THE GEOLOGICAL SOCIETY

SUPPLEMENTARY MEMORANDUM TO ENERGY AND CLIMATE CHANGE COMMITTEE INQUIRY: THE IMPACT OF SHALE GAS ON ENERGY MARKETS

Unconventional and conventional gas resource and reserve estimates for the UK

1. Unconventional gas includes tight gas, coal bed methane and shale gas. Of these, shale gas currently has the most significant growth prospects because relatively novel applications of existing technologies (coupling fracking with horizontal drilling) have enabled economically viable extraction of gas from shales, which have much lower permeability than conventional gas reservoirs.

2. As discussed at the evidence session on 27 November 2012, it is important to draw a distinction between resources and reserves. **Resource** is the amount of gas underground. **Reserve** is the amount of gas which can be produced economically – that is, which we can realistically expect to extract from the ground given current technological, economic and social/regulatory constraints. Another term which is sometimes used is 'technically recoverable' resource – this is the amount which could be extracted given current technology, but without reference to economics (cost of extraction and price) or social acceptability.

3. As set out in our main written evidence, and discussed at the 27 November evidence session, policy-makers looking to establish how much of a resource is available to come to market (that is, reserves) are faced with several types of uncertainty:

    a. The amount of **resource** in place in the ground can be more or less well defined, depending on how well the geology is understood, and the type and extent of exploration carried out for the resource in question. Typically, resources are considered in terms of discovered resource (irrespective of whether these are thought likely to be technically or economically recoverable), and undiscovered resource (based on mapped leads and knowledge of the geology, and necessarily much less reliable).
    b. **Reserve** estimation is much less certain (and more probabilistic) than the estimation of resources, as it depends on a wide variety of geological, technological, economic and socio-political factors. This is not to suggest a lack of sophistication in reserve assessment, which is the subject of a great deal of highly expert work in hydrocarbons companies (where strict standards apply – see comments on SEC guidelines at paragraph 20 below). Reserves are typically classified as

proven, probable or possible (depending on the assessed probability of their being technically and economically producible).

c. In the case of shale gas, the uncertainties are exacerbated by the different nature of the resources compared with conventional hydrocarbons, where seismic imaging of the subsurface has a major role in defining resources and reserves, and the fact that shale gas resources have been much less explored (see our original written submission and the oral evidence session for further details).

d. A further complicating factor is that different government bodies, surveys, international organisations, academic studies and commercial companies have adopted different bases for reporting their assessments, variously including or excluding: gas already produced; reserves; technically recoverable resources; discovered and undiscovered resources; onshore and offshore resources; and different geological settings for hydrocarbon resources (e.g. shale gas, all unconventional gas, or all gas including conventional gas). They often also use different units – in our comments below, we have converted all figures to trillion cubic feet (tcf) (or trillion cubic feet in gas equivalent (tcfg) for liquids).

4. With all this in mind, it is impossible to provide a single set of figures indicating how much shale gas or other unconventional gas might be economically recovered (and how this compares to reserves of conventional gas), either in the UK or more widely. In the paragraphs which follow, we have identified some sources of quantitative information which may help the Committee assess the possible impact of shale gas on UK energy markets, and which we believe are well-founded (within the limitations we have set out above and caveats attached to the sources themselves).

5. DECC provides estimated aggregate data on UK reserves and resources at http://og.decc.gov.uk/en/olgs/cms/data_maps/field_data/uk_oil_gas_res/uk_oil_gas_res.aspx. These include estimates of oil and gas reserves, potential additional resources (that is, discovered resources which are not currently technically or economically producible) and undiscovered resources. Regarding undiscovered resources, from looking at the gas fields listed and the amounts cited, we assume that these refer to conventional resources (and do not include existing DECC estimates of shale and other unconventional gas) – although this is not made explicitly clear. The figures for gas reserves are said to include 'a small amount from coal bed methane projects' – we assume therefore that most unconventional gas, including all shale gas, is excluded from these figures, although again this is not explicit. The Committee may wish to raise with DECC the ambiguity attached to the scope of these figures, and how the data themselves might be presented more clearly.

6. DECC's figures give a central estimate for UK reserves (i.e. proven and probable), possible reserves (less certain to be produced), potential additional resources (discovered but not currently technically recoverable), undiscovered resources, and cumulative production (total past production to date from UK oil and gas fields) at the end of 2011 as follows:

Oil: Reserves – 34 tcfg
(Possible reserves – 13 tcfg)
(Potential additional resources – 13 tcfg)
(Undiscovered resources – 32 tcfg)
(Cumulative production – 152 tcfg)

Gas: Reserves – 17 tcf
(Possible reserves – 8 tcf)
(Potential additional resources – 7 tcf)
(Undiscovered resources – 20 tcf)
(Cumulative production – 84 tcf)

(These figures may include some rounding errors due to unit conversions. Figures for oil include liquids from gas fields. Figures for gas include gas from oil fields.)

7. Estimates of shale gas resource are less certain than those for conventional resources (for the reasons referred to above), and this is even more true of reserve estimates. A British Geological Survey (BGS) report for DECC in 2010, which predated any exploratory drilling for shale gas in the UK, tentatively estimated 4.7 tcf shale gas **reserves** in the Upper Bowland Shale of the Carboniferous Pennine Basin and 5.3 tcf elsewhere in England (southern England basins and the Cambrian shales of central England – note that these figures exclude Wales, Scotland and Northern Ireland). (See http://og.decc.gov.uk/assets/og/bo/onshore-paper/uk-onshore-shalegas.pdf).

8. Estimates of world shale gas resources made by Advanced Resources International, Inc. in 2011 (for the US Energy Information Administration at the Department of Energy) put the total shale gas **resource** in place in the UK at 97 tcf. They assume a modest 21% recovery factor, which would result in **reserves** of 20 tcf.

9. Cuadrilla Resources estimates at least 200 tcf shale gas **resource** in place in the Bowland basin. In their submission to the present inquiry (para 1.4) they say that a conservative recovery factor of 15% would yield a **reserve** of 45 tcf, although by our calculation a 15% recovery rate on 200 tcf of resource would in fact yield 30 tcf.

10. In summary, the three estimates of UK shale gas reserve quoted here are around 10 tcf (England only), 20 tcf (UK) and 30 tcf (Bowland basin only), compared with DECC's central estimate of 17 tcf of conventional gas reserves in the UK.

11. DECC has commissioned a BGS team to provide a more detailed analysis and estimate of the entire Bowland Shale gas **resource** in place, to better understand the potential future contribution to the UK energy mix. This work is due to be completed by the end of 2012 and will provide an independent assessment of the total resource. We have tried to discover the expected publication date of their report, but BGS tell us that this will be determined by DECC.

12. Regarding other unconventional gas, the European Centre for Energy Resource Security (EUCERS) Strategy paper 'Strategic Perspectives of Unconventional Gas' (http://www.kcl.ac.uk/sspp/departments/warstudies/research/groups/eucers/strategy-paper-1.pdf) provides **resource** estimates for two coal bed methane prospects – Cheshire (4 tcf) and the Midland Valley (2 tcf).

Global shale gas resource estimates

13. The most widely used current estimates of global shale gas resources are provided by the US Energy Information Administration (EIA), although as with other estimates cited here, these are highly uncertain (see http://www.eia.gov/analysis/studies/worldshalegas). The EIA has estimated the **technically recoverable** shale gas resources for basins in 32 countries. The ten largest estimates of shale gas resource (by country) are listed below, together with the estimates of proven natural gas reserves. The UK estimates from the same source are also shown. (All figures in tcf. Technically recoverable shale gas estimates *exclude* offshore resources. For comparison, the EIA quotes proven natural gas estimates from the Oil and Gas Journal's annual survey 2010, which *include* offshore resources.)

Country	*Technically recoverable shale gas resources (EIA estimate, tcf)*	*Proven natural gas (EIA estimate, tcf)*
China	1275	107
USA	862	273
Argentina	774	13
Mexico	681	12
South Africa	485	N/A
Australia	396	110
Canada	388	62
Libya	290	55
Algeria	231	159
Brazil	226	13
UK	20	9

14. The USGS estimates undiscovered technically recoverable resources of unconventional gas in the USA of 695 tcf, compared to mean undiscovered technically recoverable resources of conventional gas of 411 tcf (see http://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment/AssessmentUpdates.aspx).

15. Other useful recent reviews of regional and global unconventional gas estimates are:

- https://workspace.imperial.ac.uk/icept/Public/121022%20Unconventional%20gas%20-%20A%20review%20of%20estimates%20%28ICEPT%20working%20paper%29.pdf (Imperial College Centre for Energy Policy and Technology working paper)
- www.ukerc.ac.uk/support/tiki-download_file.php?fileId=2672 (UK Energy Research Centre report to Energy Security Unit of the Joint Research Centre of the European Commission – same authors as the ICERT working paper)

Innovative hydraulic fracturing technologies

16. Hydraulic fracturing is not a new technology, and has been in use in the oil and gas industry for several decades. Shale gas exploration and production have stimulated research to improve fracking techniques and horizontal drilling technologies. Several US resource companies are working on projects to improve the environmental friendliness of fracturing fluids. An example is Chesapeake Energy's GreenFrac program – see http://www.chk.com/environment/drilling-and-production/pages/green-frac.aspx.

17. The company GASFRAC have patented a new fracturing technology which uses LPG (liquified petroleum gas) gel as the fracking fluid for shale gas extraction instead of water. There are two potential advantages to this method. The first is in terms of gas production: after fracturing, the well is opened up to produce gas and the pressure drop means that the LPG gel returns to its gaseous state, and becomes part of the flow of gas from the rock. When water is used, 10-50% remains trapped in the rock and this reduces the effectiveness of the fractures in producing gas. The second potential advantage relates to potential environmental impact: LPG gels reduce the reliance on water supplies, and would lead to reduced flowback water. (See www.gasfrac.com. See also SPE conference paper by Tudor et al, a copy of which we will send with this memorandum. For information on Schlumberger fracking technologies, see http://www.slb.com/~/media/Files/stimulation/product_sheets/unconventionalgas/openfrac_ps.pdf.)

Shale oil potential in the UK and USA

18. In the USA, the main shale oil play is the Bakken. It is very probable that there are shale oil resources in the UK, particularly in the East Midlands and in the Scottish Midland Valley. However, given the difficulty and cost of extracting shale oil, the likely environmental and social constraints, and the relatively extensive shale gas resources available, it seems very unlikely that these will be considered worthwhile to explore.

19. It is reasonably likely that some liquids will be co-produced with shale gas, without looking for them. In the USA, in some provinces the shale oil is in the same reservoir as the shale gas, but in a shallower belt that has simply not undergone the same burial depths. In some cases, the by-product oil is more valuable than the gas. In the USA oil is now targeted because the price of gas has dropped significantly in recent years.

Background information on the SEC guidelines

20. The Final Rule for the Modernization of Oil and Gas Reporting published in 2009 by the SEC (U.S. Securities and Exchange Commission) supercedes previous guidelines. A short guide to new rules can be found here http://www.spee.org/wp-content/uploads/pdf/ReferencesResources/OilGas_Reporting.pdf and the full report on modernisation of oil and gas reporting can be found here http://www.sec.gov/rules/final/2008/33-8995.pdf.

10 December 2012