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Conditions for environmentally-sound UK shale gas development

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Two recently published reports (McGlade & Ekins (2015), McGlade *et al.* (2014)) examine possible futures for fossil fuels, with a particular focus on the 'bridging' role that natural gas may be able to play during a transition to a global low-carbon energy system. A related report (Bradshaw *et al.* 2014) considers the UK's global gas challenge and places the development of shale gas in the wider context of the UK's energy security and climate change policies. These reports found that there is a good potential for gas to act as a transition fuel to a low-carbon future up to 2035 on a global level but with this potential varying significantly between different regions.

This is consistent with the views of the Intergovernmental Panel on Climate Change's (IPCC), which indicates that in a global context *'GHG emissions from energy supply can be reduced significantly by replacing current world average coal-fired power plants with modern, highly efficient natural gas combined-cycle power plants or combined heat and power plants'* (IPCC, 2014).

Drawing on the findings of these reports, we have commented that the UK may be able to develop some of its potential shale gas resources within the context of a global effort to keep average global warming below 2°C with a reasonable likelihood. This is again consistent with the views of the UK's Committee on Climate Change (CCC) who state that *'UK shale gas production could be compatible with meeting [its] emissions targets'* (CCC, 2013).

However, it is common for the conditions that are a necessary part of these conclusions, both for the global 'bridging' role of natural gas and more specifically shale gas development in the UK, not to be set out in full or given sufficient emphasis when communicating these findings. They may even be ignored entirely. This note therefore aims to discuss the ten caveats that we consider are fundamental to ensuring that any potential shale gas development in the UK is compatible with its required greenhouse gas emission reductions and environmental protection more broadly.

Before doing this, it is important to bear in mind that none of our work to date has focussed explicitly on modelling natural gas consumption or production in the future UK energy system. This is a subject of our current modelling work and we will be able to comment on UK natural gas and shale gas in much more detail when this is completed. An important unknown at present is therefore the level of gas consumption that there could be in the UK energy system out to 2050 even under a deep decarbonisation pathway. There is likely to be some gas consumption, in which case shale gas production could compensate for declining North Sea production, and displace imports that would otherwise be necessary. However, how much consumption and what role this gas plays is crucial to understanding the timeframes and scale that could be afforded to a potential shale gas industry consistent with overall energy system decarbonisation.

The first condition is that there must be both technically and economically recoverable volumes in the UK at costs that are below future gas prices[1], with these costs ideally including an appropriate charge for carbon emissions. As recognised by the British Geological Survey in the report on the Bowland shale, at present there are no UK shale gas reserves[2], and next-to-no information or data on volumes that could be considered to be recoverable resources. Whether any will be resources that are recoverable in an economically viable way is unknown, despite frequent claims to the contrary, and this is self-evidently necessary for there to be any development of UK shale gas.

Second, because gas produces lower combustion carbon emissions than coal, gas consumption can only increase consistently with stated commitments to limit average global warming to 2^{o}C if there is rapid and dramatic reduction in coal consumption. Within our modelled global 2^{o}C scenarios, gas acts as a transition fuel predominantly only in those regions of the world whose energy systems are currently heavily reliant on coal. For the UK the use of shale gas must be consistent with staying within the five-year carbon budgets on a trajectory to an 80% reduction in greenhouse gas emissions by 2050, which will require practically no unabated coal use in electricity generation beyond about 2025.

Since the UK began its transition period from coal to gas some time ago, the potential for replacing coal consumption is more limited. Indeed, in the UK a danger of promoting the increased use of gas for electricity generation is that there may be a stalling in the necessary shift towards lower-carbon sources of electricity. For example, if the operating life of the current fleet of nuclear power stations cannot be expanded and/or the arrival of new nuclear power stations is delayed beyond the current plans of 2023, in order to ensure that

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[1] It may be borne in mind that there is no guarantee that gas prices in the UK will be anywhere near as high as was perhaps thought one year ago. This will obviously have major implications for any potential development of UK shale gas.

[2] We define reserves as those resource that are economically viable to produce with current technologies, and which are likely to be produced within a few decades.

electricity demand is satisfied in the interim, there will be a temptation to construct a new generation of natural gas power plants (as these can be built in relatively short timeframes).

This would have serious implications for the carbon intensity of electricity generation, which the CCC suggests should be below 50g/kWh by 2030 (see e.g. CCC, 2014). Indeed, it could be argued that the UK government is planning for this by examining in its 'Gas Generation Strategy' (DECC, 2012) a scenario that includes a much more gas-reliant electricity mix that results in electricity with a carbon intensity of 200g/kWh. Given that in scenarios of a low-carbon transition the electricity sector is generally the first sector in the energy system to be significantly or almost totally decarbonised (Ekins *et al.* 2014), such a development would be tantamount to an abandonment of the UK's contribution to limiting global warming to 2^{o}C.

Third, carbon capture and storage (CCS) is key to the development of new gas resources, shale or otherwise. On a global level, our modelling suggests that in a 2^{o}C scenario in which CCS is not available, gas consumption peaks much earlier and the role that gas can play as a transition fuel is substantially reduced. If CCS does not become available commercially soon, it is unlikely that there will be much scope within available carbon budgets for significant UK and European gas consumption beyond 2050. This calls into question the wisdom of developing a whole new UK shale gas industry for such a limited period of operation.

Nevertheless, given the rapid decline that is seen in production from single shale gas wells, a shale gas industry may still be able to flourish over the short-term as long as it disassembled over the longer term as gas is removed from the UK energy system. However, such a scenario would run the risk that maintaining a domestic industry would come to be preferred over required emission reductions.

Fourth, gas can only be a short-term complement to the much larger increase in true low-carbon energy sources that must also occur to substitute for coal, and ultimately for gas too, in order for the low-carbon transition actually to be achieved.

Fifth, the bridge formed by natural gas to a low-carbon energy system, and by extension the timeframe for the development of shale gas to help reduce GHG emissions, is strictly time-limited. While gas is able to play an important role in aiding the transition to a low-carbon energy system in some regions, the length of time over which there is this bridging opportunity varies and in some regions it has next to no potential at all to act as a 'transition fuel' (McGlade *et al.* 2014). For example, gas has a strong potential to act as a bridge in China, India, Japan and South Korea, but a much more limited potential in regions such as Canada, Central and South America, and Mexico. As noted above, this bridging period is also heavily dependent on the availability of CCS, with natural gas only remaining a strong bridge over a long period of time in China if CCS is not available.

Sixth, the development of some shale gas resources is only helpful if there is real global commitment to CO_2 emissions reduction. In the absence of such an agreement additional natural gas is not helpful for reducing emissions. The IEA modelled a 'Golden Age of Gas' scenario, based upon the widespread availability and development of new gas sources (including shale gas) (IEA, 2011). This resulted in 3.5°C of global warming. Similarly, McJeon *et al.* (2014) demonstrated that on a global level gas has the potential to displace zero-carbon sources of energy (such as renewables and nuclear) as much as coal, leading to little change in overall emissions. Under such circumstances the development of shale gas could not in any way be viewed as a positive emissions reduction mechanism.

A good example of the dangers posed by this dynamic was provided by the rise in European coal consumption between 2009 and 2012 that stemmed from the rapid increases North American gas production (Broderick and Anderson 2012). The surge in natural gas production from shale in North America resulted in a large reduction in domestic gas prices, which meant that coal produced in the United States was priced out of electricity generation. This displacement of coal-for-gas meant that US domestic emissions fell by around 7% between 2008 and 2013 (2008 roughly marks the beginning of the rapid take-off in shale gas production). European gas prices were largely unaffected by the reductions in North American prices and, with the coal displaced from the United States entering international markets, a large cost differential favouring the consumption of coal over gas in the electricity sector was formed in Europe. With the low cost of carbon in the European Union's Emissions Trading Scheme (EU ETS), European companies and countries could cost-effectively switch from gas-to-coal electricity generation with very little cost penalty for the consequent increase in emissions. As a result coal consumption in Europe increased. Had there been a higher price on CO_2 emissions, or an effective global agreement on emissions mitigation, this dynamic would have been unlikely to have occurred: the US coal would have been unable to find new markets and would have remained in the ground.

Seventh, and in recognition of this dynamic, policy makers and advocates for UK shale gas development will need to recognise that, if new resources are to be developed in the UK, then fewer fossil fuel reserves need to be developed as a result elsewhere. All countries and regions already hold significant levels of 'unburnable' reserves, which will be increased by new UK production, if commitments to limit global warming are to be met. UK policy makers committed to global emissions reduction should recognise the implications of such new developments for the global climate negotiations.

Eighth, the level of fugitive emissions that occurs during production needs to be determined and managed. The literature on this issue is not yet at a mature enough stage to have any confidence on what a reasonable range for fugitive emissions might be. If they are non-negligible the usefulness of shale gas as a lower-carbon bridge fuel diminishes rapidly.

The Labour Party tabled a number of amendments as part of the Infrastructure Bill regarding UK shale gas development (HoC, 2015). These included a sensible requirement for UK shale gas companies to undertake 12 months' monitoring of existing fugitive emissions at a site before any hydraulic fracturing can take place, and further required them to monitor and disclose any fugitive emissions that occur during exploration or production. However, these requirements were subsequently amended before the Bill became an Act to require that: *'Appropriate arrangements have been made for the monitoring of emissions of methane into air.'* The 12-month requirement now only applies to methane in ground water. The amendments also require the government (in consultation with the CCC) to report on the impacts that fugitive emissions from the development of shale gas are having on the UK's ability to meet its required emissions reductions. This requirement remains in the Act (Infrastructure Act, 2015).

If fugitive emissions are negligible or are easily controlled, then as discussed by MacKay and Stone (2013), indigenous shale gas production is likely to have lower life cycle emissions than imported liquefied natural gas (LNG) or gas imported by pipeline from e.g. Russia. From a global emissions perspective, any gas that is required in the low-carbon UK energy system would therefore be better supplied from indigenous sources rather than by imports.

Ninth, development of shale gas cannot occur in an unrestricted manner. For example, the McGlade and Ekins (2015) *Nature* study suggests that 80% of potential European unconventional gas resources should still be classified as unburnable under a cost-optimal 2^{o}C scenario.

Our tenth and final condition is that both individual and cumulative local environmental impacts, including those from waste disposal, toxicity, noise and water pollution, groundwater contamination, induced seismicity, water use in water-deficient areas, and flaring, are appropriately regulated, controlled or avoided. Convincing the public that these risks can be minimised and managed is essential to gaining a 'social licence to operate', which the shale gas industry does not yet have in a UK context.

Given the current incomplete state of knowledge about shale gas and its potential role in a low-carbon transition, we suggest that policy makers should take as their basis for energy policy that there will be no shale gas produced domestically and plan their gas security strategy accordingly. Furthermore, while we are not against shale gas exploration in principle, we believe that it is incumbent upon the shale gas industry and its supporters, and the government, to demonstrate that the above conditions are met, as most if not all of them are not at present. Only then should shale gas production be permitted to proceed in the event that it is proved to be economically viable, in the knowledge that it is consistent with a decarbonised UK energy system and environmental protection more generally.

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