators across the energy industry have been ordered to help deliver Net Zero, with the consumer voice silenced".[53] On February 12th, the *Telegraph* reported that 29 Conservative MPs had called on the Prime Minister to lift the moratorium on hydraulic fracturing. David Frost, a peer and former Chief negotiator for Brexit under Boris Johnson, and Bob Blackman, the executive secretary of the 1922 committee, were included in their number.[54] Organised by the NZSG, the *Telegraph* reported news of the letter side-by-side with an opinion piece by Francis Egan, CEO of Cuadrilla.

It was this pre-made formation that was then consolidated by Russia's invasion of Ukraine on the 24th February. Just like Autumn 2021, reprisals rippled through the right-wing press. Annabel Denham, Director at the Institute of Economic Affairs, wrote in the *Spectator* that "we would not only be self-sufficient in energy but exporting it to the rest of Europe" had not the UK killed its own "fracking revolution".[55] Once more, fault was attributed to "net zero ideologies", as well as those gullible enough to swallow "Putin's anti-fracking propaganda". On March 3rd, it was reported that 40 MPs and peers had written to the Prime Minister to overturn the OGA's order to plug and abandon Cuadrilla's Preston New Road site.[56] On that same day, the *Daily Mail* published an op-ed by Nigel Farage launching what would become the 'Vote Power not

50 Heath, A. (20th October 2021) '*We need a referendum on net zero to save Britain from the green blob*', *Telegraph*.

51 Kirk, I. (January 10th 2022) '*Does Boris Johnson still have the support of Conservative party members?*', *YouGov*.

52 Cuadrilla (February 9th 2022) *Government orders "plugging and abandonment" of Britain's shale wells in midst of energy crisis.*

53 Net Zero Watch (February 10th 2022) *Government needs to get a grip of energy crisis.*

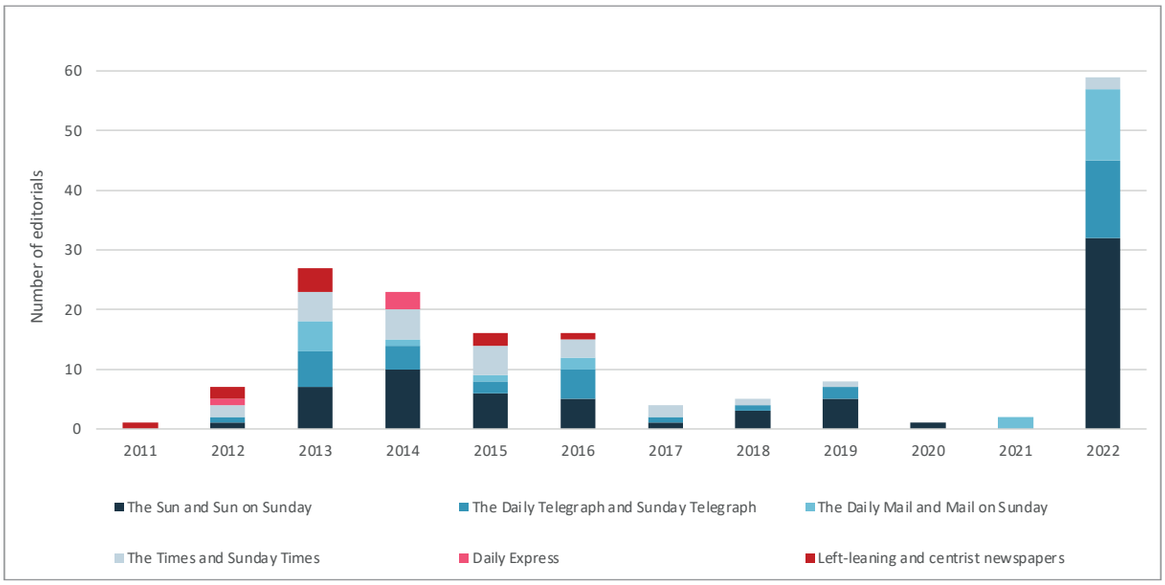
54 Malnick, E. (February 12th 2022) '*Tory grandees urge Boris Johnson to lift 'unconservative' ban on fracking*', *Telegraph*.

55 Denham, A. (March 1st 2022) '*Britain is paying the price for its fracking panic*', *The Spectator*.

56 Owen, G. and Carlin, B. (5th March) '*Frack us out of the fuel crisis, Boris*', *Daily Mail*.

Poverty' campaign – Farage's answer to the NZSG.[57] It, like the NZSG, tied the "net zero delusion" to the UK foreswearing its "vast reserves of shale gas". At its heart was the call for a popular referendum on net zero. Indeed, across the whole year, as Figure 5 shows, 2022 saw a record-breaking wave of editorial support for shale development across the UK's right-wing newspapers.

Figure 5: Editorials supporting UK shale gas development 2011-2022



Note: Data provided by Carbon Brief.

The then Secretary of State for BEIS, Kwasi Kwarteng, was originally steadfast in his opposition. Just four days after the outbreak of Russia's war on Ukraine, on the 28th of February, he wrote on Twitter that fracking "won't materially affect the wholesale market price" of gas, and that "gas is more expensive than renewable energy, so we need to move away from gas". He later expanded upon these statements in the *Mail on Sunday* on March 5th – effectively responding to the NZSG and Nigel Farage. Kwasi Kwarteng argued that the UK suffers not from a shortage of supply, but high prices, and that native shale production could never reach a large enough scale to affect European prices. [58] As such, "with gas prices at record highs, and the price of renewable energy plummeting, we need to accelerate our transition away from expensive gas".

But the government's position soon began to turn. On March 8th, the UK announced its plans to phaseout Russian oil imports.[59] In the debate on the bill in the Commons the next day, Kwasi Kwarteng was equivocal about the future of shale, and in the first sign of a change of position, remarked that "in conversation with the Prime Minister, we were clear that it did not necessarily make any sense to concrete over the wells" at Preston New Road.[60] That same day, the *Financial Times* reported that a spokesperson for Downing Street, when asked about shale gas, replied that "everyone would expect the prime Minister to look at all our options".[61] On March 15th, an urgent question was put to the government on the status of the shale industry in the Commons. Greg Hands, Minister for BEIS, advised that "we need to keep all energy options open", and that shale gas "could be part of our future energy mix, but we need to be led by the science and have the support of local communities".[62] Greg Hands obliquely suggested that moves were being made to void the OGA order to plug the wells on Preston New Road, and in a telling rhetorical shift, started to refer to the moratorium as "a pause". By the end of the month, the OGA had written to Cuadrilla to withdraw its notice to decommission the Lancashire site.

57 Farage, N. (5th March) '*The Net Zero zealots are the same elitists who sneered at Brexit and don't have to worry about paying their gas bills*', *Daily Mail*.

58 Kwarteng, K. (5th March) '*Switch to our own power supplies is a win-win for everyone – except Putin*', *Daily Mail*.

59 BEIS (March 8th 2022) *UK to phase out Russian oil imports*.

60 HC Deb, March 9th 2022, Vol. 710, Col. 347-360.

61 Pickard, J. (March 9th 2022) '*Boris Johnson opens door to fracking in response to Ukraine war*', *Financial Times*.

62 HC Deb, March 15th 2022, Vol. 710, Col. 761-774.

April to July 2022: Reviewing the moratorium, and the bind of seismicity

Boris Johnson did not lift the moratorium. Instead, on April 5th, he commissioned the British Geological Survey (BGS) to review whether there was any new evidence to suggest that seismicity induced by hydraulic fracturing could be forecast and controlled.[63] When the government published its energy security strategy two days later, it canvassed its position on shale as "open-minded", and suggested that the decision would ultimately depend on the scientific conclusions of the BGS report.[64]

Why did Boris Johnson feel it necessary to take this cautionary step? He had already intervened to void the order that Cuadrilla's Preston New Road site be plugged. Might Russia's war on Ukraine not have given him cover to placate the backbench insurgents around the NZSG calling for a revival of shale development?

On one level, Boris Johnson felt it necessary to commission the BGS report because his *own administration* had explicitly imposed the moratorium in 2019 because the seismic effects of hydraulic fracturing could not be controlled. Following a series of seismic events at Cuadrilla's Preston New Road site, which peaked with a 2.9 magnitude earthquake, the government established the moratorium through a written ministerial statement on November 4th. By way of justification, the government said that "while we cannot draw definitive direct comparisons between this site-specific evidence and other prospective shale gas sites, the limitations of current scientific evidence mean it is difficult to predict the probability and maximum magnitude of any seismic events".[65]

This created a bind of the government's own making. Before the moratorium seismicity played little if any role in the parliamentary debate. It was only after the moratorium was imposed *on the basis of induced seismicity* that the subject moved to the centre of the anti-shale gas case in Parliament. In 2016, 2017 and 2018 it found *no* mention in anti-shale gas arguments, and in 2019 it was cited 4 times (and only once after the Preston New Road quakes in August). In 2020, however, it featured in 12 arguments, in 2021 in 27 arguments, and in 2022 in 12 arguments. Unsurprisingly, national survey data shows that the public internalised the government's messaging and saw the moratorium as a direct response to induced seismicity.[66]

Among opponents of hydraulic fracturing, the rhetorical tactic was simply to use the government's own standard against it: the government prohibited 'fracking' because unacceptable seismicity could not be ruled out, and so the moratorium ought to stay in place until there is clear evidence the situation has changed. Absent that, lifting the moratorium would be hypocritical, and more to the point, would recklessly endanger the public. This was made easier by the fact that it had been the official government line, too. In an extended statement in Parliament on September 28th 2020, the Minister for BEIS, Kwasi Kwarteng, explained that:

> "My hon. friends will remember that the threshold at that time was 0.5 on the Richter scale, and that anything over that would require a necessary cessation in the fracking. So you can imagine my surprise, Mr Deputy Speaker, when one morning I was told that the Richter scale had hit 2.9. It was immediately apparent at that point that there would be no further fracking, as far as I was concerned... We will not support fracking unless the science shows categorically that it can be done safely and without inconvenience. As I have said, this is extremely unlikely to happen, as far as I am concerned".[67]

It is not incidental that Kwasi Kwarteng was here responding to a debate in the House of Commons initiated by Alexander Stafford, Conservative MP for Rother Valley, and backed by Lee Rowley, Conservative MP for North East Derbyshire. Backbench support for shale exploration in the Commons had already thinned in 2019, and the general election that gifted Boris Johnson a landfall in December of that year had, in no small part, been built on turning the 'red wall' across the Bowland shale basin Conservative. This created an inbuilt

63 A copy of the letter can be found at BEIS, (April 5th 2022*) Letter from Secretary of State to British Geological Survey outlining terms of referencing.*

64 BEIS and Prime Minister's Office (April 7th 2022) *British energy security strategy.*

65 HC WMS, November 4th 2019, Vol. 667, Col. 55-56.

66 Devine-Wright, P. *et al.* (2021), 'Induced seismicity or political ploy?: Using a novel mix of methods to identify multiple publics and track responses over time to shale gas policy change', *Energy Research & Social Science*, 81, 102247, pp.8-9; Ryder, S. and Devine-Wright, P. and Evensen, D. (February 2020), *Public Perceptions of Shale Gas Exploration in the UK: A Summary of Research (2012-2020)*, UKUH Briefing, p.10.

67 HC Deb, September 28th 2020, Vol. 681, Col. 128-134.

caucus of shale gas sceptics within the party, conscious of just how unpopular the industry was across their constituencies. Indeed, Alexander Stafford falls precisely into this category: elected in 2019 into a seat in South Yorkshire and animated by the depth of local concern. In early 2022, when the *Guardian* surveyed the same parliamentary intake, they found that only 5 of the 138 MPs whose constituencies fell on English shale plays supported shale gas development in their area.[68] *The New Statesman* put the number of Conservative seats on English shale plays at 98.[69]

By claiming to be 'led by the evidence', and commissioning the BGS review, Johnson did his best to placate *both* the NZSG campaign for the lifting of the moratorium, and the Conservatives wary of local opposition to shale gas exploration. But it also made him a hostage to the conclusions of the BGS, and the likelihood was always that they would return a negative verdict.

Already, in December of 2020, the OGA had published four long-awaited studies on the seismic events induced by hydraulic fracturing at Preston New Road in 2019.[70] 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". Given the terms of the moratorium, that was effectively a judgement in favour of its continuance.

If the terms of the 2019 moratorium placed the Johnson administration in one bind, that the definition of 'acceptable levels' of seismicity was for all practical purposes fixed, placed it in a second.

Upon the publication of the OGA report in December 2020, Cuadrilla released a press release. Cuadrilla passed over the authority's express support for the continuance of the moratorium. Instead, they highlighted that, according to the report, a 2.9 ML event of the kind that occurred on Preston New Road, "may cause sparse cases of low superficial damage". [71] In other words, it did not question that hydraulic fracturing would cause seismic events of that magnitude. It questioned whether that was a hazard worthy of prohibition. The same consternation was implicit in the letter sent by Boris Johnson to the BGS in April 2022, which asked how the seismicity induced by hydraulic fracturing compared to that of "other forms of underground energy production, such as geothermal and coal mining, or surface activities such as a construction", and whether the difference in standards between these industries and shale "remain justified".[72] It is perhaps telling that this last – politically controversial – suggestion was omitted from the government's press release.

Indeed, this was a common subject of ire ever since the moratorium was imposed on the basis that unacceptable levels of seismicity could not be reliably prevented.[73] In March of 2022, before the BGS report *had even been commissioned*, let alone written and published, Jacob Rees Mogg suggested that hydraulic fracturing was "equivalent to a bus passing by your house... it's not the San Francisco earthquake", concluding that "I think this is what needs to be looked at".[74]
In that same month, Matt Ridley, a journalist and former Conservative hereditary peer, compared the seismic level at which hydraulic fracturing is paused to "somebody sitting down hard on a chair".[75] Craig Mackinlay, Chair of the NZSG, meanwhile, called induced seismicity "a small inconvenience".[76]

As Ulrich Beck has argued, defining 'acceptable levels' of technological risk is always a latent source of political conflict.[77] Articulating the social context of risk is inherently interpretive, and deciding what kind and severity of risk to expose humans to is always value-laden. Neither can be arbitrated by science, by an analysis of the matrix of cause and effect of a technology. "*Which* interests they select, however, *on whom* or *what* they project the causes, *how* they interpret the problems of society, *what sort* of potential

68 Horton, H. and Carrington, D. (March 15th 2022) '*Blow to fracking in England as only five of 138 MPs in target areas voice support*', *Guardian*.

69 Merwe, B. and Bourke, I. (October 19th 2022) '*Mapped: Fracking sites could impact one in four Tory constituencies*', *New Statesman*.

70 OGA (December 2020) *Summary report of the scientific analysis of the data gathered from Cuadrilla's PNR2 fracturing operations at Preston New Road*

71 Cuadrilla (December 14th 2020) *OGA Preston New Road 2 Seismicity Studies*.

72 BEIS (April 5th 2022) *Letter from Secretary of State to British Geological Survey outlining terms of referencing*.

73 Though the complaint was hardly new. A 2018 study for BEIS found that the ground vibrations from an earthquake induced by hydraulic fracturing were comparable to dropping a bag of flour in the kitchen floor. See Edwards, B. and Delvoye, A, and Brtherson, L. (2018) *Seismic Context Measurements for Induced Seismicity*.

74 See Rees-Mogg, J. (March 8th 2022), '*Moggcast Episode 74*', *Conservative Home*, minutes 7-9.

75 Ridley, M. (March 3rd 2022) '*UK is sitting on gas gold mine which would blitz bills & Putin monopoly*', *The Sun*.

76 Hickey, S. (February 14th 2022) '*Fracking earthquakes 'small inconvenience' to get domestic gas stores, Tory MP claims*', *LBC*.

77 Beck, U. (1992) *Risk Society: Towards a New Modernity*. London: Sage. See pp.51-82.

solutions they bring into view – these are anything but neutral decisions... Statements of risk are the moral statements of a scientized society".[78] In the case of the traffic light system, the standard of acceptability was always *local disturbance* to residents, rather than *local damage* to the built environment.

The traffic light system was established in 2012 in the wake of a 2.3 ML event at Cuadrilla's Preese Hall site, on the strength of the recommendations of an independent review.[79] The fundamental issue highlighted by the Preese Hall event back in 2011 was that the peak of induced seismicity often occurred *after* the conclusion of hydraulic fracturing. The highest observed jump of this kind was 0.9 ML. Which meant that for any upper limit to acceptable seismicity, fracturing would have to cease at least 0.9 ML *below* that level. Otherwise, it risked creating a trail of intensifying quakes that might break through the upper limit. Cuadrilla suggested that 1.7 ML should be point at which activities stop, but the independent review suggested that "in the present state of knowledge, it would be more prudent to adopt a lower threshold" of 0.5 ML. What is crucial is that this reasoning was *not* directly coupled to a standard of acceptable damage. For the authors noted that any quake below 3 ML would cause only superficial damage – an observation that one might think would support Cuadrilla's suggestion of a 1.7 ML limit. But, instead, the authors suggest precaution given the current state of knowledge, and invoke a different standard of acceptability: namely, the "likelihood of events perceptible for local residents". We see exactly the same bifurcation in the written ministerial statement authorising the moratorium in 2019. It reasons that although "seismicity was at a level below which we would expect significant damage", it nevertheless "does impact local communities and was clearly unacceptable".[80]

This placed the government in a bind. On the one hand, the traffic light system forced companies to halt activity upon induced seismicity at a level – 0.5 ML – that threatened to inhibit effective operations altogether. Indeed, this is exactly what we saw at Preston New Road in 2018 and 2019. Although it recommended a 0.5 ML limit, the 2012 Preese Hall review framed this as a provisional measure, to be taken in the face of uncertainty, that could be "adjusted over time, if appropriate, in the light of developing experience".[81] Indeed, John Baptie, one of the two authors of the review, publicly called for this limit to be reviewed in 2019.[82] Similarly, Ed Davey, in his written ministerial statement introducing the traffic light system in 2012, noted that although the 0.5 ML limit imposed a more strenuous standard upon the shale industry than parallel regulation for induced seismicity did on geothermal energy, construction and quarrying, this was a "precautionary" step that might be "adjusted upwards" in the light of "experience".[83]

On the other hand, whether it would be justified or not, it was politically untenable to *weaken* a core plank of the regulatory regime for shale gas development. Shale development is unpopular in the UK, and the two principal reasons why are that it is seen as bearing unacceptable risks for human health and the environment, and that neither operators nor government regulation are trusted to prevent those risks from materialising.[84] In 2019, a major national survey found that 37% of respondents thought the traffic light system was too weak, and 24% thought that it was 'about right'.[85] Only 8% of respondents thought that it was too stringent, and would therefore presumably support a relaxation of existing seismic limits. In this context, from a political perspective, it would be counter-productive to soften the seismic limits for hydraulic fracturing, for the industry was already facing a crisis of legitimacy *precisely because it was perceived as failing to safeguard local communities.*

78 Beck, U. (1992) *Risk Society: Towards a New Modernity*. London: Sage. See pp.174-176.

79 DECC (April 17th 2012) *Preese Hall Shale Gas Fracturing: Review & Recommendations for Induced Seismicity Mitigation*.

80 HC WMS, November 4th 2019, Vol. 667, Col. 55-56.

81 DECC (April 17th 2012) *Preese Hall Shale Gas Fracturing: Review & Recommendations for Induced Seismicity Mitigation*, p.12.

82 BBC (22nd January 2019) *Experts call for review of quake limits on UK fracking*.

83 HC WMS, December 13th 2012, Vol. 555, Col. 44-52.

84 BEIS (February 2020) *Public Attitudes Tracker: Wave 32*, p.8; Bradshaw, M. *et al.* (2022) 'We're going all out for shale: explaining shale gas energy policy failure in the United Kingdom', *Energy Policy*, 168, 113132; Williams, L. and Macnaghten, P. and Davies, R. and Curtis, S. (2017) 'Framing 'fracking': Exploring public perceptions of hydraulic fracturing in the United Kingdom', *Public Understanding of Science*, 26(1), pp.89-104; Dunlop, L. and Atkinson, L. and Diepen, M. (2021) 'It's our future: youth and fracking justice in England', *Local Environment*, 26(1), pp.110-130.

85 Evensen, D. and Devine-Wright, P. and Whitmarsh, L. (July 2019) *UK National Survey of Public Attitudes Towards Shale Gas*, UKUH Briefing.

The shale industry thus found itself hamstrung by a seismic regime that there was no viable political route to reforming. We find this catch-22 reflected in the comments of an individual from Fylde, Lancashire, affected by shale exploration:

> "I don't see why these applications to relax some of the regulation around tremors, when they keep having to stop drilling, I've heard on the news a few times that they've stopped drilling a lot, where the government overrode the council, and there's people at Cuadrilla complaining and lobbying for the rules and the regulations to be relaxed. Well, if it's as great as you said, then why do we then have to move the goalposts [to change seismicity regulations]?"[86]

When Cuadrilla was forced to repeatedly pause hydraulic fracturing at Preston New Road in late 2018, it urged the government to revise the traffic light system. But the response of an otherwise sympathetic Conservative administration was unwavering: "at no point" did Cuadrilla express that "it would not be possible to proceed without a change in regulation", a system which the government believes "is fit for purpose and has no intention of changing".[87]

If the government was bound to *this* definition of acceptable levels of seismicity, and to lifting the moratorium only upon new evidence showing that it could be reliably avoided, then this double bind effectively amounted to a *seismicity test*. This was promulgated both as the official government line until the Truss administration, including in the letter requesting the BGS report, and as a fundamental plank of opposition to 'fracking' after 2019. It became a settled norm, whose apparent violation would help fuel the eruption of opposition when the moratorium was lifted in September 2022.

Returning to our chronological narrative, the months after Boris Johnson commissioned the BGS report saw two developments.

First, the government's decision to review the moratorium stirred the shale industry back to life. On April 10th, INEOS challenged the government to give it permission to develop a test site to demonstrate that fracking "can be safe and secure in the UK".[88] In a dramatic reversal, on June 2022, Spirit Energy re-entered into its 25% participating interest in Cuadrilla's Bowland licences, as well as entering into a 22.75% participating interest in its Elswick exploration.[89] For Cuadrilla, and its parent group AJ Lucas, this resuscitated a lifeline of capital investment: the contingent carry agreement under which Spirit Energy would pay $46.7m to help Cuadrilla develop production.

Second, the Johnson administration fell, and at an important juncture in the shale gas debate. The BGS announced that it had delivered its scientific update on hydraulic fracturing to BEIS on July 6th. But, the day after, Boris Johnson announced his resignation. What followed was a long, drawn-out contest for the Conservative Party leadership that would not issue in a new leader until the September 6th. During this limbo, the BGS report and the whole question of the moratorium was shelved by the government.

August to November 2022: Liz Truss ties herself in knots over local consent

Shale gas bookended the Truss premiership. In an interview with the *Telegraph* published July 16th, midway through the parliamentary selection for the Conservative leadership, she threw her lot in for shale development. It was a transparent bid for support for the NZSG wing of the party.[90] "I support the Net Zero objective, but we need to reach Net Zero in a way that doesn't harm businesses or consumers … I am very supportive of using gas as a transition fuel". Is she in favour of lifting the moratorium? "Yes", Liz Truss replied.

Rishi Sunak came out of the parliamentary selection alongside Liz Truss. He voiced tentative support for shale development. Asked in a television debate, "fracking, yes or no?", both chimed, "yes, if local

86 Sovacool, B. *et al.* (2020) 'Humanizing hydrocarbon frontiers: the "lived experience" of shale gas fracking in the United Kingdom's Fylde communities', *Local Environment*, 25(11-12), p.955.

87 BBC (January 14th 2019) *No plan to relax fracking regulations, says minister.*

88 INEOS (April 10th 2022) *INEOS challenges government with shale gas test offer.*

89 AJ Lucas (June 16th 2022) *Spirit Energy Withdraws Notice to Exit Lancashire Shale Exploration Licences.*

90 Malnick, E. (July 16th 2022) '*Liz Truss: I want the biggest change in economic policy for 30 years*', *The Telegraph.*

communities support it". It bears noting that, according to YouGov, support among Conservative Party members for shale development had become net positive in Spring 2022, rising to +16% by September.[91] On the whole, however, Sunak avoided the subject. In an interview by the Conservative Environment Network in August, Rishi Sunak was asked how he would tackle the energy crisis without undercutting the net zero transition.[92] He had no compunction in replying that he would "drive up North Sea gas production", and "scale up domestic gas storage", alongside renewables. But shale gas was conspicuously absent from his answer.

Liz Truss showed none of this hesitancy, using the pages of the *Daily Mail* to broadcast her intention to "end the effective ban on extracting our huge reserves of shale gas" on August 25th.[93] As she had from the beginning, she added the qualification that "fracking will only take place in areas with clear public consensus behind it". Development would be conditional upon a democratic social licence.

What was the calculation here? The balance of forces within the parliamentary party tilted against shale gas extraction. Bowland MPs did not want to endanger re-election by inflaming constituents, and the NZSG was far outnumbered by the Conservative Environment Network, whose July 2019 manifesto went *beyond* support for the moratorium – calling instead for an outright ban.[94] But shale development did have favour within a right-wing faction of the parliamentary party empowered by Brexit and the Johnson administration. More importantly, shale development was popular with the membership and *especially* the right-wing press, and the populist language of net zero scepticism allowed Liz Truss to appeal over the head of the party to this base. By making shale development conditional upon local consent, she hoped to neutralise the fears of Bowland MPs while capitalising on the fact shale gas had been made into a right-wing *cause celebre*. It was a precarious balancing act, one that won her the membership ballot, but that would catch up to her in the Commons.

Liz Truss took the reins of her – ultimately short-lived – leadership on September 6th amidst acute concerns about the effect of spiralling energy bills on the cost of living. In her first address to the Commons, on the 7th, she repeatedly centred her response upon securing 'long-term supplies' of energy.[95] The next day, in a scheduled debate on energy costs, she announced her government's intention to lift the moratorium, as well as a review into how to "deliver net zero by 2050 in a way that is pro-business and pro-growth".[96] Her framing was clear cut: shale gas would strengthen the UK's national defence, helping to protect the "free world" from despots like Vladimir Putin.

The response of the pro-shale caucus was to press Liz Truss to go *further*. On the eve of her inauguration, the NZSG gave her one last push in the pages of the *Telegraph*. Rearing the spectre of "a Russia-dominated European gas market", they refloated the idea that shale gas should be designated a Nationally Significant Infrastructure Project such that it could bypass the local planning system.[97] Days later, IGas also called for regulatory lassitude, while the industry trade association, UK Onshore Oil and Gas, asked only "to be treated fairly in terms of... earthquake regulations. We would want to be treated in line with construction, geothermal, quarrying and coal mining".[98]

On September 22nd, the moratorium was lifted. But this was a top-down decision introduced *before* it had won political legitimacy, across the Conservative party, across Parliament, or across the country. It thus faced an uphill battle, with three tests – on climate, seismicity and local consent – to surmount. How did it stand vis-à-vis these tests?

The Truss administration did not last long enough for shale development to be put to the test of net zero. Preliminary indications were not positive, however. Lord Deben and Sir Armitt, the respective chairs of the CCC and the National Infrastructure Commission, took it upon themselves to write a cautionary letter to

91 Smith, M. (September 22nd 2022) '*While opposition has dropped, Britons remain against fracking for shale gas*', *YouGov*.

92 Conservative Environment Network (August 17th 2022) *Rishi Sunak: I am absolutely committed to protecting our environment for future generations*.

93 Groves, J. (August 25th 2022) '*Truss unveils plans to beat energy crisis*', *Daily Mail*.

94 Conservative Environment Network, July 2019, *The CEN Manifesto*.

95 HC Deb, September 7th 2022, Vol. 719, Col. 229-238.

96 HC Deb, September 8th 2022, Vol. 719, Col. 398-451.

97 Telegraph (September 4th 2022) *Letters: Time for the Tories to come together and get on with the business of governing*.

98 Tani, S. and Thomas, N. (September 11th 2022) '*Fracking groups seek further steps in Truss reforms*', *Financial Times*. See also IGas (September 22nd 2022) *Response to Government's Written Ministerial Statement on Shale Gas Extraction*.

Liz Truss on her first day in office.[99] She would be well-advised, they counselled, to "end our dependence on gas". Shale gas was a red herring, as its size was too diminutive to bring down wholesale prices. The energy crisis was an opportunity to accelerate decarbonisation, not an excuse to reverse it. "If you want to deal with climate change and you want to deal with the cost-of-living crisis and oil and gas prices you have to do the same things – renewable energy and energy efficiency – they are the answers".

They were not alone. After Liz Truss' fall, but before the reversal of the decision to lift the moratorium, Alok Sharma – COP26 President – stood before several House of Commons select committees.[100] "I personally am not supportive of the idea of fracking". Why? Its introduction preceded its justification: the onus is upon the government "to demonstrate how the policies they are putting forward are consistent with legally binding commitments" to net zero, including "near-term carbon budgets".

These are not marginal figures. Lord Deben is a pedigreed Conservative, having entered the Commons in 1970, chaired the party for a spell under Margaret Thatcher, and ascended to the Lords in 2010. Alok Sharma was the Conservative's face of COP26 in Glasgow. They are arguably two of Parliament's leading authorities on climate change. Voices from outside the party clamoured to make the same essential point. Of the 71 interventions against 'fracking' in the Commons during Liz Truss' tenure, 39 invoke climate change. Wera Hobhouse, the Liberal Democrat spokesperson for Energy and Climate, forced the point:

> "The Climate Change Committee has said that before the Government lift the moratorium on fracking, they must conduct "an in-depth independent review of the evidence" of its climate impact. When will the Government do that review, and will it be followed by a statement in this House?"[101]

If the question of net zero could be deferred, seismicity could not. Boris Johnson had established and continued the moratorium on the explicit basis that induced macro-seismicity could not be controlled. Its future was supposed to rest on this specifically scientific standard, and it was up to the BGS to independently determine whether it had been met. The BGS report was, finally, published on the day that the government lifted the moratorium. Read within the received terms of the Johnson policy, it clearly *did not* support the lifting of the moratorium. Forecasting induced seismicity "remains a scientific challenge", while the fact that the UK's shale basins have been so little explored makes "it impossible to determine with statistical significance the rates of occurrence of induced seismicity".[102]

How, then, did the government defend their stance? First, Jacob Rees-Mogg, now the Minister at BEIS, advocated that the governance of shale gas extraction move from a *precautionary* to an *experimental* approach. The "report makes clear that forecasting the occurrence of felt seismic events remains a scientific challenge", he conceded, but "it also makes clear that to improve our understanding we need more exploratory sites to gather the necessary data".[103] Certainly, the report is open to this interpretation. Ulrich Beck presciently diagnosed this "experimental logic" three decades ago, wherein risks "on people can ultimately only be studied reliably *with* people. Society is becoming a laboratory".[104] Of course, this was politically treacherous. Greg Knight, Conservative MP for East Yorkshire, spoke for many when he said:

> "Despite what the Secretary of State said, is it not the case that forecasting the occurrence of seismic events as a result of fracking remains a challenge to the experts? Is it not therefore creating a risk of an unknown quantity to pursue shale gas exploration at the present time? Is he aware that the safety of the public is not a currency in which some of us choose to speculate?"[105]

Second, Jacob Rees-Mogg reasoned that exposing the public to a modicum of seismic hazard was, on balance, justified by national security. "Putin's invasion of Ukraine and the resulting restricting of gas supply in Europe" is a wild card that upturns the calculus.[106] In light of the matters of "national interest" at stake, he suggested that exposing those "living and working near to [shale gas] sites" to a "higher degree of risk and disturbance" seems like an acceptable trade-off.

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99 CCC & National Infrastructure Commission (September 6th 2022) *Policies to support energy security.*

100 House of Commons BEIS Committee (October 25th 2022) *Oral Evidence: Preparations for UNFCCC COP27, HC 813.*

101 HC Deb, 13th October 2022, Vol. 720, Col. 258-279.

102 BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales.*

103 HC WMS, September 22nd 2022, Vol. 719, Col. 38-41.

104 Beck, U. (1992) *Risk Society: Towards a New Modernity.* London: Sage. See p.69.

105 HC Deb, September 22nd 2022, Vol. 719, Col. 790-809.

106 HC WMS, September 22nd 2022, Vol. 719, Col. 38-41.

Third, inherent in this argument is the idea that 'local disturbance' is the *wrong standard* of acceptable seismicity. Jacob Rees-Mogg floated the explosive idea that "we need to revisit seismic limits to ensure that shale gas extraction can be done in an effective and efficient way", later telling journalists that the extant standard is "too low", and is "being looked at".[107] Yet this risked charges of hypocrisy, and certainly Ed Miliband, Shadow Secretary of State of Climate Change and Net Zero, did not mince his words: "I look forward to him and his colleagues explaining his charter *for* earthquakes... we will hang this broken promise round their necks in every part of the country between now and the next general election".[108]

What of the standard of local consent? Establishing this social test to development might, in retrospect, look like a capricious act of self-harm. For that the majority of the public opposed shale gas development was well-known, and no doubt fed into Boris Johnson's decision to impose the moratorium in the run up to the last election. But it was not without strategy. It was a sop to win the favour of the NZSG caucus during the leadership without making an enemy of the MPs of the Bowland. Where Conservatives felt threatened by the weight of local opposition, shale extraction would not take place. Thus: the practical and political coordinates of shale development would align. But this circle could not be squared without careful consideration. A rigid definition of local consent would strangle the shale industry at birth.

On the day the moratorium was lifted, Jacob Rees-Mogg engaged in a long and torturous exchange in the Commons.[109] With feints of guilelessness, he sought to equate 'consent' with 'compensation'. It is worth reconstructing this at some length. Mark Menzies, a key Conservative figure in the shale debate, as an MP for the Lancashire constituency for Fylde, asks the government to "outline how local consent will be given and demonstrated in my constituency of Fylde?" Jacob Rees-Mogg replies that "it is really important that companies that seek to extract shale gas come up with the packages that make what they are proposing to do welcome to local communities". Helen Morgan, a Liberal Democrat, later interjects to ask the Minister to "explain in detail – he has not so far – exactly the mechanism through which communities will be able to refuse consent for... shale gas fracking? Compensation is not consent". He counters that "compensation and consent become two sides of the same coin". Mark Fletcher, another Conservative backbencher, tries again. "It seems to come back to communities being bought off rather than having a vote. Can the Secretary of State confirm once and for all that residents across Bolsover who are concerned about fracking will be given a vote to object to these schemes locally?" The Minister answers, simply, "I think I have made it very clear that the companies will have a deep responsibility to develop packages that make the extraction of shale gas attractive to local communities". Soon after, speaking on BBC Radio Lancashire, Liz Truss struggled upon being asked the simple question, "What does local consent look like?" She was only able to muster that "various detailed issues" need to be "worked through".

Whatever the vagaries of this battle for legitimacy, the mere fact of the lifting of the moratorium kickstarted the shale industry. Within a single week, AJ Lucas, the owner of Cuadrilla, had raised $19.7m through a new share issuance, to "be used for funding UK operations to respond to recent regulatory changes, expenditure on new and existing plant and equipment and for working capital".[110] Its presentation to investors makes for interesting reading. It canvasses "quicker and improved operating and planning conditions" – according to whom, one might wonder? – and intimates that a single pad could "hold up to 72 lateral wells across 6 vertically stacked levels". It also highlights its ongoing £46.7m carry agreement with Spirit Energy. This ambition notwithstanding, the presentation ends with an 11-page appendix breaking down the multitudinous risks to development – not least the possibility of a "suspension of activities" again. Soon after, when AJ Lucas gave notice of its AGM, it included a resolution to increase the capacity of the company to issue shares without a direct mandate from shareholders, suggesting imminent plans to raise yet more capital.[111]

107 HC Deb, September 22nd 2022, Vol. 719, Col. 790-809; Forrest, A. (September 22nd 2022) *Government will allow higher levels of 'seismic activity' at fracking sites, Jacob Rees-Mogg suggests*, *Independent*.

108 HC Deb, September 22nd 2022, Vol. 719, Col. 790-809.

109 HC Deb, September 22nd 2022, Vol. 719, Col. 790-809.

110 AJ Lucas (September 29th 2022) *AJ Lucas Group Limited Completes $19.7m placement*.

111 AJ Lucas (October 2022) *Notice of AGM 2022*.

In the meantime, however, the country had stumbled into an economic whirlwind. Liz Truss had begun her premiership by pledging to freeze energy bills at £2,500 a year for the next two years,a measure tendentially likely to save the best-off more than the worst-off more than the worst-off. This lack of means-testing led to a potential fiscal burden of over £100bn. A fortnight later – the day after the moratorium was lifted – Liz Truss announced a mini-budget that included £45bn in tax cuts, while foregoing the independent costing by the Office for Budget Responsibility that would normally be expected. Sterling plunged to its lowest level on record, almost reaching parity with the dollar, and took the gilts market with it.[112] Pension funds invested in gilt-linked derivatives faced a sudden wave of margin calls, forcing the Bank of England to step in to prop up the market. Within a month of taking office, the Truss administration was in mortal crisis. Its shale policy was not insulated from this turbulence. Already a lightning rod for controversy, the government no longer had the authority to revive the industry in the face of fierce opposition.

Sensing an opportunity, the Labour Party brought forward a bill to ban 'fracking', bringing the conflict in the Conservatives, over both shale gas and the Liz Truss administration writ large, to a head. Fearing a backbench rebellion, the government imposed a three-line whip, and even went so far as to claim – though then subsequently deny – that the vote was tantamount to a confidence motion in the government.[113]

The debate involved the normal battery of criticisms, criss-crossing the three tests to development, while the government foregrounded energy security.[114] But the *sui generis* factor was that the government had tied itself in knots over 'local consent'. Jacob Rees-Mogg's attempt to equate consent with compensation was unanimously rebuffed, but he now stood incapable of articulating what mechanism the government would use. Instead, he cited all the different mechanisms it *might* use. "We want to ensure that the consultation considers the views of regional Mayors and local authorities, as well as the immediate concerns of those most directly affected. I also want it to consider the views of MPs, as well as the use of local referendums", and indeed, he also pledged to consult on the consultation mechanism itself' on the consultation mechanism itself. Crucially, he was forced to concede on a fundamental point. Once the consultation mechanism was chosen, "the results would be brought to the House for approval", and that if the House did not approve of that mechanism, "fracking could not go ahead". But concession or not, the debate had exposed grave rancour within the Conservative party. The next day, Liz Truss resigned.

Within a week, the new Prime Minister Rishi Sunak announced that he would reimpose the moratorium. After a turbulent month of party infighting and economic crisis, the Conservatives had nose-dived in the polls, with Labour opening as much as a 33-point lead.[115] Rishi Sunak's priority was to restore party unity and a sense of calm and competence. The argument over shale gas ran directly contrary to that aim. Liz Truss' performance had, after all, only exacerbated the electoral anxieties of Bowland Conservatives. Speaking in the Commons, Rishi Sunak framed his decision as an act of fidelity to the 2019 party manifesto – which he claimed to be the basis of his electoral mandate. This Johnson-era pledge had read: "Having listened to local communities, we have ruled out changes to the planning system. We will not support fracking unless the science shows categorically that it can be done safely".[116] It foregrounded a weak social license – not overriding the local planning system – and seismic hazards. In the same breath as Rishi Sunak ruled out shale development, he touted his commitment to "deliver on what we said at COP26". In the end, Sunak's decision reflected the influence of all three tests to development, on climate, seismicity and local consent. Together, they had always meant that the shale industry's demise was over-determined.

Part 2: Why shale gas is not coming back

Shale gas development faces an unforgiving future in the UK. The beginning of any path forward, in England at least, is Parliament lifting the moratorium. This is not likely, as three of the four largest parties – Labour, the SNP and the Liberal Democrats – support a ban. The future of shale gas, if it has any, is therefore entwined with that of the Conservative party.

112 Rennison, J. (September 30th 2022) '*Sleepy Corner of UK's Pension Industry Forced the Bank of England's Hand*', *New York Times*.

113 Crerar, P. and Walker, P. and Allegretti, A. (October 19th 2022) '*Truss faces major rebellion on fracking as senior Tories pledge to defy whip*', *Guardian*.

114 HC Deb, October 19th 2022, Vol. 720, Col. 748-804.

115 Pickard, J. *et al.* (September 29th 2022) '*Liz Truss faces growing Tory pressure as Labour opens 33-point poll lead*', *Financial Times*.

116 Conservative Party (2019) *Get Brexit Done: Unleash Britain's Potential*, p.55.

But even here, the balance of forces within the parliamentary party are stacked against shale development. Just under 100 sitting Conservative MPs represent constituencies straddling shale plays, while the Conservative Environment Network – while has called for an outright ban on hydraulic fracturing – has more than double the MPs of the Net Zero Scrutiny Group. Liz Truss' pledge to lift the moratorium won favour with the membership and the right-wing press, and she attempted to neutralise the opposition of MPs sitting on shale plays by making her support for development conditional on local consent. But that gambit failed, and parliamentary opposition – including within her own party – caught up with her. It was the threat of a Conservative revolt in favour of Labour's bill to proscribe fracking that, ultimately, tipped her over the brink. Sunak was certainly quick to see the writing on the wall.

In large part, this opposition was consolidated by the fact the Truss administration had no answer to the three tests to development. Even if the moratorium were lifted again, the industry would still have to win legitimacy by meeting this triumvirate of challenges. It would have to show that tapping new gas resources is compatible with net zero, that macro-seismicity can be effectively managed, and that shale gas development enjoys local consent. What is more, lying beyond that point is another class of problem, which the industry has never had to face, given its tortoise-like pace of development: commercial viability. The industry has not even completed the basic exploratory drilling on the strength of the results of which its production rates, and thus its economic prospects, might be estimated. It has done little to develop the investors, industrial strategy and midstream infrastructure necessary to scale the industry. In light of these multiplying challenges and uncertainties, we believe it is reasonable to conclude that shale development in the UK is dead. Although we can never say never, the way back is just too treacherous. In what follows, we comprehensively set out the political and economic barriers facing shale development, even if it were, somehow, to win parliamentary support in England.

Political barriers

Seismicity test

We need not detain ourselves at length with the seismicity test because shale gas has only just failed it. We have the 2022 BGS report. But it is worth spelling out *why* controlling induced seismicity is a fundamental challenge that it will not be easy to overcome. Four points bear emphasising.[117]

1. The UK's complex geological history means that faulting is widespread. But these faults are not placed under proximate stimulation from plate boundaries, the nearest of which lie in the mid-Atlantic and the Mediterranean. This means the UK's baseline rate of tectonic earthquakes is low, but that this does not necessarily predict a low rate of induced earthquakes. Indeed, in the 1980s and 1990s, when seismic monitoring became more comprehensive, it was established that around 25% of all earthquakes in the UK were induced by coal mining. The largest magnitude events were only around 3 ML, however.

2. Induced earthquakes follow the same Gutenberg-Richter law as tectonic earthquakes. The law says that the relationship between the magnitude of an earthquake and its frequency obeys the equation $M = 10^{a-bm}$. The a-value is a constant, the total seismicity in the area, so the relative distribution of different magnitudes of earthquake is determined by the b-value. While b-values vary, they are typically taken to be around 1 for tectonic earthquakes. This creates a power law distribution where a rise in the magnitude of an earthquake by 1, sees a decrease in its frequency by ten. As the 2022 BGS report outlines, there has been debate among geologists as to whether the *maximum* magnitude of hydraulic fracturing-induced earthquakes is bounded by the volume of fluid injected into the well to fracture the rock. They conclude that it is not: "for faults that extend outside the immediate hydraulically fractured zone, the maximum magnitude will be controlled by local geology and tectonics, not only by operational parameters, such as the amount of injected fluid".[118] What matters for our purposes is the implication that, while the likelihood of a >3 ML event in any single fractured well is low, as the sample of fractured wells increases, the likelihood of a significant seismic event eventually becomes overwhelming.

117 What follows draws primarily upon BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales*, as well as an independent report commissioned by the Scottish government, BGS (November 8th 2016) *Unconventional oil and gas: Understanding and monitoring induced seismic activity.*

118 BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales*, pp.9-10 & p.26.

3. If the distribution of earthquakes follows a power law distribution, this itself does not tell us the rate of earthquakes in an area – the a-value in the Gutenberg-Richter law. Crucial in this respect is that hydraulic fracturing-induced seismicity rates show huge geographical variation. What interests us is the >2 ML events that usually involve the displacement of a pre-existing fault and can be felt from the surface. On the one hand, research shows that just 0.05% of hydraulically fractured wells in Pennsylvania led to felt seismicity, as did 0.3% of wells in West Virginia, 1.8% of wells in Oklahoma, and 2.7% of wells in Ohio.[119] On the other hand, it has also been found that 15% of wells in the Kaybob region of Alberta were associated with felt seismicity, and that in four 20x20km regions of Ohio, between 10% and 33% of wells precipitated felt seismicity. In the UK, although only three wells have been partially hydraulically fractured, all of them saw substantial peaks of seismicity: of 2.3, 1.6 and 2.9 ML. Some geologists have suggested that because all three fracks occurred in a small radius in Lancashire, shale companies might find more success pursuing operations elsewhere on the Bowland shale. Other geologists cite reasons – such as the fact that the East Midlands has historically been the site of a disproportionate number of earthquakes – as to why other areas of the Bowland might be susceptible to equal or greater rates of induced seismicity.

Even a modest rate of felt seismicity – of, say, 1% of fractured wells – would eventually lead to events equal to the PNR 2.9 quake that compelled the Johnson administration to impose a moratorium on activity in 2019. If 1% of wells lead to felt seismicity of >2, given the Gutenberg-Richter law, it would take on average a maximum of 1,000 wells to lead to a 3 ML event. But given the record of hydraulic fracturing in the UK so far, it seems likely that the rate of felt seismicity is *far* higher than 1%. It is worth reiterating, too, that the more wells subjected to hydraulic fracturing, the likelier it is that the UK will experience higher magnitude earthquakes – though the relatively soft sediment of the UK's Carboniferous section may place a physical upper limit upon the scale of possible induced seismicity at (geologically speaking) shallow depths.

4. The best hope for the industry, then, is to circumvent the Gutenberg-Richter law by *not* randomly selecting wells to hydraulically fracture, and to identify those wells proximate to pre-stressed faults that are to be avoided. But this is no mean feat. As the BGS report explains, "induced seismicity depends on the complex relationship between stress changes caused by operations, the existing faults, state of stress and the mechanical properties of the rocks themselves, e.g., coefficient of friction".[120] But the key characteristics of shale are highly heterogeneous, and so cannot be extrapolated from one area to the next. Worse, even state-of-the-art 3D seismic reflection data cannot reliably identify faults. Indeed, as the official interim review of the events at Preston New Road in 2019 found, "a moderately sized, previously unidentified, strike slip fault intersected with the PNR1Z well. Ruptures on that fault generated the majority, if not all, of the larger observed events".[121] One potentially promising option might be to use real-time micro-seismic monitoring to identify faults and steer ongoing operations away from them, but this technique remains embryonic, and its use at Preston New Road in late 2018 did not stop Cuadrilla exceeding the 0.5 ML limit (even if it may have helped reduce the frequency and severity of seismicity).[122] In their 2022 assessment, the BGS concluded that seismic hazard "cannot be mitigated through analysis of seismic data alone".[123] If and when this will become possible is unclear.

Climate test

What role might shale gas have in the UK's energy transition? At present, the UK only has three operating coal-fired power stations, and these are due to close by late 2024. The comparatively easy emissions reductions achieved from coal-to-gas switching are therefore at an end. In the power sector, gas is now a problem, not a solution. But, as was true of the last two decades, production on the UK Continental Shelf (UKCS) is projected to decline faster than natural gas consumption will (see Figure 6). This means the *relative* share of imports in the UK's gas mix will increase, but that their *absolute* size will shrink.

119 BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales*, pp.22-25. See also Verdon, J. and Rodriguez-Pradilla, G. (2023) *Assessing the variability in hydraulic fracturing-induced seismicity between North American shale plays*. Working paper.

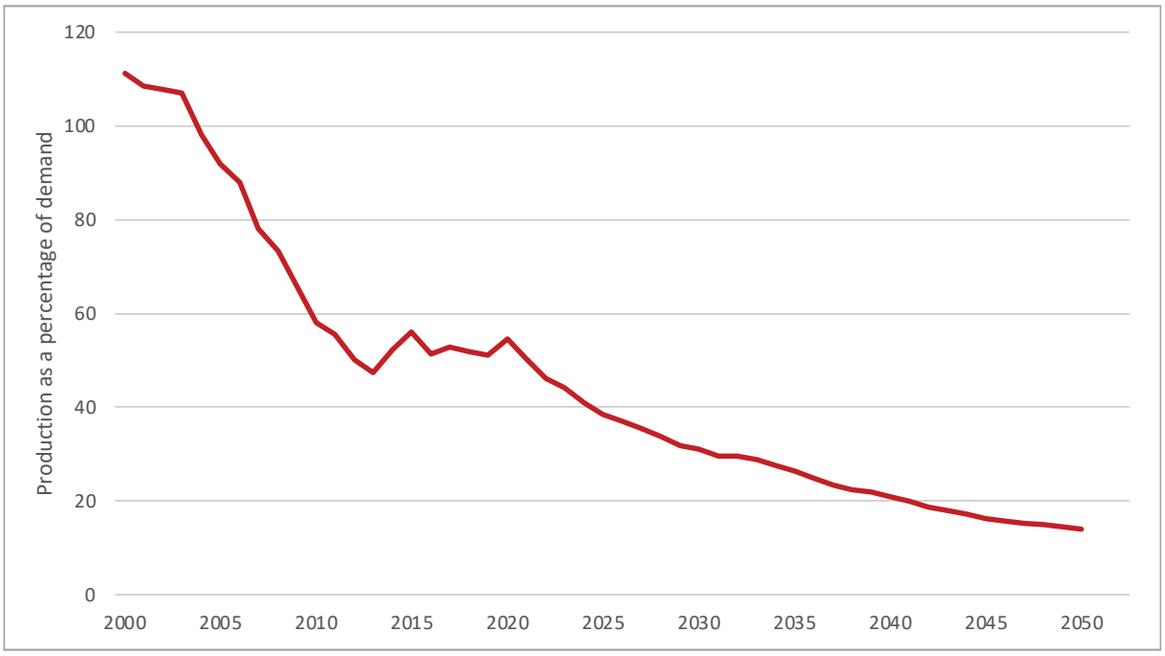
120 BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales*, p.16.

121 OGA (2019) *Interim report of the scientific analysis of data gathered from Cuadrilla's operations at Preston New Road*, p.3.

122 See, for example, Clarke, H. and Verdon, J. and Kettlety, T. (July 2019), 'Real-time imaging, forecasting, and management of human-induced seismicity at Preston New Road, Lancashire England', *Seismological Research Letters*, 90(5), pp.1902-1915.

123 BGS (September 22nd 2022) *Recent scientific advances in the understanding of induced seismicity from hydraulic fracturing of shales*, p.18.

Figure 6: Gross UKCS gas production as percentage of demand



Note: These figures are calculated from the NSTA's comparison of its gas production projections with demand in the CCC's balanced pathway to net zero.

Consider National Grid's most recent Future Energy Scenarios.[124] Its gas-light scenario sees the UK's import dependency increase from 58% in 2015 to 73% in 2050, at the same time as absolute imports over the period fall ninefold, from 45 billion cubic metres (bcm) a year to just 5 bcm a year. Even in its gas-heavy scenario, where the UK's import dependency hits the ceiling at 98%, absolute imports fall to 35 bcm a year. In this sense, it is wrong to assume that as the UK's gas import dependency grows, its energy supply necessarily and absolutely becomes less secure. There is a relative-absolute trade-off.

What share of gas demand in these scenarios could shale gas meet? If we take a middling estimate of UK shale reserves of 200 bcm[125], this would equate to 23.8% of total demand in the gas-light scenario, and 13.4% in the gas-heavy scenario. But, in both scenarios, gas consumption peaks in the middle of the 2020s. Clearly, there is no prospect of UK shale gas meeting this cresting demand. What separates these two scenarios? Modelling by both National Grid and McGlade et al. show that the future size of natural gas in the UK energy mix fundamentally depends on whether it is used with CCS and steam methane reformation (SMR) to produce large quantities of hydrogen, or whether it is eclipsed by electrification and the production of green hydrogen with electrolysis.[126] In turn, the quantities at issue depend on the demand for hydrogen from industry, heating and transport.

It is reasonable to conclude that shale gas could make an appreciable contribution to reducing the UK's gas import dependency up to 2050. The question at the heart of the climate test is whether shale gas or LNG should fill this supply. Which of these two options would result in higher aggregate emissions?[127]

What immediately separates them is their lifecycle, the emissions involved in their production, processing and transportation. On average, the lifecycle emissions of conventional gas are lower than for shale gas,

124 National Grid consider three net zero natural gas supply scenarios, one of which is relatively gas-heavy ('system transformation'), another of which is relatively gas-light ('leading the way'). They also model a non-aligned, 'falling short' scenario. See National Grid (July 2022) *Future Energy Scenarios*, pp. 119-128. Their underlying data can be downloaded from their landing page.

125 See Solman, N. and Bradshaw, M. (March 2020) *Shale Gas and UK Energy Security*, UKUH Briefing, pp.9-10.

126 McGlade, C. *et al.* (February 2018) 'The future role of natural gas in the UK: A bridge to nowhere?', *Energy Policy*, 113, pp.454-465.

127 For a systematic overview of this question, drawn on here, see Stamford, L. (June 2020) *Shale Gas and the UK's Low Carbon Transition*, UKUH Briefing. A previous government study reached similar conclusions, in MacKay, D. and Stone, T. (2013) *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction*, Department of Energy & Climate Change. See also the CCC findings mentioned at the beginning of Part 1 of this report, in CCC (31st March 2021) *Advice to the UK government on compatibility of onshore petroleum with UK carbon budgets*.

which are in turn lower than the lifecycle emissions for LNG. But the margins involved are small: the average carbon footprint of LNG is estimated to be around 10% higher than it is for conventional gas. In practice, fugitive emissions rates – and there are controversial claims that they are particularly high for shale – insert a large dose of uncertainty into this rank-ordering.[128] In large part, methane leakage depends on the stringency of regulations binding production. In its 2016 report on onshore petroleum, the CCC estimated that the quality of regulation of shale production affected methane emissions by a factor of six.[129]

But this is only half the story. Developing new shale gas resources would have secondary effects on global energy consumption, along two dimensions: displacement and price. If the UK substitutes domestic shale for imported LNG, some proportion of that LNG may continue to be produced and redirected to another port.[130] Where it is sent to matters. If it offloads in a country where it replaces coal, that will tend to reduce emissions. But, if it is shipped party to a long-term contract that crowds out renewables in the receiving country, that will tend to increase emissions. These displacement effects are extremely hard to predict *ex ante*. It is also worth noting that the role of LNG in the global energy system has been complicated by the impact of Russia's war in Ukraine, with Europe likely to import a lot more LNG than might otherwise have been the case. Significant quantities of LNG could therefore be displaced.

Shale gas extraction would increase the supply of natural gas and should, therefore, lead to a fall in prices and a consequent rise in consumption. There is some evidence that natural gas demand is price elastic and that – though varying by season, sector and country – a given percentage fall in gas prices leads to a proportionally greater percentage rise in gas consumption.[131] If true, the likely reason is that sources of power generation are relatively cross-substitutable, and can increase and decrease operations to balance the grid in a more or less cost-responsive way.[132] It is unclear, however, if UK shale extraction, or the LNG it could displace, would be of a scale large enough to materially affect prices.

What is crucial here is that shale gas is only marginally less carbon-intensive than LNG. This small first-order emissions reduction can therefore be offset by a modest second-order increase in emissions from displaced LNG or rising gas consumption. In their 2021 report on onshore petroleum, the CCC estimated that "the lifecycle emissions savings of UK shale gas over LNG imports would be counteracted if global unabated fossil gas consumption increases by a mere 7% of the extra UK production".[133]

Finally, the CCC was clear that an independent review of shale production should also assess "the implications of fracking for public acceptance of the energy transition, and the risk of lock-in to fossil fuel infrastructure". In this sense, the climate case for shale cannot be neatly walled-off from either its popularity or economics. It is to these issues that we turn next.

Social test

Not only did Liz Truss fail to resurrect the shale gas industry, she dented its prospects by establishing 'local consent' as a test to development, despite the fact that the public oppose shale gas development. 'Local consent' was a gambit to reconcile anti-shale gas MPs from the Bowland with the net zero sceptic wing of the party. But it may be that it could only have succeeded on these terms with a non-majoritarian definition of 'local consent'. Jacob Rees-Mogg tried and failed to equate 'consent' with 'compensation', and before long, was forced into a concession that announced the failure of Liz Truss' gambit. Any definition of local consent would have to win the support of Parliament, and failing that, shale gas exploration could not proceed. It is highly improbable that Parliament will ever vouchsafe anything less than a democratic standard of local consent, meaning that the shale industry only has a future if it can win public support. Is that likely?

128 On fugitive emissions, see, for example, Turk, J. and Reay, D. and Haszeldine, S. (March 2018) 'Gas-fired power in the UK: Bridging supply gaps and implications of domestic shale gas exploitation for UK climate change targets', *Science of the Total Environment*, 616-617, p.323.

129 CCC (March 2016) *The compatibility of onshore petroleum with meeting the UK's carbon budget*, p.56.

130 Along similar lines, researchers have looked at how the US shale boom displaced coal into the export market. See Broderick, J. and Anderson, K. (October 2012) *Has US shale gas reduced CO2 emissions: Examining recent changes in emissions from the US power sector and traded fossil fuels*, Tyndall Manchester Climate Change Centre.

131 See, for example, Burke, P. and Yang, H. (September 2016) 'The price and income elasticities of natural gas demand: International evidence, *Energy Economics*, 59, pp.466-474.

132 Collier, P. and Venables, A. (Autumn 2014) 'Closing coal: moral and economic incentives', *Oxford Review of Economic Policy*, 30(3), pp.497-498; Burke, P. and Yang, H. (September 2016) 'The price and income elasticities of natural gas demand: International evidence, *Energy Economics*, 59, p.473.

133 CCC (31st March 2021) *Advice to the UK government on compatibility of onshore petroleum with UK carbon budgets*.

Consider how the shale gas industry in the UK has fared locally up to this point. The local politics of shale gas has been defined by the fact that its only institutional outlet is the planning process. Drilling for shale gas requires, among a long list of other regulatory accoutrements, planning permission from Local Mineral Planning Authorities. These are usually county councils or their near-relation, unitary authorities. The National Policy Planning Framework (NPPF) sets out the terms along which these planning decisions ought to be made.[134] In particular, it sets out three sources of 'material considerations': the policies in the NPPF itself, local development plans, and government policy.

The local planning system is weighted in favour of shale gas development. Local authorities have only been able to deny permission on highly circumscribed grounds, like traffic, noise and light. At the same time, the government can revise these material considerations, and have done so repeatedly, to create a presumption in favour of shale gas development.[135] Yet, despite both tendencies, shale gas companies have not fared well. Local planning decisions have been long, fraught with controversy, and more often than not, have ended with a negative verdict. One presentation by the industry trade association, UK Onshore Oil & Gas, lamented that "almost 70% of the onshore oil and gas planning applications have been rejected on initial application since 2014".[136] A 2016 Cabinet Office report, only reluctantly released after several years, relays that "industry/HMG [Her Majesty's Government] agree" that the "root cause" of shale's anaemic development is "the long decision timelines and uncertainty experienced in local planning".[137]

For supporters, one temptation has therefore been to circumvent the planning process. In 2016, Lancashire County Council's refusal at Preston New Road and Roseacre was appealed, recovered by the Secretary of State, and then overturned. The government later pursued plans to designate shale wells as Nationally Significant Infrastructure Projects (NSIP), which would have allowed them to bypass local planning. Both only served to inflame public opinion, however. When the NSIP proposal was put to an official consultation, for example, just 1% of respondents supported the idea.[138]

The implications are twofold. First, any future shale gas industry will have to retread this treacherous ground. No company presently has planning permission. It also bears noting that permission is required for exploration and production *separately*, and that the relevant criteria are not the same for both. Lancashire County Council dismissed the relevance of future emissions when reviewing Cuadrilla's planning application at Preston New Road and Roseacre in 2014, for example, on the premise that it was only assessing the exploration and not the production of shale gas. "The impacts of this application must… be assessed against the greenhouse gas emissions from the project for four exploratory wells only".[139] The upshot is that shale gas companies may have to endure not one, but two, multi-year planning applications under the current system before they can begin commercial production. There are also indications that, in what could be a major shift, climate change could move to the centre of future planning decisions. In 2022, the government refused IGas' appeal to develop a shale test well at Ellesmere Port, citing climate change as decisive: they pointed to both the national goal of net zero, and paragraph 152 of the NPPF, which states that projects ought to shape areas to help radically curtail greenhouse gas emissions.[140]

134 See Ministry of Housing, Communities & Local Government (July 2021) *National Planning Policy Framework*. For an overview, see Hawkins, J. (June 2020) *The Shale Gas Legal Landscape*, UKUH Briefing.

135 In 2013, the government wrote into planning guidance that "planning authorities should not consider demand for, or consider alternatives to, oil and gas resources when determining planning applications… energy supplies should come from a variety of sources". See Department for Communities and Local Government (July 2013) *Planning practice guidance for onshore oil and gas*, p.15. In 2018, it inserted a clause into the NPPF advising that "when determining planning applications, great weight should be given to the benefits of mineral extraction, including to the economy". This still stands. It also tried to prescribe that local authorities should "recognise the benefits of on-shore oil and gas development, including unconventional hydrocarbons, for the security of energy supplies and supporting the transition to a low-carbon economy; and put in place policies to facilitate their exploration and extraction". But it was later quashed in the High Court. See Hussain, T. (2019) *UK Planning Policy on Shale Gas Found "Unlawful" by the High Court*, White & Case.

136 McAllister, C. and Yates, G. (undated) *The Case for Shale Gas in the UK*, UKOOG.

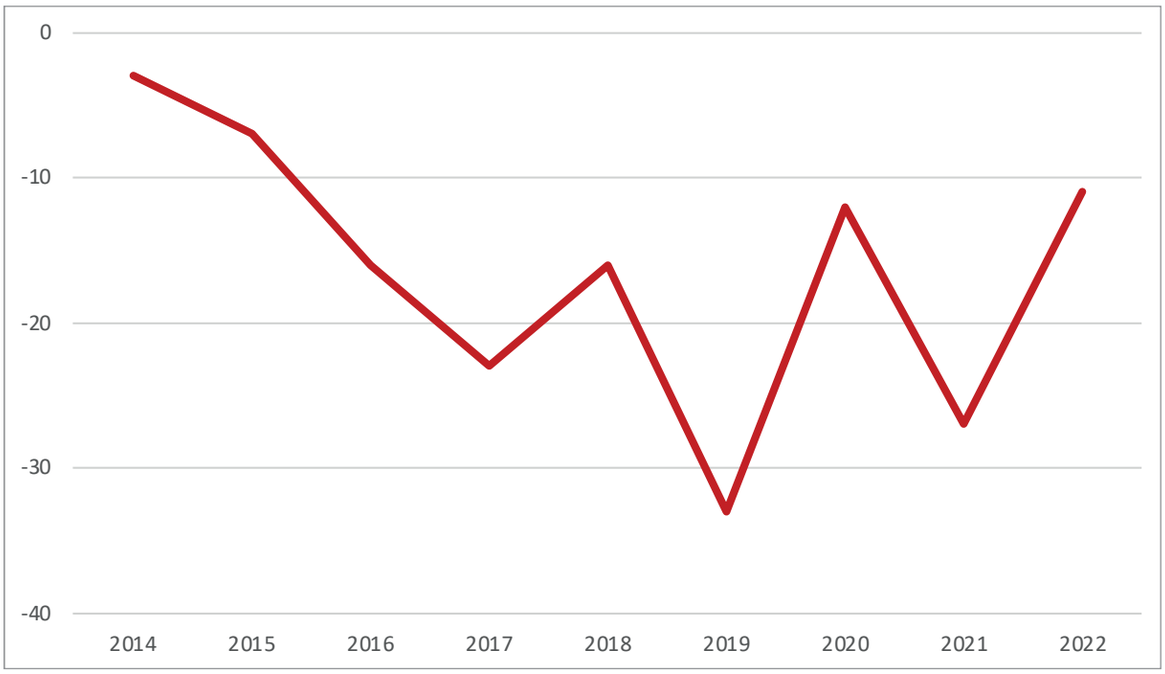
137 Cabinet Office (April 2016) *State of UK shale industry by 2020 and 2025*, p.3.

138 BEIS (November 2019) *Inclusion of shale gas production in the Nationally Significance Infrastructure Project regime: Government response*, p.7.

139 Lancashire County Council (January 2015) *Planning Application LCC/2014/0096 Report and Decision Notice*, Appendix 5: Greenhouse Gas Emissions, p.4.

140 Department for Levelling Up, Housing & Communities (June 2022), *Recovered appeal: land at Ellesmere Port Wellsite.*

Figure 7: Net public support for shale gas



Note: Annual data from each Autumn edition of the BEIS WAVES/PAT surveys.

Second, given that this circumscribed process that grants only a modest role to public opinion has consistently stymied shale exploration, a properly *democratic* test to development would likely be far worse for the industry. We have only to turn to survey evidence. BEIS has run a Public Attitude Tracker (previously known as WAVES) surveying opinions on shale gas since 2014. These results are brought together in the graph above.[141] The UKUH project ASSISST also ran a longitudinal survey from 2019 to 2022.[142] The takeaway from both datasets is clear: the majority of the public have opposed shale gas development since it first began. There is little reason to believe that local opinion deviates from this national picture. In fact, quite the opposite. For example, one recent survey looking at five locations, two in North Yorkshire, one in Lancashire, one in Surrey, and one in Albury, found that hydraulic fracturing was consistently less popular than conventional oil and gas extraction – finding support from between just 5% and 20% of residents.[143]

Economic barriers

The shale gas industry has never cleared the political barriers to its development, so it has never had the *chance* to test its commercial viability. It has not even completed the exploratory drilling on which the productivity of shale wells, and so the profitability of the business of drilling those wells, could be judged. Clearly, companies dedicated to shale gas development are not going concerns. From an investment perspective, they are a long bet on an unproven industry. It would be foolhardy to pretend to cut through this miasma of uncertainty and declare one way or the other on whether shale gas is, in principle, a commercially viable industry in the UK. But this compounding uncertainty is *alone* sufficient to scare off level-headed investors. What we are suggesting is a distinction between whether the industry is 'viable', and whether the industry can resolve the key economic uncertainties afflicting it on a quick enough timeline to attract the investment necessary to reach scale before it is too late.

141 Note two things. Results from the BEIS PAT are here recorded for every Autumn, and a large fraction of survey respondents report neither support nor opposition – these are excluded from the net figures, which simply show support minus opposition.

142 See the data summary at the end of Evensen, D. *et al.* (2nd March 2023) *Growing importance of climate change beliefs for attitudes towards gas*, *Nature Climate Change*.

143 Bradshaw, M. *et al.* (2022) 'We're going all out for shale: explaining shale gas energy policy failure in the United Kingdom', *Energy Policy*, 168, 113132, p.8.

Breakeven price

At a high level, the economics of shale gas production is a function of four factors:

1. Cost of production per well
2. Estimated ultimate recovery (EUR) per well
3. Hurdle rate, as set by the cost of capital
4. Gas prices

The net present value of a shale gas well can be calculated from these values. A well's production curve (2) can be set against projected gas prices (4) to define a cash flow. We then discount this cash flow at an annual rate defined by the cost of capital (3) and subtract the initial production costs (1).

A brief word of explanation on hurdle rates. The cost of capital available to a company should reflect the return investors expect from investments with a comparable risk profile, and thus, it defines the return that the company has to meet to be investable. In reality, different projects will have different risk-return profiles, and so a company's cost of capital, unless earmarked, is the weighted average opportunity cost of its total portfolio of projects. What matters is this: the more uncertain the project the riskier it is, and the riskier the investment, the higher the cost of capital. What, then, are the economic uncertainties haunting UK shale gas development?

To date, there have been two systemic estimates of the breakeven price for UK shale gas – the unit price at which discounted profits would equal costs. One by Bloomberg's New Energy Finance centre (BloombergNEF) in 2013, the other by the academics Jasmin Cooper, Laurence Stamford and Adisa Azapagic in 2018.[144] Their key figures are displayed in Figure 8 below.

Figure 8: Key figures in Bloomberg and Cooper et al. breakeven price estimates

	Wells per pad	Cost per well	EUR per well	Discount rate	Breakeven price
Bloomberg	6	£6.6-9m	~132mcm[145]	15%	1.8-2.5 p/kWh
Cooper et al.	40	£18m	122mcm	10%	2.6 p/kWh

BloombergNEF reaches a central breakeven price for UK shale 1.7 times more expensive than the dry US shale plays, and 3 times more expensive than the wet US plays.[146] It also finds that in all but the most optimistic scenario, shale fuelled CCGT generation is more expensive than onshore wind generation. Cooper et al. put the central breakeven price for UK shale at 1.45 times the gas price of the UK National Balancing Point, and 3.37 times the price of the US Henry Hub.[147] They also find that, while the levelised cost of electricity produced by CCGT plants is cheaper than existing nuclear and renewable alternatives, because fuel accounts for more than half of its costs, and shale gas has a higher breakeven price than conventional gas and LNG, shale gas is not a competitive fuel for power generation.

Cooper et al. conclude that "the results of this study suggest that shale gas may not be economically viable as a fuel for electricity generation", without presuming to rule out its use for heat generation and as a petrochemical feedstock, the economics of which remains "unknown". BloombergNEF's analysis is only incrementally more positive for shale gas development. According to these studies, our baseline expectations should be that the economics of shale are marginal. But what if we insert into this picture deep-seated uncertainty? In what follows, we look at a series of unanswered questions regarding the production costs, and production rates, of shale gas. We then reflect on what this means for shale gas as an investment proposition, and in turn, the industry's cost of capital.

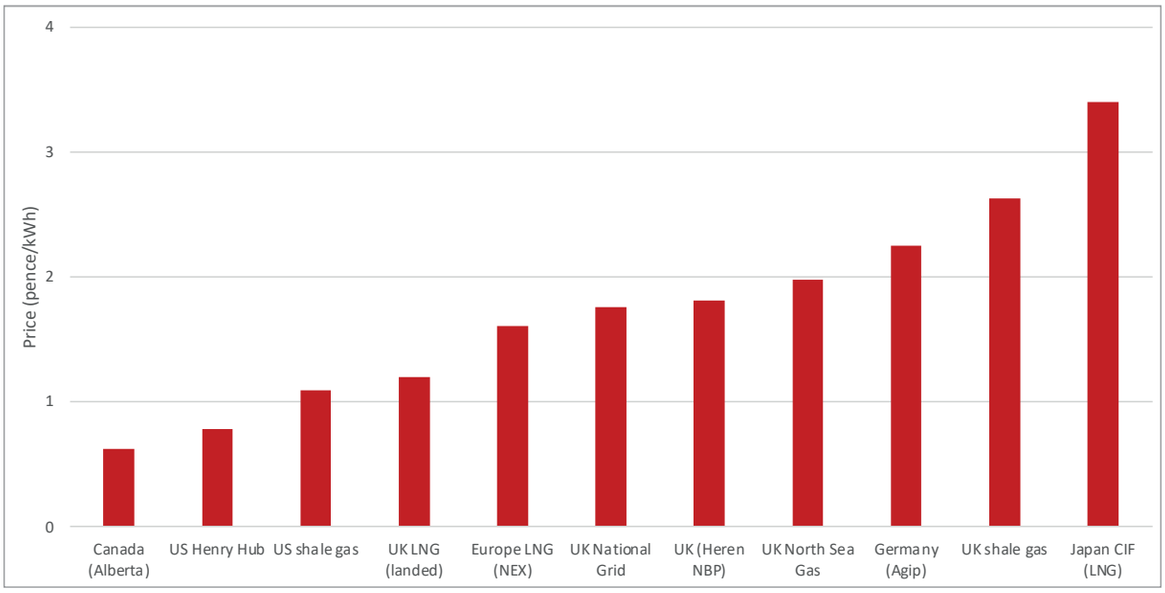
144 House of Lords Select Committee on Economic Affairs (2013) 'Bloomberg – Written Evidence', in *The Economic Impact on UK Energy Policy of Shale Gas and Oil: Oral and Written Evidence*, pp.3-14; Cooper, J. and Stamford, L. and Azapagic, A. (2018) 'Economic viability of UK shale gas and potential impacts on the energy market up to 2030', *Applied Energy*, 215, pp.577-590.

145 Bloomberg does not show a lot of its workings, including its posited EUR. However, it does reveal the initial 30-day well production rate it assumes. If we put this alongside median values for the rate of decline of production, we can reach a (very rough) estimate of Bloomberg's posited EUR – which is what is shown here. Note also that 'mcm' designates million cubic metres.

146 House of Lords Select Committee on Economic Affairs (2013) 'Bloomberg – Written Evidence', in *The Economic Impact on UK Energy Policy of Shale Gas and Oil: Oral and Written Evidence*, pp.5-6.

147 The authors relate that they use market spot prices for this comparison, though whether this is an average, and if so, over what time period, is unstated.

Figure 9: Cooper et al. breakeven price for UK shale gas versus competitors



Note: Sourced from p.8 of Cooper et al. (2018)

Production rates

How much gas will the average shale well in the UK produce? The simple answer is that we don't know. Researchers have, until now, been forced to rely on extrapolations from US analogues. Cooper et al. base their production figures on a database of nearly 3000 US wells, while Bloomberg models their optimistic scenario on the Marcellus and Eagle Ford plays, and their pessimistic scenario upon the Barnett shale. Both, recall, estimate that a UK shale well's average lifetime production will be around 120-130 million cubic metres (mcm). By contrast, the European Commission's Joint Research Centre put the most likely EUR of a shale gas well at 56 mcm[148], while Cuadrilla have since published a 'central estimate' of no less than 155 mcm per lateral.[149] Uncertainty prevails.

In 2013, the BGS estimated that the total gas-in-place in the UK was between 23 and 64 trillion cubic metres.[150] But this was attended by two caveats. One, the BGS was clear that "not enough is yet known to estimate a recovery factor", the volume of this gas-in-place that could be *economically* recovered. "Only with further shale gas exploration drilling and testing over an extended period... will it be possible to determine whether this identified shale gas prospectivity can be exploited commercially".[151] The BGS emphasise that one of the criteria of a successful shale play is "large, stable basins, without complex tectonics", before observing that "Britain is located at the junction of several structural terrains and has undergone a complex geological history; the basins are also generally small. Locally, faulting occurs at high densities".[152] This complex geology is routinely cited as the principal uncertainty facing UK shale development. Two, the BGS' estimate is reached through a bottom-up assessment of geological parameters, filled in with data gleaned from outcrop geology, 3D mapping, magnetic evidence, borehole data, and information from US plays. But this is widely considered, including by the BGS, to be a preliminary to a far more reliable top-down assessment based directly on well data. Clearly, that has not happened since.

Consider two recent papers, which speak to each of these uncertainties. Ian de Jonge-Anderson and John Underhill explore how the Bowland shale has been deformed and bisected into a series of uneven compartments.[153] If the aim is to drill along a horizontal plane multiple times from a single vertical well,

148 Pearson, I. *et al.* (2012) *Unconventional Gas: Potential Energy Market Impacts in the European Union*, JRC Scientific and Policy Reports, p.50.

149 UKOOG (March 2019) *Updated hale gas production scenarios*, p.3.

150 BGS (2013) *The Carboniferous Bowland Shale gas study: geology and resource estimation*.

151 BGS (2013) *The Carboniferous Bowland Shale gas study: geology and resource estimation*, p.3 & p.47.

152 BGS (2013) *The Carboniferous Bowland Shale gas study: geology and resource estimation*, p.9.

153 Jonge-Anderson, I. and Underhill, J. (May 2020) 'Structural constraints on Lower Carboniferous shale gas exploration in the Craven Basin, NW England', *Petroleum Geoscience*, 26, pp.303-324.

the fact these compartments often stand askew from one another represents an obvious problem. The authors conclude that "the Bowland shale gas play remains highly challenged, with significant uncertainty in its resource estimates, the planning well site locations, horizontal wellbore pathways and risk of induced seismicity". In a major paper, Patrick Whitelaw and colleagues use a novel technique to estimate the UK's gas-in-place: they stimulate shale rock within a laboratory using high-pressure water pyrolysis, before scaling these results to the whole Bowland shale.[154] They find that the 2013 BGS report betrays systematically optimistic assumptions and reach an alternative gas-in-place estimate that is smaller by a factor of 10. These studies are far from definitive, and have been met with healthy debate, but the point is this: whether UK shale wells can produce at economic rates is as questionable as ever.

Production costs

Drilling and hydraulically fracturing a well is cost intensive. It requires land rigs to drill vertical and horizontal bores, high-pressure pumps capable of exerting 12,000 pounds per square inch of pressure on subterranean rock, proppants to hold open these fissures and chemicals to ease the flow of fluid, as well as water and waste treatment to recycle or dispose of the staggering volumes of liquids involved.[155] In tandem, it needs skilled labour to plan and operate this technological system: engineers, geoscientists, surveyors and architects, to say nothing of accountants, plumbers, mechanics, welders and carpenters. It may also need midstream infrastructure to separate methane from inert and toxic gasses, and to transit the gas into the mainline transmission system. This means gathering pipelines have to be laid, and processing facilities built where none are within reach. What is more, all of this has to be iterated at a swift clip. Shale wells follow a hyperbolic decline curve such that they produce the majority of gas within the first one or two years of their 30-year lifetime. So, to hold production steady or increase it over time, new wells have to be drilled and fractured constantly – hence the adage in the US of 'drill baby drill'. A range of questions can be asked of these costs.

1. While the UK has a long-standing onshore oil and gas industry, by international standards it is negligible. If we look at Baker Hughes' monthly land rig count for the UK over the last decade, it averages a vanishing 0.3 rigs.[156] Europe at large does not have a large onshore industry, either. It follows that the UK would have to pay a premium to import specialist equipment and services from North America, while pursuing an industrial strategy to bring costs down over the long-term. No such strategy presently exists.

2. The more wells per pad, and the more laterals per well, the lower the cost per unit of gas produced. Unfortunately, these ratios are usually just assumed, giving rise to a wide variance. Ricardo Energy & Environment assume just 1 lateral per well[157], while Cuadrilla have recently canvassed the possibility of 12 laterals per well.[158] In reality, these judgements will be site-specific, constrained by land use, geology and infrastructure, and ultimately, only revealed in practice.

3. Training a large pool of skilled labour to plug into an onshore gas industry requires long-term strategic planning and institutional buy-in. As a government commissioned EY report found in 2014, "unless early action is taken, there is a risk that... new demand makes existing skill shortages worse. Forward planning poses challenges whilst uncertainty still exists about the speed at which the shale industry will develop".[159] This skill shortage has only worsened since. In 2022, 97% of industry respondents report difficulties attracting skilled staff, amidst a tight labour market and competition from abroad.[160]

4. US shale today stands chastened. One well-known reason is that it spent years ploughing its cash flow into growth, burning investors when prices stuttered after 2014, and then crashed during the COVID pandemic. The industry has refocused on dividends and buybacks to satiate its Wall Street backers, ignoring Biden's pleas to expand production to fill the breach during the energy crisis, and transforming shale into the highest-performing sector in the S&P 500 over the last two years. But a more prosaic reason for its

154 Whitelaw, P. *et al.* (2019) 'Shale gas reserve evaluation by laboratory pyrolysis and gas holding capacity consistent with field data', *Nature Communications*, 10 (3659).

155 For systematic cost estimates, see Institute of Directors (2013) *Getting shale gas working*; EY (2014) *Getting ready for UK shale: Supply chain and skills requirements and opportunities*.

156 Baker Hughes' rig counts can be viewed *here*.

157 Ricardo-AEA (2014) *Unconventional gas in England: Description of infrastructure and future scenarios*, p.61

158 AJ Lucas (September 2022) *Equity Raising Presentation*, p.8.

159 EY (2014) *Getting ready for UK shale: Supply chain and skills requirements and opportunities*, p.26.

160 OEUK (2022) *Workforce Insight 2022*, p.11.

dimmed horizons is that its costs are soaring. A range of sources have cited an increase in the cost of shale gas production of between 20% and 30%, in what Rystad has called "a year plagued by bottlenecks and cost inflation".[161] Shortages of rigs to drill, steel to encase wells, sand to act as a proppant, as well as rising wages to attract staff – all have amplified costs. Bloomberg reported a 150% rise in the cost of frack sand alone in July 2022, and a shortage on the order of 1 million tons.[162] Shale companies in the UK could therefore find themselves in a position of importing equipment and services from a market that is itself riven by spiralling costs. Add to this an ever-present exchange rate risk, with sterling falling in value from $1.35 in 2021 to $1.20 today, having hit a low of $1.08 in the wake of Liz Truss' mini-budget.

Hurdle rates

The criterion of success for a commercial project is not mere profitability, but the hurdle rate. If an equally risky project promises a 10% return, and you return 8%, then the opportunity cost of the investment is negative. It is a bad investment. But the higher the chance of failure – of devaluation, foregone dividends and default – the higher the anticipated return has to be for the investment to offset this risk. Crudely, expected value is the return promised multiplied by the probability of its realisation. This is a problem before the fact, as much as after the fact: companies will only raise investments at scale in the first place with a convincing risk-return profile. Given everything that we have seen – political and economic – that is an enormous, perhaps insuperable, roadblock to the development of the UK shale gas industry.

First, the higher the cost of capital, the more difficult the economics of shale gas production. If, as the studies of Cooper et al. and Bloomberg suggested, the economics of shale are marginal, piling uncertainty onto the equation will render the industry unviable. As Cooper et al. emphasised, the breakeven price of shale is highly sensitive to the discount rate, which is set by the cost of capital.[163] Oddly, they assume a 10% discount rate for UK shale, and a 15% discount rate for US shale. But when these rates are equalised, the breakeven price for UK shale jumps to 3.13 p/kWh, as compared to 1.09 p/kWh for US shale. At 20% it becomes crippling 3.62 p/kWh. Even established companies in the oil and gas sector have reported that their cost of capital has soared over recent years. BP reports a cost of capital of 20%, Goldman Sachs put the cost of capital for offshore oil at over 20% for 2018-2020, and in a survey of investors, Bassam Fattouh at the Oxford Institute for Energy Studies discovered a spike in the cost of capital: to 18-20% for conventional oil projects, and to 15% for short-cycle US shale oil.[164] Investors are circumspect, alive to the possibility that fossil fuel assets could become stranded, as clean energy alternatives, political regulation and consumer sentiment conspire against the sector. The problem is that the UK shale industry is not an established player, but a new entrant, without the capital, infrastructure or political legitimacy of its competitors, and plagued by wide-ranging risks. At scale, its cost of capital is therefore likely to be prohibitive.

Second, the industry has only a small window in which to reach scale, a window defined by the energy transition. The UK's carbon budget will shrink year-on-year and, as we noted earlier in relation to National Grid's Future Energy Scenarios, depending on the extent to which CCS+SMR is used to create blue hydrogen, gas demand will fall sharply too. It is not alone. The IEA's net zero scenario has global gas demand peaking before 2030, and then arching downwards to 2050, totalling a 55% cut.[165] Of course, this is a scenario, but the point is that gas demand will fall, and as it does, falling prices will crush high-cost producers. If we imagine global gas projects arranged along a cost supply curve, as the price falls, more and more projects will fall below the waterline. If the shale industry cannot attract the investment to reach scale at pace, it risks missing the closing window of opportunity for high-cost gas producers during the energy transition.

161 Brower, D. and McCormick, M. (January 2023) '*What the end of the US shale revolution would mean for the world*', *Financial Times*; Rystad Energy (December 2022) *Whitepaper: US shale industry bottlenecks linger, weigh on activity despite capacity additions*; Kearney, L. and Hampton, L. and Somasekhar (December 2022) '*Europe can't look to US shale to fill any OPEC gap*', *Reuters*.

162 Wethe, D. (July 2022) '*The Cost of Sand has Spiked 150% in Texas*', *Bloomberg*.

163 Cooper, J. and Stamford, L. and Azapagic, A. (2018) 'Economic viability of UK shale gas and potential impacts on the energy market up to 2030', *Applied Energy*, 215, pp.583-584.

164 BP (2nd August) *2Q 2022 Results: Webcast and Q&A Transcript*, p.2; Goldman Sachs (March 2022) *Carbonomics: Security of Supply and Return of Energy Capex*, p.6; Fattouh, B. (2019) *Energy Transition, Uncertainty, and the Implications of Change in the Risk Preferences of Fossil Fuels Investors*, The Oxford Institute for Energy Studies, Oxford Energy Insight 45.

165 IEA (May 2021) *Net Zero by 2050*, p.101.

Conclusion

Liz Truss' attempt to revive shale gas was improbable from the start. Boris Johnson pledged to proscribe hydraulic fracturing until evidence emerged that induced seismicity could be controlled. But, given the ingrained standard of acceptable seismicity - 'local disturbance' - Johnson's test to development threatened to establish a bar that could never be met. Net zero was incorporated into law in 2019, becoming a subject of bipartisan consensus, and the CCC and NSTA both went on to suggest that the development of any new oil and gas fields ought only to take place upon passing a climate test. Finally, shale development had always faced majority opposition nationwide, and intense protest locally. Boris Johnson's decision to impose a moratorium was, likely, partly an effort to garner support across the 'red wall'. But for precisely the same reason, this new intake of MPs created an inbuilt constituency within the Conservative Party who, channelling their constituencies, stood adamantly opposed to shale gas development.

What is striking, therefore, is that Liz Truss ever decided to make the revival of shale gas a flagship policy of her premiership. But this decision did not emerge from nowhere. Beginning September 2021, as the post-pandemic energy price crisis crashed into the UK, a populist campaign emerged to resuscitate shale gas, coordinated between the Conservative party, leading newspapers, and the industry. Liz Truss aligned herself with this campaign to win the favour of the right-wing of the Conservative Party in her bid for leadership. But she made her support for shale development conditional on 'local consent' to calm the fears of Bowland MPs. However, this did not resolve the conflict in her party, so much as delay it.

On the day the moratorium was lifted, Jacob Rees-Mogg tried and failed to wriggle out of this bind, equating 'consent' with 'compensation'. The next day, the administration self-detonated when it released its 'mini-budget'. It would not be entirely unreasonable to say that, within a day of the moratorium having been lifted, the revival of shale gas development was dead. With its authority stripped, and bound to a standard of 'local consent' that it could not meet, not to mention no answer to the climate and seismicity tests, Labour's bill to ban hydraulic fracturing brought these contradictions to a head within the Conservative party. Turmoil ensued, quickly followed by Liz Truss' resignation.

In the end, Liz Truss only damaged the prospects of the shale industry. She has made any future development conditional on the industry winning local consent, and her example will only warn off imitators. At the same time, the industry has no planning permissions in place to drill, and its petroleum exploration licences will soon begin to expire. It is far from clear that it is possible to prevent induced seismicity liable to 'disturb' local residents, and it seems likely that the UK has a risk of seismicity that means earthquakes of this magnitude simply *will* occur, sooner or later, if the shale industry were ever to begin operations again. In the case of climate change, there is a trade-off between the savings in lifecycle emissions achieved by switching from imported LNG to domestic shale, and the increase in global aggregate gas production that a native shale industry would bring about. There is a large dose of uncertainty involved in this calculation, and it is unclear what an independent review, of the kind recommended by the CCC, would find. Finally, after the last decade, it is difficult to imagine the communities across the Bowland consenting to shale development, or Parliament assenting to any standard of 'consent' other than a democratic one. The three tests represent three barriers to development, each one perhaps insuperable.

The UK's shale gas potential remains unclear, we do not know how much a given well will produce, as the geology still remains fundamentally untested. Nor do we know how much it will cost to produce shale gas per well, only that the industry will have to import equipment and labour at a premium from North America, because it does not have its own industrial strategy. Equally serious is that the compounding political, geological and economic uncertainties afflicting the industry – on top the transition risks facing the entire fossil fuel economy – will push its cost of capital up to prohibitive levels. At worst, this would torpedo the economics the entire industry; at best, it would prevent it from reaching scale at any pace. The latter alone is a problem, however, because as a relatively high-cost producer confronting a period of declining global, and domestic, gas demand, it has only a brief window of opportunity.

If we can therefore pronounce the shale industry dead, what follows from this? The principal argument for the shale industry was always that it would help offset the decline of UKCS production, providing a fresh source of secure, native gas. But this was never a cut and dried argument, given questions about the scale of possible shale production, and the fact that it would be priced and sold on the European gas market.

In any case, shale's death settles the matter, and forces the question of UK energy security anew. With declining UKCS production and the death of shale, it is now clear that a growing proportion of natural gas consumption will depend on imports, exposing the UK to volatile international prices and supply shocks. This growing insecurity has an obvious answer on the demand side: accelerate the roll-out of heat pumps to replace gas boilers, and return energy efficiency installations to their 2012 peak. But it also raises supply-side questions. In the future the role of natural gas will depend, to a significant extent, on the scale at which blue hydrogen is used with CCUS as a flexible source of power generation to help balance variable renewables in the 2030s, and to replace fossil fuels in hard-to-abate industrial processes. But if natural gas has an insecurity premium, this might weigh in favour of maximising the proportion of green over blue hydrogen. The problem is that renewable build rates are not sufficient to produce the level of green hydrogen required. One option, however, would be to import green hydrogen or, more likely, to import low-carbon electricity to power electrolysers here in the UK. This would have the added benefit of diversifying the hydrogen supply mix, balancing electricity and gas imports. Another option would simply be to reduce hydrogen's role in the future energy system.

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