Written evidence submitted by Dr John Broderick, Tyndall Centre for Climate Change Research, University of Manchester

Shale Gas and Carbon Budgets

Dr John Broderick is a Knowledge Exchange Fellow at the Tyndall Centre for Climate Change Research within the School of Mechanical, Aerospace and Civil Engineering, University of Manchester www.tyndall.manchester.ac.uk. All views contained within are attributable to the author and do not necessarily reflect those of other researchers at the Tyndall Centre or University of Manchester. This briefing concerns the climate change consequences of a potential shale gas industry in the UK and not the full range of conceivable benefits and negative impacts.

Avoiding dangerous climate change and meeting UK commitments means phasing our fossil fuels in the next two decades.

1. The problem of climate change is largely due to the transfer of carbon from fossil fuel reservoirs into the atmosphere as carbon dioxide. Fossil fuels of all kinds are high carbon. Although the carbon content varies between them, it would be erroneous to regard any fossil fuel as "low carbon".[1] Therefore, delivering a stable climate will entail a very much reduced use of all fossil fuels, through a consistent set of actions and policies.

2. Cumulative greenhouse gas emissions largely determine the extent of climate change so the timescales of changes in the energy system, and the quantities of emissions during this period of change, matter a great deal.[2] Any meaningful claim to gas being a 'transition fuel' must relate the time period of transition to the cumulative emissions released along the way and therefore the likelihood of dangerous climate change arising.

3. The arithmetic of carbon budgets make it clear that the UK requires a transition to a low carbon energy system within the next two decades with an 80% reduction from the energy system by 2030.[3] The rate and extent of the change implied suggests that our efforts ought to be focussed on reducing the demand for energy through, for instance, retrofitting existing buildings, introducing performance standards for cars and consumer goods, and delivering genuinely low carbon energy supply.

Early UK shale 'gas in place' estimates greatly exceed the emissions space available in the Interim carbon budget presented by the CCC.

4. Consider the claim that the Bowland Shale contains sufficient gas to meet our current demand for gas for up to 51 years on the basis of 10% recovery rate.[4] This amount could not be accommodated in the CCC's Interim budget when deductions are made for non-CO2 emissions from agriculture. In the UK, it is unlikely we would have commercial production of this scale (~80bcm p.a.) before 2025 even with favourable geology. The budget available from this date is

---

[1] Broderick, J. and Anderson, K. (2012) Regulation of the unconventional fossil fuels extraction; Climate change considerations. https://www.escholar.manchester.ac.uk/jrul/item/?pid=uk-ac-man-scw:221718

[2] IPCC (2013) Working Group 1: The Physical Science Basis, SPM E8 p27 http://www.ipcc.ch/report/ar5/wg1/

[3] Anderson, K. (2014) Open Letter to the Prime Minister http://kevinanderson.info/blog/letter-to-the-pm-outlining-how-2c-demands-an-80-cut-in-eu-emissions-by-2030/; Anderson, K., and Bows., A. (2011) Beyond dangerous climate change: emission pathways for a new world, Philosophical Transactions of the Royal Society A, 369, 20-44, DOI:10.1098/rsta.2010.0290

[4] For instance, Cameron, D., The Telegraph 11th Aug 2013, http://www.telegraph.co.uk/news/politics/10236664/We-cannot-afford-to-miss-out-on-shale-gas.html

equivalent to 3% to 4% of the central BGS gas in place (GIP) estimate for Bowland shale (see Fig 1). Even with very optimistic assumptions on carbon capture and storage (CCS) deployment a maximum of 6% of the Bowland GIP could be burned in the UK; this would leave *no* emission space for oil use in any surface and air transport. It seems reasonable to conclude that a large scale, long lived UK shale gas industry, would therefore include a substantial export element and without internationally binding and stringent emissions caps this would likely be detrimental to efforts to stay below the 2°C characterisation of dangerous climate change. If such caps were in place then it is likely that only gas resources at the bottom of the supply cost curve would be exploited and it is questionable whether UK shale gas would fall into this category.

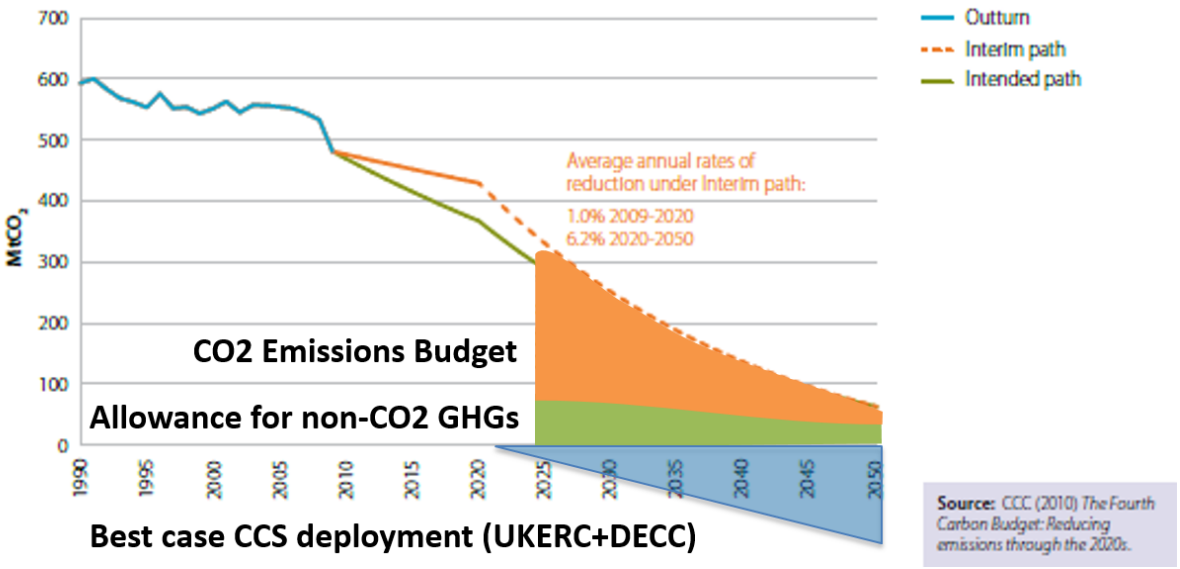

Figure 1 UK CO2 emissions space available to gas under CCC Interim budget

5. It is clear that much of existing, economically recoverable fossil fuel reserves, must be left underground to give even a 50% chance of avoiding 2°C warming. McGlade and Ekins (2015) conclude that 50% of global gas reserves are 'unburnable', including >80% of global potential unconventional gas reserves, in addition to a third of oil and 80% of coal.[5] Inevitably, agreements must be made between governments, investors and the fossil fuel industry as to which fossil fuels are not developed.

There is substantial discrepancy between UK domestic carbon budgets and our international commitments.

6. From the Copenhagen Accord (2009) and subsequent UN climate negotiations the UK has repeatedly committed to making its fair contribution to "hold the increase in global temperature below 2°C, and take action to meet this objective consistent with science and on the basis of equity". However, the Government's choice of a global budget, from which our national budget is derived, is equivalent to a 63% chance of exceeding 2°C; a postion clearly inconsistent with the language of "hold below" and "must not exceed".

7. This variation in probability makes a substantial difference to the size of the emissions budget and hence how appropriate different energy technologies and policies are. The UK budgets also assume all nations undertake emissions reductions concurrently, making little allowance for historical responsibility or financial and technical capability.

[5] McGlade, C. and Ekins, P. (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2°C, Nature 517, 187—190, doi:10.1038/nature14016

Abundant gas supply is not good for the climate in and of itself and may work against climate policy.

8. In his review of the topic, Prof David Mackay, previous DECC Chief Scientific Advisor concluded *"If a country brings any additional fossil fuel reserve into production, then in the absence of strong climate policies, we believe it is likely that this production would increase cumulative emissions in the long run. This increase would work against global efforts on climate change."*[6]

9. The 'Golden Age of Gas' scenario presented by the IEA indicated projected 3.5 °C warming.[7] Their Chief Economist, Fatih Birol, commented that "We are not saying that it will be a golden age for humanity – we are saying it will be a golden age for gas".[8] More recent research compared five different integrated assessment models and found that the majority indicated modest increases in CO2 emissions given globally abundant gas. [9] All five models found that gas substitutes largely for coal, but also nuclear and renewable energy, and tended to increase economic activity and hence overall emissions unless it was specifically restricted to coal substitution.

Much discussion of the climate change performance of shale gas has centred on relative intensity comparisons with coal, in the form greenhouse gas emissions per unit energy or on fugitive methane releases. These concerns have limited relevance to UK energy policy.

10. Most existing coal plants will be retired, due to national and European environmental regulations, before substantial commercial production of shale gas. New-build unabated coal has been ruled out by all major political parties. Therefore, the relevant direct comparison for UK shale gas is with biogas, other natural gas sources, and biomass (in the power sector). Estimates of shale gas emissions intensity being greater than coal (e.g. Howarth et al 2011) typically use a Global Warming Potential (GWP) calculated over 20 years to relate the impact of methane from leakage to carbon dioxide from combustion. Impacts on ecosystems, food systems and infrastructure beyond 20 years are significant so this time period is not favoured in climate and energy policy.

11. Methane leakage is uncertain and found to vary substantially between sites in US academic studies. In the UK, a transparent and rigorous programme of monitoring during any development will be important. For instance, Dr Grant Allen in the University of Manchester School of Earth Atmospheric and Environmental Sciences, is undertaking background and ongoing methane and carbon dioxide measurements of Cuadrilla's sites in the North West. Once characterised emissions sources from shale gas production ought to be accounted for within UK carbon budgets. "On-shoring" these sources of emissions, although arguably beneficial from a global climate change perspective, may increase pressure on other sectors within the UK budgets.

12. Local fuel switching only has its full net climate benefit if there is no production of the higher intensity fossil fuel. Empirical evidence from the USA suggests this is unlikely to be the case. [10] The latest US government data (Figure 2) shows that during the recent growth in shale gas and oil production, CO2 emissions from combustion of fossil fuels produced in the US has risen by

---

[6] D. J. MacKay and T. J. Stone, Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use, DECC, 2013

[7] IEA, *World Energy Outlook 2011 Special Report: Are We Entering A Golden Age of Gas?*, International Energy Agency, Paris, France, 2011.

[8] Harrabin, R. *Anger over agency's shale report*, BBC, London, UK, 2012.

[9] McJeon, H et al (2014) Limited impact on decadal-scale climate change from increased use of natural gas, Nature 514, 482–485, doi:10.1038/nature13837

[10] Broderick and Anderson (2012) Has US Shale Gas Reduced CO2 Emissions? https://www.escholar.manchester.ac.uk/uk-ac-man-scw:211539

approximately 10%, whilst emissions from US consumption have decreased by the same amount.

12 January 2015

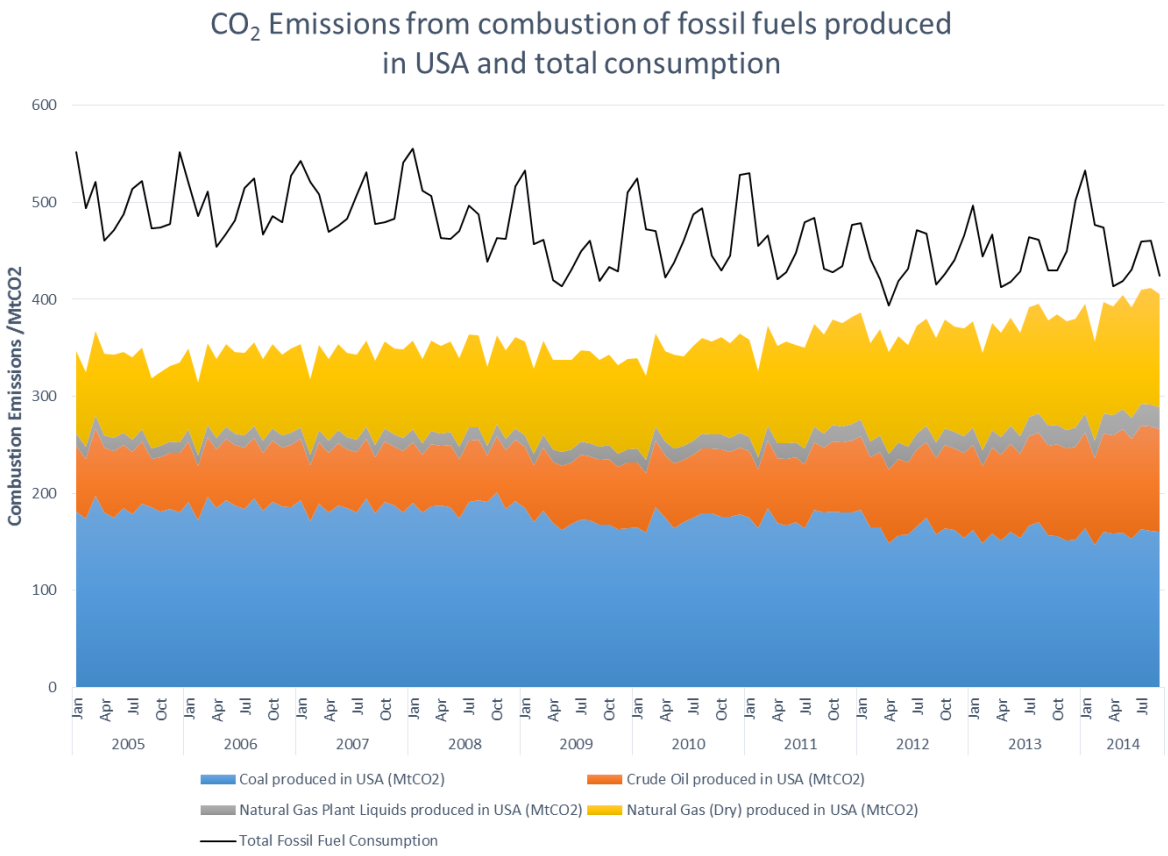

Figure 2 US EIA December 2014 Monthly Energy Review, conversions to CO2 by author