Pre-cognition by Dr John Broderick in
Planning Permission Appeal PPA-240-2032

COAL BED METHANE PRODUCTION, INCLUDING DRILLING, WELL SITE ESTABLISHMENT AT 14 LOCATIONS AND ASSOCIATED INFRASTRUCTURE AT LETHAM MOSS, FALKIRK FK2 8RT Falkirk (P-12-0521-FUL) and Stirling (12/00576/FUL)

on behalf of FoE Scotland; FoE Falkirk; FoE Stirling; and supported by Transition Stirling (referred to as ‘FoE Scotland’)

Compatibility of Coal Bed Methane Extraction with UK and Scottish Commitments on Climate Change

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I am a member of the Tyndall Manchester research group, a core partner of the UK's leading interdisciplinary climate change research centre. I hold a PhD in climate policy from Manchester Business School and a BA/MA (Cantab) in natural sciences from Cambridge University. In late 2011 I led the production of a high profile assessment of the climate change and environmental impacts of shale gas.[1] This was followed by a quantitative estimate of the emissions embodied in coal displaced in part by shale gas in the USA.[2] With Professor Kevin Anderson, I was commissioned by the European Parliament Petitions Committee to review the ‘low carbon’ credentials of unconventional natural gas[3] and have acted as a peer reviewer for the Department of Energy and Climate Change report on the same topic.[4]

All views contained within this statement are attributable to the author and do not necessarily reflect those of researchers within the wider Tyndall Centre or the University of Manchester.

This statement argues that with current trends we are likely to exceed 2°C of mean global warming associated with dangerous climate change. Bringing additional fossil fuel reserves into production, in the absence of an effective global carbon cap, will likely increase global cumulative emissions, a position held by the DECC Chief Scientific Advisor. As such, coal bed methane production is inconsistent with current national and international commitments on climate change and the emissions reductions necessary to avoid dangerous climate change.

Context – current emissions trends, targets and implications

1. We are currently on a path towards very dangerous climate change.[5] Global emissions of CO_2 have increased by 3.1% per year since 2000 on average, three times faster than the 1.0% per year

[1] https://www.escholar.manchester.ac.uk/uk-ac-man-scw:156730
[2] https://www.escholar.manchester.ac.uk/uk-ac-man-scw:211539
[3] http://www.europarl.europa.eu/RegData/etudes/workshop/join/2012/462486/IPOL-PETI_AT(2012)462486_EN.pdf
[4] https://www.gov.uk/government/publications/potential-greenhouse-gas-emissions-associated-with-shale-gas-production-and-use
[5] Anderson, K., & Bows, A. (2011). Beyond 'dangerous' climate change: emission scenarios for a new world. *Philosophical Transactions of the Royal Society A - Mathematical Physical and Engineering Sciences, 369* (1934), 20-44.

increase observed in the 1990s.[6] Observed global CO_2 emissions are following the upper end of the emissions scenarios used in the 5th report of the Intergovernmental Panel on Climate Change[7] and are increasingly diverging from the emissions required to limit global warming to the 2°C characterisation of "dangerous global climate change". The current trend scenario (RCP 8.5) has a central estimate of mean global warming of 3.7°C above pre-industrial temperatures at the end of the century (IPCC 2013), above any warming levels that is thought to have occurred on Earth in the past 5 million years.

2. From the Copenhagen Accord (2009)[8] and subsequent UN climate negotiations through to the G8 Camp David Declaration (May 2012)[9] 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". Whilst this qualitative language of consensus around 2°C has been clear and consistent for many years ("hold below", "must not exceed", etc.) there has been no open clarification as to what quantitative probabilities such language represents. In the absence of any explicit quantification, probabilities may be inferred by adopting the approach developed for the IPCC's reports, whereby a correlation is made between the language of likelihood and quantified probabilities.[10] Following this approach, the Accord's, EU's and UK Government's statements all clearly imply very low (0%-10%) probabilities of exceeding 2°C. Even a highly conservative judgement would suggest the statements represent no more than a 33% chance of exceeding 2°C. However in 2013, and with the UK's preferred probability density function (PDF) of temperature increase for a given trajectory (taken from Murphy et al, 2004)[11], a 0%-10% chance of exceeding 2°C would leave almost no available carbon budget. Stretching the probabilities further detracts from any reasonable interpretation of the "must not exceed" language; though given the emissions released since 2000, it is now difficult to envisage anything much lower than 30%-40% chance of 2°C being either physically viable or deliverable in practice.

3. Against this quantitative backdrop, it is clear that the UK Government's choice of a global budget equivalent to a 63% chance of exceeding 2°C is incompatible with the UK's repeated commitments made at international forums.[12] Exacerbating the inconsistent domestic and international positions on climate change are issues related to how the UK chooses to apportion global emissions to the national level. Anderson and Bows (2011) take a framing of equity starting with the question "what reduction profiles could non-Annex 1 (i.e. developing) nations reasonably be expected to achieve if pushed extremely hard in terms of a rapid transition away from their growing emissions, and towards absolute mitigation". They adopted a range of scenarios, but suffice to say the budget remaining for the Annex 1 (developed) nations in all of these was significantly more challenging than the proportional budget adopted by the UK government.

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[6] Peters, G.P., Andrew, R.M., Boden, T., Canadell, J.G., Ciais, P., Le Quéré, C., Marland, G., Raupach, M.R., Wilson, C. (2013) The challenge to keep global warming below 2°C. *Nature Climate Change* 3, 4-6.

[7] T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley, eds., *Climate Change 2013: The Physical Science Basis*, Cambridge University Press, Cambridge, UK and New York, USA, 2013.

[8] Copenhagen Accord (2009) 3 Report of the Conference of the Parties; fifteenth session; Copenhagen, 7 to 19 December 2009. Part Two: Action taken by the Conference of the Parties FCCC/CP/2009/11/Add.1 30 March 2010 http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

[9] Camp David Declaration: Camp David, Maryland, United States; May 18-19, 2012 http://www.whitehouse.gov/the-press-office/2012/05/19/camp-david-declaration

[10] Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. IPCC Cross-Working Group Meeting on Consistent Treatment of Uncertainties. Jasper Ridge, CA, USA. 6-7 July 2010 http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf

[11] Murphy, J.M., et al. (2004) Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 429, 768–772.

[12] Anderson, K., R. Starkey, and A. Bows (2009) Defining dangerous climate change - A call for consistency. Tyndall Centre Briefing Note 40.

4. In brief, and to put some perspective on the change in the scale of the challenge, even if non-Annex 1 nations can peak by 2025, and reduce emissions thereafter at around 7% p.a. (approximately twice the level Stern *et al* suggest is possible with economic growth), then there is no discernible emission space remaining for Annex 1 nations. Only if the growth to a 2025 peak in non-Annex 1 emissions is radically curtailed to just 1% p.a. and subsequently reduced at over 7% from 2025, is there any space for Annex 1 emissions – but still only if the latter's emissions begin reducing at over 10% p.a. immediately.

5. As Anderson and Bows (2011) demonstrate, the proportion of the global carbon budget derived for the UK, and similarly Scottish, carbon budgets are premised on an apportionment regime that is not in keeping with the UK's explicit and international commitments on equity. Far from being a technical and nuanced issue, the disjuncture is profound and results in fundamentally different criteria for judging the appropriateness or otherwise of alternative carbon-reduction options.

6. The current UK legally binding budgets essentially reject 2°C in favour of maintaining some emission space out to 2050 and hence a relatively slow transition to a lower-carbon society. By contrast, taking international statements on 2°C as an honest reflection of commitment demands an immediate reduction in energy demand alongside rapid penetration of low-carbon technologies, with almost complete decarbonisation of the energy system by 2030. Ultimately, if the UK wants to develop a consistent and evidence-based framing of its climate change commitments, it needs to match its legally binding domestic budgets with its international rhetoric on 2°C.

7. The budgets outlined under the Climate Change (Scotland) Act 2009 and included in the Scottish Government's Second Report on Proposals and Policies 2013 (RPP2) do not make reference to a specific probability of exceeding 2°C. In providing recommendations to Roseanna Cunningham MSP, Minister for Environment and Climate Change, the Committee on Climate Change (CCC) refer to "a fair and safe" Scottish cumulative emissions budget. This is based on equal international apportionment which may not be regarded by all nations as 'fair'. The historic responsibility of developed countries for the bulk of emissions to date and their greater wealth with which to tackle decarbonisation suggests that parity is not 'fair'. Although the statutory annual greenhouse gas emissions targets set by the Scottish Government for the period 2013 to 2027, with annual rates of reduction between 2 and 5%, are more stringent than the UK national targets, they fall short of action necessary to afford a low or very low chance of exceeding 2°C.

Emissions intensity of coal bed methane

8. It is often reported that natural gas has lower emissions per unit energy than coal. Although the carbon content varies between them, and between production methods, it would be erroneous to regard any fossil fuel as "low carbon"; fossil fuels are by their nature high carbon energy sources. Whilst evidence for the specific emissions intensity of coal bed methane is poor, it is likely to have a carbon footprint slightly larger than conventional gas and slightly smaller than imported LNG.[13]

9. Recent atmospheric research, in multiple locations, suggests that leakage from natural gas production may be up to 5 times higher than that included within current emissions inventories.[14,15,16] This therefore questions the accuracy of current bottom up estimates of emissions intensity. Such

[13] Broderick & Sharmina (2014) *The Greenhouse Gas Emissions Profile of Coal Bed Methane (CBM) Production: A Review of Existing Research*, Report for FoE Scotland

[14] Petron, G., Frost, G., Miller, B. R., Hirsch, A. I., Montzka, S. A., Karion, A., . . . Tans, P. (2012). *Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study*. Journal of Geophysical Research-Atmospheres, 117.

[15] Karion, A., Sweeney, C., Petron, G., Frost, G., Hardesty, R. M., Kofler, J., . . . Conley, S. (2013). *Methane emissions estimate from airborne measurements over a western United States natural gas field.* Geophysical Research Letters, 40(16), 4393-4397. doi: Doi 10.1002/Grl.50811

[16] Miller, S. M., Wofsy, S. C., Michalak, A. M., Kort, E. A., Andrews, A. E., Biraud, S. C., . . . Sweeney, C. (2013). *Anthropogenic emissions of methane in the United States.* Proceedings of the National Academy of Sciences of the United States of America, 110(50), 20018-20022.

discrepancies indicate the need for greater attention to be paid to monitoring, the process of inventory production and background measurement prior to development, at the appropriate field scale and sensitivity.[17]

10. Were leakage rates for a coal bed methane field to be found to be in the range measured by Petron et al (2012), 2.3 to 7.7% of production, methane emissions would contribute approximately 40 to 130 gCO2e/kWh(th) to the carbon footprint.[18,19] This is substantially more than the life cycle emissions range estimated from the literature for CBM of 26 to 31 gCO2e/kWh(th). For context, added to the combustion emissions of methane of 190 gCO2e/kWh(th), the GHG impact of gas produced with this rate of leakage would be 230 to 320 gCO2e/kWh(th).[20]

11. As outlined above, there is the need to almost completely decarbonise the UK's energy system in the next two decades. Even, a gas plus carbon capture and storage (CCS) energy pathway is unlikely to realise very low or zero carbon emissions and so will be restricted in the ultimate potential scale of deployment. For instance, gas plus CCS could not form the majority of an electricity grid with an emissions intensity of 50 g/kWh(e) as is Scotland's electricity generation decarbonisation target. Although not a dominant component of the emissions footprint of unabated gas, emissions from production may add a significant penalty of up to 20%, dependent upon the source and transport of the gas. This has particular implications for CCS where the capture process itself imposes an energy penalty, requiring more fuel and hence realising greater upstream emissions outside of the capture mechanism. As a result, Hammond *et al* (2012) estimate the final emissions intensity of electricity from gas CCS to be approximately 80 g CO_2e/kWh(e), approximately four to five times more than nuclear power per kWh of electricity generated.[21]

Fossil fuels in relation to carbon budgets

12. The most relevant metric in considering climate change is the cumulative amount of greenhouse gases released during the next century, particularly in the next 35 years where we have the most immediate influence over emissions. Not only is the carbon intensity of a fuel important but also the quantity of it which is used and, therefore, the cumulative amount of CO_2 it contributes to the atmosphere.

13. A comparative per unit footprint is relevant only if the coal displaced by gas remains in the ground and is not combusted elsewhere. In practice, the net effect of displacing coal with gas depends upon the subsequent impact on energy commodity markets. In the case of the USA, with no national drivers to reduce coal use, evidence suggests that during the rapid expansion of shale gas production, and corresponding price reduction locally within the USA, there was some displacement of coal use in electricity generation. Between 2005 and 2012 carbon emissions from energy use in the USA fell by 12%, in part due to a reduction in coal consumption of 25% in the same period.[22] However, during the same time frame much of the displaced coal production was sold on global markets, exported and burnt elsewhere. The 32% drop in EU coal import prices between 2005 and 2011 and an increase of US coal exports to the EU of 187% have been

[17] Environment Agency, *Monitoring and Control of Methane from Unconventional Gas Operations*, DEFRA, 2012.
[18] Broderick & Sharmina (2014) *The Greenhouse Gas Emissions Profile of Coal Bed Methane (CBM) Production: A Review of Existing Research*, Report for FoE Scotland
[19] This field may not be directly comparable with CBM or a number of reasons and more representative field scale atmospheric measurements from on-going activity, e.g. Australian coal seam gas production, would offer greater insight. See Day, S. et al., 2012. Fugitive Greenhouse Gas Emissions from Coal Seam Gas Production in Australia, Available at: http://www.csiro.au/Outcomes/Energy/Fugitive-Greenhouse-Gas-Emissions-from-Coal-Seam-Gas-Production-in-Australia.aspx
[20] This figure is not directly comparable with whole life cycle estimates as it does not include other 'midstream' sources of emissions (e.g. those arising from transmission, storage & distribution).
[21] G. P. Hammond, H. R. Howard and C. I. Jones, *Energy Policy*, 2013, **52**, 103-116.
[22] Energy Information Administration, *Short Term Energy Outlook January 2014*, 2014 http://www.eia.gov/forecasts/steo/archives/Jan14.pdf

attributed to the reduction in the USA's indigenous demand for coal.[23] Broderick and Anderson (2012) found that more than half of the emissions avoided in the US power sector may have been exported as coal.[24]

14. If monitored effectively, the GHG emissions from CBM operations within the UK and Scotland ought to be captured and reported in respective national emissions inventories. If carbon budgets are adhered to, then no increase in national emissions should arise within their scope. However, this may not be the case for net global emissions. As DECC's Chief Scientific Advisor concludes "*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.*" (MacKay & Stone 2013, p.33). The greater stringency of Scottish national commitments does not alter this conclusion.

15. For a similar reason, the IEA reported in their World Energy Outlook 2011 supplement, "Are We Entering a Golden Age of Gas?", that a high-gas-use scenario would probably result in 3.5 °C warming, well beyond what is generally regarded as dangerous climate change.[25] 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"*.[26]

16. The science of global warming, the maths of our emissions to date and our Copenhagen pledge to limit temperature increases to below a 2°C rise lead to the clear conclusion that coal bed methane must remain in the ground if we are not to renege on our commitment to avoid "dangerous climate change". In drawing these conclusions no distinction is made between gas produced from conventional and unconventional reserves. The argument equally applies to all novel and additional sources of fossil fuels. However, committing to new high carbon infrastructure runs the risk of it not being used for its full design life and becoming a 'stranded asset'[27], or worse, it locks a nation into dependency on fossil fuels, creating higher cost barriers for alternative energy sources to compete with.

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[23] D. J. MacKay and T. J. Stone, *Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use*, DECC, 2013 https://www.gov.uk/government/publications/potential-greenhouse-gas-emissions-associated-with-shale-gas-production-and-use

[24] J. Broderick & K. Anderson (2012) *Has US Shale Gas Reduced CO2 Emissions? Examining recent changes in emissions from the US power sector and traded fossil fuels,* Tyndall Manchester, University of Manchester https://www.escholar.manchester.ac.uk/uk-ac-man-scw:211539

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

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

[27] A situation where "*environmentally unsustainable assets suffer from unanticipated or premature write-offs, downward revaluations or are converted to liabilities*", see A. Ansar, B. Caldecott and J. Tilbury, *Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?*, Smith School of Enterprise and Environment, University of Oxford, Oxford, UK, 2013.