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Energy and Climate Change Committee

Shale Gas

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Volume II

Additional written evidence

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The Energy and Climate Change Committee

The Energy and Climate Change Committee is appointed by the House of Commons to examine the expenditure, administration, and policy of the Department of Energy and Climate Change and associated public bodies.

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Contacts

All correspondence should be addressed to the Clerk of the Energy and Climate Change Committee, House of Commons, 7 Millbank, London SW1P 3JA. The telephone number for general enquiries is 020 7219 2569; the Committee's email address is ecc@parliament.uk

List of additional written evidence

(published in Volume II on the Committee's website www.parliament.uk/ecc)

Written evidence

Memorandum submitted by the World Coal Association

1. Given the recent increase in shale gas extraction in the United States and the subsequent deliberations on shale gas development in other countries, including the UK, the World Coal Association (WCA) welcomes the call for written evidence for the forthcoming inquiry into shale gas, launched by the Energy and Climate Change Committee.

2. As a non-profit, non-governmental industry association working internationally on behalf of the world's major coal producers and stakeholders, WCA follows closely the work of energy research institutes and other international organisations. It is as an association analysing and disseminating information on energy-related issues that we would like to contribute to this public inquiry.

3. In this response, the WCA has sought to address one of the four questions posed in the Energy and Climate Change Committee's call for written evidence:

— How does the carbon footprint of shale gas compare to other fossil fuels?

Academic studies and other documents referred to in this response are available in the annex to this document.

Possible Greenhouse Footprint Of Natural Gas From Shale Gas Formations

4. The carbon footprint of coal extraction and coal combustion is now well documented. However, due to the recent character of large scale shale gas extraction in the USA, the overall greenhouse footprint of the so called shale gas, including direct and indirect emissions of both CO2 and methane, is not yet fully understood.

5. An assessment of greenhouse footprint of natural gas from shale formations obtained by high-volume, slick-water hydraulic fracturing, undertaken by professor of Ecology & Environmental Biology at Cornell University, Robert W. Howarth, indicates that high volume slick-water hydraulic fracturing, an extraction method which, combined with horizontal drilling techniques, allowed a substantial increase in shale gas extraction productivity in the USA, might substantially increase the overall greenhouse footprint of natural gas extracted from shale formations (Annex I and II) This is mainly due to potential leakages of methane gas which, according to the IPCC, is a greenhouse gas 72 times more powerful than CO2 during the first 20 years after its release (Annex III).

6. This would make the overall greenhouse footprint of shale gas similar to the one of coal at a low end estimate and substantially greater at a high end estimate. In fact, in the light of this study, it seems important to consider the overall greenhouse gas footprint of shale gas, as opposed to a carbon footprint which takes account exclusively of CO2 emissions.

The Importance Of A Full Greenhouse Footprint Approach In The Context Of The Current Policy Context

7. We encourage the Energy and Climate Change Committee to investigate the possible greenhouse footprint of shale gas before further encouraging the development of shale gas extraction in the UK and to take account of its findings when considering the introduction of an Emission Performance Standard (EPS).

8. Given the current increase in natural gas consumption in the UK, as stimulated by the EU Emissions Trading Scheme and by parallel environmental policies and owing to the fact that more investors are now considering shale gas extraction on UK territory, it is important that the greenhouse footprint of natural gas from shale formations is more understood.

9. This is especially important in the light of a possible introduction of an Emission Performance Standard, considered by the current government. In fact, if introduced, an EPS will likely take account of CO2 emissions associated with the combustion process of natural gas and coal. As a result, there is a potential that other greenhouse gas emissions at the extraction stage could be ignored. This could lead to shifts in the UK's energy mix which might produce unintended and adverse environmental effects to the ones desired.

10. In fact, in the USA, where shale gas extraction is most developed, National Academy of Sciences and the Council of Scientific Presidents have called for caution before proceeding with further development of the unconventional technology of natural gas extraction.

11. The WCA hopes that this response to the Energy and Climate Change Committee's call for written evidence will encourage further investigation of the overall greenhouse gas footprint of natural gas obtained from shale formations and will contribute to stimulating an informed debate about the possible environmental impacts of shale gas.

December 2010

Annex I

Howart, R W *Preliminary assessment of the greenhouse gas emissions from natural gas obtained by hydraulic fracturing*, Department of Ecology and Evolutionary Biology, Cornell University, 1 April 2010

CORNELL UNIVERSITY

Department of Ecology and Evolutionary Biology

Preliminary Assessment of the Greenhouse Gas Emissions from Natural Gas obtained by Hydraulic Fracturing

Robert W Howarth

David R Atkinson Professor of Ecology & Environmental Biology, Cornell University (1 April 2010 Draft)

Natural gas is being widely advertised and promoted as a clean burning fuel that produces less greenhouse gas emissions than coal when burned. While it is true that less carbon dioxide is emitted from burning natural gas than from burning coal per unit of energy generated, the combustion emissions are only part of story and the comparison is quite misleading. **A complete consideration of all emissions from using natural gas seems likely to make natural gas far less attractive than oil and not significantly better than coal in terms of the consequences for global warming.**

There is an urgent need for a comprehensive assessment of the full range of emission of greenhouse gases from using natural gas obtained by high-volume, slick water hydraulic fracturing (HVSWHF, or "hydrofracking"). I am aware of no such analysis that is publicly available. Some information suggests that one or more assessments may have been conducted by industry groups, but if so these are available only to industry on a confidential basis. If such assessments exist, they have not been subjected to external, unbiased scientific review.

A first attempt at comparing the total emissions of greenhouse gas emissions from HVWWHF obtained natural gas suggests that they are 2.4-fold greater than are the emissions just from the combustion of the natural gas. This estimate is highly uncertain, but is likely conservative, with true emissions being even greater. When the total emissions of greenhouse gases are considered, Greenhouse gas emissions from HVSWHF-obtained natural gas are estimated to be 60% more than for diesel fuel and gasoline. HVSWHF-obtained natural gas and coal from mountain-top removal probably have similar releases. These numbers should be treated with caution. Nonetheless, until better estimates are generated and rigorously reviewed, society should be wary of claims that natural gas is a desirable fuel in terms of the consequences on global warming. **Far better would be to rapidly move towards an economy based on renewable fuels. Recent studies indicate the U.S. and the world could rely 100% on such green energy sources within 20 years if we dedicate ourselves to that course.** See Jacobson & Delucchi (2009) A Path to Sustainable Energy by 2030, Scientific American 301: 58–65.

Presentation of assumptions and uncertainties behind estimates:

Considering the release during combustion alone, greenhouse gas emissions from burning natural gas average 13.7 g C of CO_2 per million joules of energy compared to 18.6 for gasoline, 18.9 for diesel fuel, and 24.0 for bituminous coal (U. S. Department of Energy: http://www.eia.doe.gov/oiaf/1605/coefficients.html). Additional emissions of greenhouse gas occur during the development, processing, and transport of natural gas (due to the use of fossil fuels to build pipelines, truck water, drill wells, make the compounds used in drilling and fracturing, and treat wastes, and the loss of carbon-trapping forests). I am aware of no rigorous estimate for these additional greenhouse gas emissions, but they appear likely to equal at least one third of those released during combustion (4.5 g C of CO2 per milli$_o$n joules of energy). For comparison, the greenhouse gas emissions from obtaining, processing, and transporting diesel fuel and gasoline are in the range of 8% (Howarth et al. 2009: http://cip.cornell.edu/biofuels/), or perhaps 1.5 g C of CO2 per milli$_o$n joules of energy. Note that as fossil fuel energy resources become more diffuse and difficult to obtain (as is gas in the Marcellus Shale), the energy needed to extract them and the greenhouse gas emissions associated with this effort go up substantially.

The leakage of methane gas during production, transport, processing, and use of natural gas is probably a far more important consideration. Methane is by the far the major component of natural gas, and it is a powerful greenhouse gas: 72-times more powerful than is CO_2 per molecule in the atmosphere (Table 2.14 in the Intergovernmental Panel on Climate Change Fourth Assessment Report (AR4), Climate Change 2007: The Physical Science Basis. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm). Note that this comparison of the global warming potential of methane with CO_2 is based on a 20-year assessment time; the factor decreases to 25-fold for an 100-year assessment time. The shorter time with the higher relative global warming potential is the appropriate one, if one is concerned about the effects of methane during the time a natural gas field is developed, and for the few decades after production in the field ends. Since methane is such a powerful greenhouse gas, even small leakages of natural gas to the atmosphere have very large consequences on global warming.

The most recent data I could find for the US (from 2006) suggest a leakage rate from the oil and gas industry of an amount of methane equal to 1.5% of the natural gas consumed (based on leakage data reported in EPA

(2008) Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990—2006 and consumption data from the U.S. Department of Energy: http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_monthly/current/pdf/table_02.pdf). This leakage rate is roughly equal to that estimated by the EPA in 1997 (http://p2pays.net/ref/07/06348.pdf). However, as noted by Andrew Revkin in the New York Times in October 2009, the actual leakage is not well known, as monitoring is quite limited, and "government scientists and some industry officials caution that the real figure is actually higher" (http://www.nytimes.com/2009/10/15/business/energyenvironment/15degrees.html?_r=2&scp=1&sq=natural%20gas%20leaks%20tanks&st=cse).

If we assume a 1.5% leakage rate, this would have a greenhouse gas warming potential equal to 14.8 g C of CO_2 per million joules of energy. This would be additive to the emissions during combustion (13.7 g C of CO_2 per million joules of energy) and to the emissions associated with obtaining and transporting the natural gas (very roughly estimated above as 4.5 g C of CO_2 per million joules of energy). Total greenhouse gas emissions from natural gas from hydraulic fracturing may, therefore, be equivalent to 33 g C of CO_2 per million joules of energy. For diesel fuel or gasoline, the total greenhouse gas emissions are equivalent to approximately 20.3 g C of CO_2 per million joules of energy.

The comparison with coal is difficult, as the energy needs and greenhouse gas emissions from mining and transporting the coal are not well known. As a first cut, it may make sense to assume that these are roughly equal to those for obtaining shale gas. Some methane leakage also occurs when mining coal, but the amount varies greatly with the type and location of the coal and the mining technology used. A preliminary assessment suggests methane leakage is less than for natural gas. If so, total emissions from coal are probably quite similar to those for natural gas obtained from shale formations such as the Marcellus Shale.

Annex II

Howart, R W *Assessment of the greenhouse gas footprint of natural gas from shale formations obtained by high-volume, slick-water hydraulic fracturing*, Department of Ecology and Evolutionary Biology, Cornell University, 15 November 2010

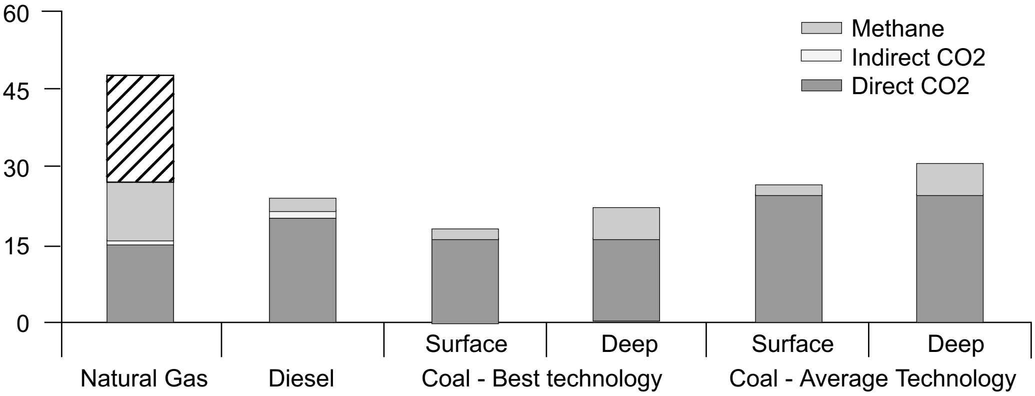
CORNELL UNIVERSITY

Department of Ecology and Evolutionary Biology

Assessment of the Greenhouse Gas Footprint of Natural Gas from Shale Formations Obtained by High-Volume, Slick-Water Hydraulic Fracturing Robert W. Howarth

David R Atkinson Professor of Ecology & Environmental Biology, Cornell University (*15 November 2010*)

Natural gas is widely advertised and promoted as a clean burning fuel that produces less greenhouse gas emissions than coal when burned. While it is true that less carbon dioxide is emitted from burning natural gas than from burning coal per unit of energy generated, the combustion emissions are only part of story and the comparison is quite misleading. With funding from the Park Foundation, my colleagues Renee Santoro, Tony Ingraffea, and I have assessed the likely footprint from natural gas in comparison to coal. We have now submitted a manuscript for publication in a peer-reviewed journal. A summary figure from the submission is shown here. Please note this should be treated tentatively, as changes or refinements in response to reviewer comments are likely. We nonetheless post the update now due to the tremendous interest in the topic, and its importance in deciding the wisdom of viewing natural gas as a transitional fuel over the coming decades, with a lower greenhouse gas footprint than coal. The figure illustrates a comparison using a 20-year horizon for the relative importance of methane and carbon dioxide.



Comparison of greenhouse gas emissions from natural gas, diesel oil, and coal, including both direct emissions of CO_2 during combustion, indirect emissions of CO_2 necessary to develop and use the energy source, and fugitive emissions of methane, converted to equivalent value of CO_2 for global warming potential assuming a 20-year time horizon. For natural gas, the solid bar represents the low end estimate, and the striped bar represents the high end. Units are grams carbon per million joules of energy.

We urge caution in viewing natural gas as good fuel choice for the future. Using the best available science, we conclude that natural gas is no better than coal and may in fact be worse than coal in terms of its greenhouse gas footprint when evaluated over the time course of the next several decades. Note that both the National Academy of Sciences and the Council of Scientific Society Presidents have urged great caution before proceeding with the development of diffuse natural gas from shale formations using unconventional technology. See: National Research Council (2009). Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. National Academy of Sciences Press; and Letter to President Obama and senior administration officials, 4 May 2009, from the Council of Scientific Society Presidents. http://www.eeb.cornell.edu/howarth/CCSP%20letter%20on%20energy%20&%20environment.pdf

Annex III

Lifetimes, radiative efficiencies and direct global warming potential relative to CO2, source: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, page 212.

Table 2.14. *Lifetimes, radiative efficiencies and direct (except for CH_4) GWPs relative to CO_2. For ozone-depleting substances and their replacements, data are taken from IPCC/TEAP (2005) unless otherwise indicated.*

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]$1.4x10^{-5}$	1	1	1	1
Methane[c]	CH_4	12[c]	$3.7x10^{-4}$	21	72	25	7.6
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	$CClF_2CClF_2$	300	0.31		8,040	10,000	8,730
CFC-115	$CClF_2CF_3$	1,700	0.18		5,310	7,370	9,990
Halon-1301	$CBrF_3$	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435
Methyl bromide	CH_3Br	0.7	0.01		17	5	1
Methyl chloroform	CH_3CCl_3	5	0.06		506	146	45
HCFC-22	$CHClF_2$	12	0.2	1,500	5,160	1,810	549
HCFC-123	$CHCl_2CF_3$	1.3	0.14	90	273	77	24
HCFC-124	$CHClFCF_3$	5.8	0.22	470	2,070	609	185
HCFC-141b	CH_3CCl_2F	9.3	0.14		2,250	725	220
HCFC-142b	CH_3CClF_2	17.9	0.2	1,800	5,490	2,310	705
HCFC-225ca	$CHCl_2CF_2CF_3$	1.9	0.2		429	122	37
HCFC-225cb	$CHClFCF_2CClF_2$	5.8	0.32		2,030	595	181
Hydrofluorocarbons							
HFC-23	CHF_3	270	0.19	11,700	12,000	14,800	12,200
HFC-32	CH_2F_2	4.9	0.11	650	2,330	675	205
HFC-125	CHF_2CF_3	29	0.23	2,800	6,350	3,500	1,100
HFC-134a	CH_2FCF_3	14	0.16	1,300	3,830	1,430	435
HFC-143a	CH_3CF_3	52	0.13	3,800	5,890	4,470	1,590
HFC-152a	CH_3CHF_2	1.4	0.09	140	437	124	38
HFC-227ea	CF_3CHFCF_3	34.2	0.26	2,900	5,310	3,220	1,040
HFC-236fa	$CF_3CH_2CF_3$	240	0.28	6,300	8,100	9,810	7,660
HFC-245fa	$CHF_2CH_2CF_3$	7.6	0.28		3,380	1030	314
HFC-365mfc	$CH_3CF_2CH_2CF_3$	8.6	0.21		2,520	794	241
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	15.9	0.4	1,300	4,140	1,640	500
Perfluorinated compounds							
Sulphur hexafluoride	SF_6	3,200	0.52	23,900	16,300	22,800	32,600
Nitrogen trifluoride	NF_3	740	0.21		12,300	17,200	20,700
PFC-14	CF_4	50,000	0.10	6,500	5,210	7,390	11,200
PFC-116	C_2F_6	10,000	0.26	9,200	8,630	12,200	18,200

Memorandum submitted by Martin Quick

SUMMARY

S1 This submission proposes that if shale gas turns out to be a large scale environmentally acceptable energy source, it should be used to provide the funding and energy for the development of a sustainable long term energy system. Assuming such a system incorporates a high proportion of intermittent renewables, as well as methods of demand management and demand time shifting and possible means of energy storage, sufficient gas should be reserved for power generation in the relatively small number of hours in a typical year when there is a shortage of generation relative to demand.

S2 Leakage of shale gas to the atmosphere in other than very small quantities would offset any climate change benefits this gas could have

S3 The UK should investigate its shale gas potential, but (assuming environmental factors are acceptable) we should delay exploitation until global energy prices become very high.

1. IMPLICATIONS OF GLOBAL EXPLOITATION OF SHALE GAS ON CLIMATE CHANGE MITIGATION

1.1 The exploitation of shale gas in a number of countries, particularly the USA, is likely to extend the availability of gas at reasonable prices for a number of years, but for how long is uncertain. While this must ease issues of energy security, its impact on climate change mitigation efforts is less clear. In principle, if uncontrolled leakage is minimal (see 1.3 below), if this gas were to be used in power stations to substitute directly for electricity generation in coal burning power stations, the immediate effect in the shorter to medium term would be beneficial. This is because of the lower amount of carbon per unit of energy in gas compared with coal, and the generally greater efficiency of gas fired power stations. However, if the exploitation of shale gas were to reduce the drive to develop low carbon energy sources as fears of an energy crisis in the near term are lessened, this could have an adverse effect on longer term climate change mitigation efforts.

1.3 If the exploitation of shale gas gives rise to any significant leakage of gas to the atmosphere, any climate change mitigation potential from shale gas could be negated. The fact that shale gas (methane) has penetrated the water supplies in some sites in the USA suggests that the escape paths for the gas are not very well controlled. As the global warming potential of methane is ~20 times that of CO_2, if, for example, 5% of the gas were to escape the climate change impact of gas from this source would be about twice that of gas produced more locally under tighter control. This would make the climate change impact of energy from shale gas greater than that from coal. If power stations were operating with CCS, the climate change impact of such escaping gas would be many times that from the fuel actually producing energy.

2. IMPLICATIONS FOR THE UK OF SHALE GAS EXPLOITATION

2.1 If it turns out that the UK has significant reserves of shale gas, these should not be exploited as soon and as fast as possible, as in effect happened to the UK North Sea hydrocarbon resources. We continued to extract oil and gas from the North Sea at a high rate even when prices were very low, for example in the 1990s when oil was priced at about $10 per barrel. Now, when prices are much higher our reserves are very much depleted, we have become net importers of oil and gas. While global gas costs remain tolerable, any UK shale gas should be conserved until global gas supplies become very expensive.

3. ROLE OF SHALE GAS IN UK AND EUROPEAN ENERGY SYSTEMS

3.1 The government's target for reduction of CO_2 emissions is 80% reduction by 2050. Many climate change scientists believe that to achieve an acceptably low risk if dangerous climate change and an equable distribution of greenhouse gas emission allowances between countries, even more stringent reductions may be needed[1]. Some studies for the UK [2 3] and Europe [4] have proposed energy systems based totally or largely on renewables. However, to achieve the last few percentage points of energy from renewables may be disproportionately expensive, and in the case of a Europe wide system, there could be political delays. To achieve very major reductions in greenhouse gas emissions, in the longer term, the electricity system will need to be almost totally decarbonised. Some sectors currently largely dependent on fossil fuels such as heating and transport will need to switch largely to low carbon electricity. Nearly all fossil fired generating plant would require carbon capture and storage (CCS) to meet very low greenhouse gas emissions targets, but it must be recognised that CCS still is not fully proven and has its own problems.

3.2 In an energy system with a high proportion of intermittent renewables (in the UK, mainly wind power), demand side management will have an important role to play. Some electricity demands can be shut down, possibly by a signal from the utility, for varying lengths of time without adverse consequences. Heating provided by heat pumps on a community or district scale could incorporate heat storage in large hot water stores for a few days supply. Electric vehicles and plug-in hybrids can be charged mainly at night or at other periods of low demand. There are also different forms of energy storage. Today, these are applicable only in some geographical locations (eg pumped storage), or are at the development stage (eg flow batteries) and may remain expensive. If there is a Trans European electricity grid, possibly with connections to North Africa, as being promoted by a number of organisations [4] with generation from a variety of renewable sources, the likelihood of large scale loss of power generation would be reduced.

3.3 However, it is likely there will be some periods when wind and other renewables cannot meet demand, and there may be insufficient "dispatchable" power (ie power that can be turned on at will) from renewable sources such as biomass or hydro power. It is for such conditions that generation by gas should be reserved. Gas fired power stations, including those with Carbon Capture and Storage are more suitable for catering for intermittent use and load changes than comparable coal fired stations, and their lower capital cost makes them more suitable for low load factor operations.

4. Optimum use of Shale Gas

4.1 The supply of easily accessible hydrocarbons is likely to fall short of potential demand within a few years. Even the International Energy Agency, for many years in denial over this, now accepts this is likely. Coal, the most plentiful fossil fuel, may become expensive as China becomes a significant purchaser of coal on the world market, as is predicted by some analysts [5]. If significant shale gas is produced globally, this would postpone the energy crunch when the supply of relatively low cost fossil fuels falls short of potential demand. Any such postponement should not be used as a "get out of jail free" card, but should be used to ensure a sustainable energy system is developed while funds and energy are less constrained. The main costs and energy input for most renewable energy systems (eg wind, solar, tidal) and for efficient transport and energy efficient buildings are in the construction stage. While the energy for manufacture of wind turbines (mainly for producing steel and cement) is relatively low in relation to the lifetime energy generation, this energy is required up front. Building a super-grid for linking varied sources of renewable energy to centres of consumption will require large amounts of copper and aluminium and energy is required to produce these. Any period of easing of energy supplies should be used for constructing the infrastructure for a long term sustainable energy system.

5. Risks and Hazards of Drilling.

5.1 From the experience in the USA it is clear that there are significant risks of pollution of water sources and of methane getting into water supplies. Given the higher population density in the UK, such risks may be more significant.

6. Recommendations

6.1 The potential for leakage of gas from shale gas exploitation should be fully investigated, and means of monitoring leakage developed. If there are circumstances where it is not possible to guarantee leakage remains very low, exploitation should be discouraged. The global warming potential of any leaking gas should be included in assessing allocations of greenhouse gas emissions between countries in any global agreement.

6.2 If significant shale gas able to be tapped in an environmentally acceptable way is found in the UK, it should not be rapidly exploited, but reserved until global energy prices reach very high levels.

6.3 Any postponement of the global energy crunch anticipated by many analysts provided by shale gas exploitation should be used to build a long term sustainable energy system with minimal greenhouse gas emissions.

References

[1] James Hansen "Climate target is not radical enough" *Guardian* 7 April.2010

[2] Zero carbon Britain2030. Centre for alternative technology

[3] The offshore valuation www.offshorevaluation.org

[4] The European roadmap

[5] China set to become largest importer of thermal coal. *Financial Times* 23 June 2010

Martin Quick is a Chartered Mechanical Engineer, having graduated from Cambridge University and done practical training with Rolls Royce Motors and GEC. Most of his professional career was in the electricity supply industry, and he has also carried out consultancy on building energy efficiency

January 2011

Memorandum submitted by National Grid

Introduction to National Grid

1. National Grid owns and operates the national gas transmission system (NTS) throughout Great Britain and, through its four gas distribution networks, distributes gas in the heart of England to approximately eleven million offices, schools and homes. National Grid also owns and operates the high voltage electricity transmission system in England and Wales and, as National Electricity Transmission System Operator (NETSO), operates the Scottish high voltage transmission system. In addition National Grid owns and operates significant electricity and gas assets in the US, operating in the states of New England and New York.

2. In the UK, National Grid's primary duties under the Electricity and Gas Acts are to develop and maintain efficient networks and also facilitate competition in the generation and supply of electricity and the supply of gas. Activities include the residual balancing in close to real time of the electricity and gas markets.

3. Through its subsidiaries, National Grid also own and maintain around 18 million domestic and commercial meters, the electricity Interconnector between England and France, and a Liquid Natural Gas importation terminal at the Isle of Grain. The wholly owned subsidiary National Grid Carbon Limited has advanced the transportation and storage elements of the Carbon Capture and Storage (CCS) supply chain.

4. This response is on behalf of National Grid Gas (NGG).

Shale Gas Inquiry

5. If UK produced shale gas can be developed economically then it could make a useful contribution to the UK's gas supply in terms of diversity and security of supply. There are likely to be technical challenges associated with the use of shale gas (in particular the UK requirements for gas quality and for entry capacity). However we do not anticipate that these should be insurmountable and we have experience of working with shale gas from our US operations which may be beneficial in developing the use of this new source of gas in the UK.

6. If shale gas becomes a significant contributor to UK gas supplies, this would represent an important development that we would need to take account of in relation to future network investment (potentially in relation to both the NTS and the Distribution Networks), so it will be important that developers provide us with a clear understanding of the scale, timing and locations of shale gas developments. This inquiry into shale gas is therefore timely given the fact we are currently undertaking a Price Control Review under the new RIIO[1] framework as it should give us some ability to reflect the implications of UK shale gas development in our submissions to this process.

7. If plans for significant UK shale gas development are forthcoming, we will reflect the impact of this new source of gas in our "Ten Year Statement". This report is published annually and provides a ten-year forecast of the gas transportation system usage and likely system developments. It is produced in response to obligations placed on us under our Gas Transporters' Licence and the Uniform Network Code and is designed to help current and future potential users of the NTS who are contemplating connecting to or using our system to identify and evaluate opportunities.

8. Subject to meeting existing network entry arrangements (including in relation to gas quality) NGG would welcome the additional supply diversity that indigenous shale gas production would deliver.

9. NGG are not in a position to comment further on the questions raised in the call for evidence. NGG would look forward to supporting and working with the Energy and Climate Change Committee, DECC and other stakeholders to address the challenges that development of shale gas may present.

January 2011

Memorandum submitted by the Campaign to Protect Rural England (CPRE)

Introduction

We welcome the opportunity to submit evidence to the Energy and Climate Change Committee on the future of shale gas in the UK. As a leading environmental charity, the Campaign to Protect Rural England (CPRE) has worked to promote and protect the beauty, tranquillity and diversity of rural England by encouraging the sustainable use of land and other natural resources since our formation in 1926. We are concerned to ensure that any shale gas extraction in England does not cause unacceptable damage to the countryside. Our comments are therefore focused primarily on the environmental impact of domestic exploitation of shale gas.

General Points

1. The majority of oil and gas production in the UK has taken place offshore, which has meant that the immediate environmental impacts of the industry have had limited visibility. At present, most industry expertise is in onshore shale gas production, and much of the near term UK shale gas resource, if developed, is likely to be exploited in the East of England, Surrey, Hampshire and Lancashire. The landscape implications of onshore shale gas production are likely to be visually and ecologically intrusive. Experience from the United States suggests that drilling "pads"—land which must be completely cleared and flattened, destroying topsoil and the immediate environment—vary from two to six acres, with pads being spaced between one every four and one every sixteen hectares, depending on the shale in question and drilling method used. Each pad also requires roads and gas capture facilities. As such, large scale exploitation could lead to unacceptable, sprawling, low density industrial development in the countryside. This is likely to face significant opposition on the grounds of landscape and wildlife conservation and rural character and amenity.

[1] **R**evenue using **I**ncentives to deliver **I**nnovation and **O**utputs

2. CPRE is also concerned that "hydrofracking"—the technique used to fracture rock to release gas from shale—is extremely water intensive and may pose risks to groundwater supplies. Large shale gas resources potentially exist under the South West and South East of England, areas which already suffer from water stress. In some areas, surface water consumption is already above environmentally sustainable levels. At a time when Defra is considering whether or not a national policy statement enabling a large scale water network is required to serve existing domestic and commercial water consumption, and at least six large reservoirs are planned in the South East of England to cater for existing water demand, fostering a water intensive industry which is likely significantly to increase demand for a scarce resource is highly questionable. Moreover, experience from the United States suggests that in the absence of effective regulation and enforcement, fracking leads to groundwater contamination.[2] CPRE suggests that the UK government pay close attention to a new study by the US EPA on the issue of fracking and groundwater contamination.

3. In addition, there is some evidence, though it is contested, that methane leaks from shale gas production substantially increase the CO2e emissions from shale gas compared with conventional UK Continental Shelf gas.[3] Evidence from Canada shows that the majority of existing wells in Quebec leak methane, despite industry claims of low leak rates.[4] Much of the appeal of shale gas rests on the idea that it will enable the UK to continue to reduce emissions in the short term by substituting gas for coal. If the overall emissions from shale gas are high, however, this removes the justification for investing in shale gas over and above other alternatives. This argument applies equally to foreign and domestic shale gas production.

Conclusion

4. CPRE believes that gas has a role to play in balancing renewables and in supplanting unabated coal fired power plants in the short to medium term. However, significant domestic exploitation of onshore shale gas poses risks to the ecology and character of rural England. Overreliance on gas also risks locking the UK into high carbon infrastructure which may need to be shut down prematurely if the UK is to meet its carbon budgets. Shale gas should not be seen as an environmentally beneficial panacea for declining conventional gas production in the North Sea.

January 2011

Memorandum submitted by Scottish & Southern Energy

SSE would like to thank the Energy and Climate Change Committee for this opportunity to respond to their inquiry into shale gas. Although SSE, formerly Scottish & Southern Energy, does not have any immediate shale gas prospects, it has been examining its potential development in the UK after the significant role it has played in the US. SSE has seen how shale gas developments have reduced the US's potential dependence on LNG imports, a situation of relevance to the UK given its growing dependence on importing LNG and concerns about security of supply.

1. *What are the prospects for shale gas in the UK, and what are the risks of rapid depletion of shale gas resources?*

1.1. There are certain factors which were pivotal to the increased production of shale gas in the US, which may not be applicable in the UK. Firstly, the geology of the UK in regard to shale gas resources is not as favourable as it is for the US, but the available resource is still potentially significant. Due to higher production costs, the economically viable prospects in the UK will be a fraction of the potential resource as most will not be economic to exploit in the current market with current technology. If the wholesale price of gas were to rise in the future, the relatively high production cost of shale gas would become more acceptable to developers.

1.2. A second factor for the rapid development of shale gas in the US was easy and low-cost access to the gas transport network, and this could prove to be an advantage in the development of shale gas in the UK with our existing gas distribution network, which is one of the most developed in the world. This could partially offset the higher production cost, as exploiting domestic sources of shale gas would lead to an inevitable reduction in transit costs, which are particularly high for energy intensive LNG imports.

1.3. Another major barrier to shale gas development in the UK would be land access. In the US there was an opportunity for rapid leasing of large areas of land for development at a low cost. This is unlikely to be replicated in densely populated regions of the UK where initial resources are located. This issue can be highlighted in the relative population densities, which in England has 383 people per km^2, as opposed to the US, which has 27 people per km^2.[5] This is particularly relevant when compared with conventional gas reserves, as shale gas resources are spread more thinly over much wider areas.

[2] A useful, relatively conservative overview of the current evidence can be found in: Manuel J 2010. EPA Tackles Fracking. Environ Health Perspect 118:a199-a199. doi:10.1289/ehp.118-a199, available from http://ehp03.niehs.nih.gov/article/info%3Adoi%2F10.1289%2Fehp.118-a199

[3] Howarth, Robert 2010. Preliminary Assessment of the Greenhouse Gas Emissions from Natural Gas obtained by Hydraulic Fracturing, available from http://www.eeb.cornell.edu/howarth/GHG%20emissions%20from%20Marcellus%20Shale%20—%20with%20figure%20—%203.17.2010%20draft.doc.pdf

[4] See, for example, http://www.cbc.ca/money/story/2011/01/05/shale-quebec-bape.html

[5] Stevens, P (2010) The "Shale Gas Revolution": Hype and reality, Chatham House, London

1.4. As for the risks of rapid depletion of resources, it is unlikely that the depletion rates of shale gas wells would be a problem. Whilst it has been noted that shale gas wells deplete rapidly compared to conventional wells, individual shale gas wells can maintain a level of production, albeit at a lower level than at first production, for a significant period of time. This should not discourage initial projects, as long as this depletion rate is factored into the economic rationale behind the investment.

2. *What are the implications of large discoveries of shale gas around the world for UK energy and climate change policy?*

2.1. The implications of large discoveries of shale gas for US energy policy have been significant, as it has greatly reduced its potential dependence on LNG imports. The recent increase in US production of shale gas has also benefited the UK by freeing up LNG supply in the Atlantic basin, and thus reducing the price of uncontracted LNG supplies for the UK's spot market. The initial implications of large discoveries in other regions around the world could benefit the UK in a similar fashion by further reducing wholesale prices by widening the gap between supply and demand, improving security of supply.

2.2. For the UK's energy and climate policy, shale gas discoveries could be positive. For the electricity sector, lower costs would likely increase coal to gas switching in the short term, meaning gas-fired electricity would be able to displace coal in the electricity market, with a consequent reduction in the CO_2 intensity of the electricity sector. There would also be a medium term benefit as there will be a need for continued significant amount of gas-fired generation capacity to balance issues of intermittency associated with increased renewable deployment.

2.3. In the domestic sector, which comprises a third of the UK's gas demand,[6] any significant discoveries of shale gas could reduce the costs for consumers reliant on gas who may be unable to switch to alternative sources of energy, for heating and cooking. This would have positive short and medium term implications for the Government's fuel poverty objectives.

2.4. However, it should be noted that a low wholesale gas price caused by potential shale gas discoveries would encourage significant investment in gas infrastructure, which would lock carbon into the UK's energy system. Furthermore, if the UK is consuming shale gas directly or imported conventional gas displaced by shale gas consumed elsewhere in the world, then there are negative implications for additionality of CO_2 emissions globally.

3. *What are the risks and hazards associated with drilling for shale gas?*

3.1. The risks and hazards are connected with water consumption for hydraulic fracturing and/or methane leakage. The technique of hydraulic fracturing requires large amounts of water, with estimates of 4–5 million gallons needed to fracture one well[7]. This waste water has to be carefully managed and there have been concerns that chemicals used in the fracturing process can contaminate local water supplies. To mitigate these risks, closed loop water systems are being developed by industry to reduce water requirements. There is currently work being undertaken by the Environmental Protection Agency in the US, which is looking into the process of hydraulic fracturing and its potential adverse effects on water quality and public health, which should bring greater clarity on the risk and hazards associated with the process of hydraulic fracturing.

4. *How does the carbon footprint of shale gas compare to other fossil fuels?*

4.1. Currently there is not a definitive answer. The carbon footprint of shale gas extraction is uncertain but it is provisionally seen as slightly above onshore conventional gas drilling, but it must be noted there are reports suggesting that its lifecycle carbon emissions are significantly higher. More detailed analysis will be required for greater understanding the carbon lifecycle of shale gas production, as even with development of CCS for gas-fired generation it will not be able to capture the carbon emitted during the production of shale gas. Even so, domestically produced shale gas would have the benefit of not needing to be processed and transported vast distances, as is the case for imports from LNG and pipeline supplies, partially offsetting any potential additional carbon emissions from production.

5. Conclusions

5.1. Increased shale gas production in the UK and worldwide is likely to result in a market of excess supply and subsequently low prices in the short and medium term. Combined with the relatively attractive low carbon emissions of natural gas and the low cost and speed of construction of gas-fired generation plant, this is likely to increase gas demand in the electricity sector. The increased electrification of heat and transport will exacerbate this trend.

5.2. However, natural gas remains a finite resource, regardless of source, and UK supplies of shale gas cannot totally replace reliance on importing supply. There is a concern that with limited capital for investment in the energy industry, significant development of policy incentives to encourage development of shale gas resources in the UK, alongside uncontrolled growth in gas-fired generation could decrease investor certainty

[6] DECC (2010) Digest of UK Energy Statistics, London
[7] IEA (2009) World Energy Outlook, Paris

on UK policy direction towards renewables, CCS and/ or nuclear. Although this would lead to a short term gain in carbon emission reductions, it would be to the detriment of the long term decarbonisation of the UK power sector.

5.3. SSE believes that shale gas could prove to be a viable and attractive resource for the UK to exploit in the future. This would however, be at a significantly reduced scale compared to that of the US, due to a number of factors, most notably potential issues with land access and secondly the issues over the necessary water use, which Government will need to consider.

January 2011

Memorandum submitted by Scotia Gas Networks

1. Scotia Gas Networks (SGN) Response to the Energy and Climate Change Committee's Inquiry into Shale Gas

1.1. SGN would like to thank the Energy and Climate Change Committee for the opportunity to respond to the inquiry into shale gas. Scotia Gas Networks is the UK's 2nd largest gas distribution company providing a safe and secure supply of natural gas to 5.7 million customers through 74,000km of gas mains and services. SGN own and operate two gas distribution networks, one covers the whole of Scotland whilst the other network covers the South East stretching from Milton Keynes to Dover in the east and Lyme Regis in the west, including London Boroughs south of the River Thames.

1.2. As the UK's second largest gas distribution company, SGN is extremely interested in the prospects for future gas reserves in the UK. As a distributed source of gas, shale wells are likely to need large numbers of smaller scale connections to gas distribution networks than typical conventional gas wells which require larger connections to the national gas transmission system; in our licensed area, it is likely that SGN will be the provider of many of these connections and all of these connections will need to join our network.

1.3. Last year, work commissioned by the Energy Networks Association and carried out by Redpoint showed that in 2050, gas could still be supplying a significant proportion of the UK's total energy demand through both heating and electricity generation whilst ensuring that carbon targets were met.[8] Further still, this work showed that by utilising the existing asset base, ie the gas networks, the costs of meeting carbon targets and supplying clean energy were significantly reduced. If gas used in the UK's energy mix is sourced domestically and is not imported, this also has clear benefits for energy security and the UK economy along with the carbon benefits associated with the reduced greenhouse gas emissions from reduced use of Liquefied Natural Gas (LNG).

2. *What are the prospects for shale gas in the UK, and what are the risks of rapid depletion of shale gas resources?*

2.1. As with the rest of Western Europe, it appears that the geology of the UK could provide significant volumes of shale gas. It is however access to these sources of gas that may reduce total availability. The UK has a much higher population density than the US where levels of shale gas production have been very high. In the US, a more favourable geology with higher concentrations of shale rocks combined with free or easy access to much of the land allowed this rapid expansion.[9] In the UK, the availability of shale gas is likely to be less due to this major human constraint. However, the large scale and wide coverage of the UK gas distribution network could, by providing easy and quick connections to the networks, increase the speed at which shale wells can connect to the system and increase the availability of the gas.

2.2. It is very likely that gas prices will affect the rate at which shale gas is developed in the UK and if wholesale prices increase as they are expected to do, the viability of domestically produced shale gas is also likely to increase. In this situation, it is therefore likely that the most readily accessible shale wells will be used first and then, if wholesale prices increase further, more expensive wells will be developed.

2.3. The rapid depletion of shale gas resources does not appear to be a problem. The reserves of shale gas worldwide are extremely large and it is likely that a long way into the future, shale gas will be available even if significant volume of gas has been used. In Western Europe for example, reserves of shale gas are predicted to be larger that known reserves of conventional gas. Although the actual wells may deplete much more quickly than conventional gas reserves, the wells are likely to keep producing gas for a number of years.

3. *What are the implications of large discoveries of shale gas around the world for UK energy and climate change policy?*

3.1. Gas is generally considered a "clean fuel" as a result of having lower carbon emissions than other solid and liquid fuels when combusted. Its use, particularly in the domestic arena, is almost always associated with being more energy efficient and also more cost effective than equivalent electric or oil fired systems. It could

[8] Redpoint 2010, Gas Future Scenarios Project, Available from: http://energynetworks.squarespace.com/storage/ena_publications/ena_gas_future_scenarios_report.pdf.

[9] Stevens, P, (2010), The "Shale Gas Revolution": Hype and Reality, Chatham House.

therefore be suggested that if the availability of the gas resource increases through the production of shale gas, wholesale prices could be reduced and this will result in the increased use of gas and in many instances, this could result in lower greenhouse gas emissions.

3.2. The SGN "Assisted Connections" programme focuses on helping the fuel poor connect to the gas network as installing gas heating can remove a significant proportion of households from fuel poverty.[10] Increasing the availability and therefore reducing the wholesale cost of gas could therefore not only reduce consumer's bills, but would also ensure that gas is still a fuel that can assist with the issue of fuel poverty.

3.3. Even though shale gas is not likely to provide as high a percentage of total gas demand as it does in the US, if it can supply only a few percent of total demand, this will have significant implications for energy security as this source of gas will not be affected by any geopolitical or international energy issues.

4. *What are the risks and hazards associated with drilling for shale gas?*

4.1. The main hazards associated with the use of shale gas result directly from the process of extracting the gas. The process requires large volumes of water combined with chemicals and sand to fracture rock and thus release the gas. In the US, there have been some issues associated with the leaking of chemicals and methane gas into the domestic water system. When this has occurred, this is likely to have been due to poor management and low project standards. The release of a documentary/film in the US appears to have increased media coverage of the shale gas issue which often focuses on the negative aspects of the industry. Work currently underway by the Environmental Protection Agency in the US will hopefully shed some objective light on the real risks associated with shale gas. It is however very likely that investment in innovative approaches will reduce the risks associated with shale gas extraction in the future.

5. *How does the carbon footprint of shale gas compare to other fossil fuels?*

5.1. At the point of use, because of the composition of shale gas, the carbon footprint will be the same as conventional gas however, because of the way shale gas is extracted, it is likely that life-cycle emissions for shale gas will be slightly higher than for conventional gas. However, it must be considered that LNG, which requires compression into liquid, storage at very cold temperatures and high pressures and transportation by boat across very large distances will also have associated lifecycle emissions. We are not aware of the existence of exact numbers on the lifecycle emissions of shale gas however this is an area where perhaps further work is required.

6. Conclusions

6.1. Any increase in the use of shale gas in the UK and also across the world is likely to increase the availability of natural gas both reducing the costs of gas (relative to if there was no shale gas) and increasing supply margins. This could in the short term, result in the increased use of gas and reductions in carbon emissions.

6.2. However, the government needs to consider long term energy strategy to plan for a low-carbon future. The Gas Future Scenarios Project carried out by Redpoint shows how gas can fit into a low carbon future helping to meet 2050 carbon targets. Although the development of biogas is key to the future use of gas in these scenarios, biogas will need to be used in conjunction with some other sources of gas and in fact, as the UK continental shelf gas supplies decrease further, nationally sourced shale gas may be a very valuable resource if global gas prices rise as predicted. Shale gas may also help to increase the security of the gas supply.

6.3. Most importantly, the analysis by Redpoint showed that a future energy mix that included gas resulted in a lower system costs than scenarios in which more heat was provided by electric heating systems. In the period from 2010–50, the analysis showed that by using gas, total system costs were reduced by £10,000 per person on a net present value basis. This is simply due to the fact that reduced investment is required in infrastructure as the capacity to transport gas already exists whereas, for increases in electric heating, greater electricity generating capacity is required and significant investment in electricity infrastructure is also required to carry the greater electric load. SGN therefore believes that shale gas could make an important contribution to national energy policy goals.

January 2011

[10] DECC, (2010), Fuel Poverty 2008-Detailed Tables, Available from: http://www.decc.gov.uk/en/content/cms/statistics/fuelpov_stats/fuelpov_stats.aspx

Memorandum submitted by the Office of Gas and Electricity Markets (Ofgem)

Summary

- There is consensus that unconventional gas production from within Europe is unlikely to make a significant contribution to gas supply until 2020 at the earliest. Estimates put European unconventional gas resources at around 35tcm (trillion cubic meters, annual demand in GB is around 90 billion cubic meters), which gives an unconventional supply figure of around 1.75tcm based on an extraction rate of 5% (this is equivalent to 19 years of current GB annual gas demand).
- Levels of unconventional gas production from outside Europe (excluding Australia and North America) are also highly uncertain although significant resources exist in Asia. Resources in North America and the Asia Pacific area are estimated at 233tcm and 274tcm respectively.
- Production of shale gas in Europe is likely to be significantly more challenging than in North America. Key challenges include planning (including access to land), water availability, stricter environmental regulations and availability of support services for drilling operations.
- Large scale unconventional gas production in the UK could displace some imports whilst large scale foreign production could free up conventional gas supply for alternative destinations, potentially improving UK/European security of supply.

About Ofgem

Ofgem is the Office of the Gas and Electricity Markets. Protecting consumers is our first priority. We do this by promoting competition, wherever appropriate, and regulating the monopoly companies which run the gas and electricity networks. The interests of gas and electricity consumers are their interests taken as a whole, including their interests in the reduction of greenhouse gas emissions and in the security of the supply of gas and electricity to them. As part of meeting our duties and functions Ofgem actively monitors the energy market and this includes looking at range of issues such as the impact of new energy sources on the market

1. Background

Ofgem is monitoring closely the development of unconventional gas due to the impact of production from these sources on global and UK energy markets. The rapid development of unconventional gas has already had a profound impact on gas production in the US. The resulting reduction in demand for both imports of pipeline gas (from Canada and Mexico) and LNG (liquefied natural gas) has released incremental LNG supply to other markets and means that the US is unlikely to present a significant source of additional demand for LNG in the medium term (although the US still imports a large volume of LNG—12bcm in 2010). In our work on project Discovery (published in October 2009) we assumed a further expansion of unconventional gas in the US under all but one of the four scenarios modelled.

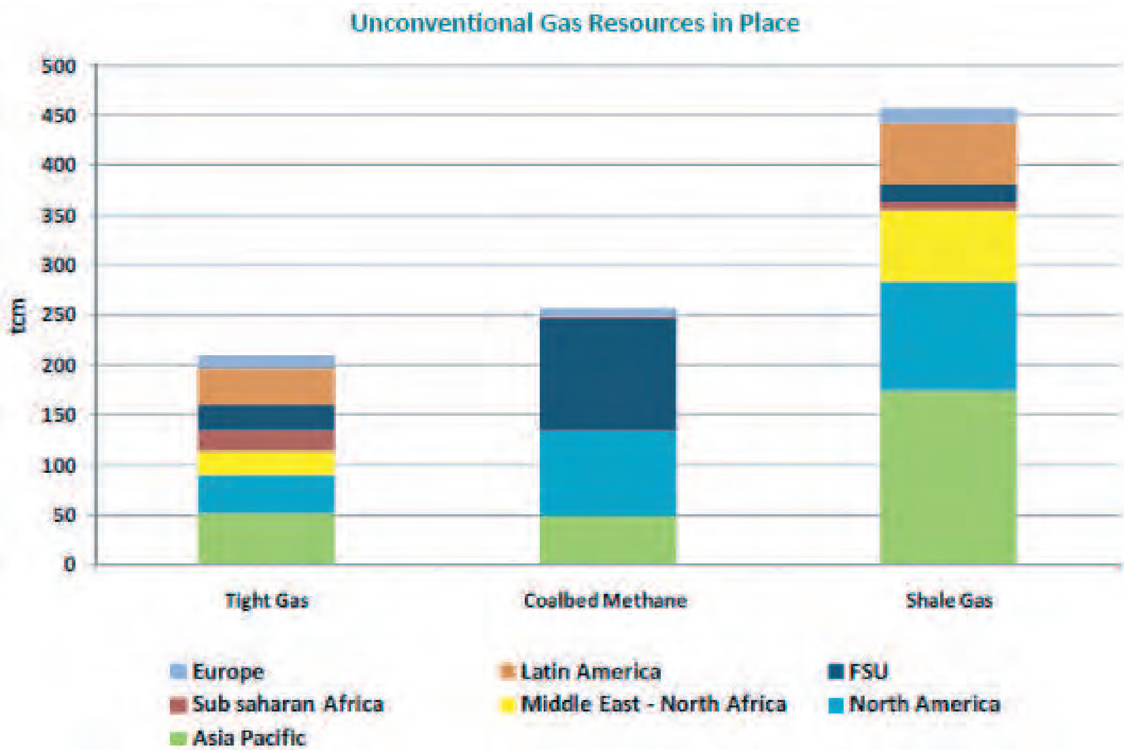
In this note we have attempted to provide material we hope the committee will find useful. The material has largely been drawn from publically available sources. The note firstly sets out forecasts for unconventional gas resources and outlines a range of technical factors relating to the extraction of unconventional gas. The note also considers the economics of shale gas production, presents estimates of potential unconventional gas production in Europe and outlines a number of barriers to large scale production in Europe/UK. Section 7 responds to specific questions raised by the committee where these are not addressed in other sections.

In this note we have focused on unconventional gas more generally. Shale gas is considered to be a type of unconventional gas which also includes coal bed methane (CBM) and tight gas.[11]

2. Unconventional Resources

The chart shows that the total volume of global unconventional gas in the ground is estimated to be around 921tcm. In comparison conventional resources at the end of 2008 were estimated at 184tcm. However, the majority of this is difficult to extract. If we assume that 5% is recoverable (based on US experience), this gives a supply of around 46tcm compared to total global consumption of gas in 2009 of 2.9tcm.

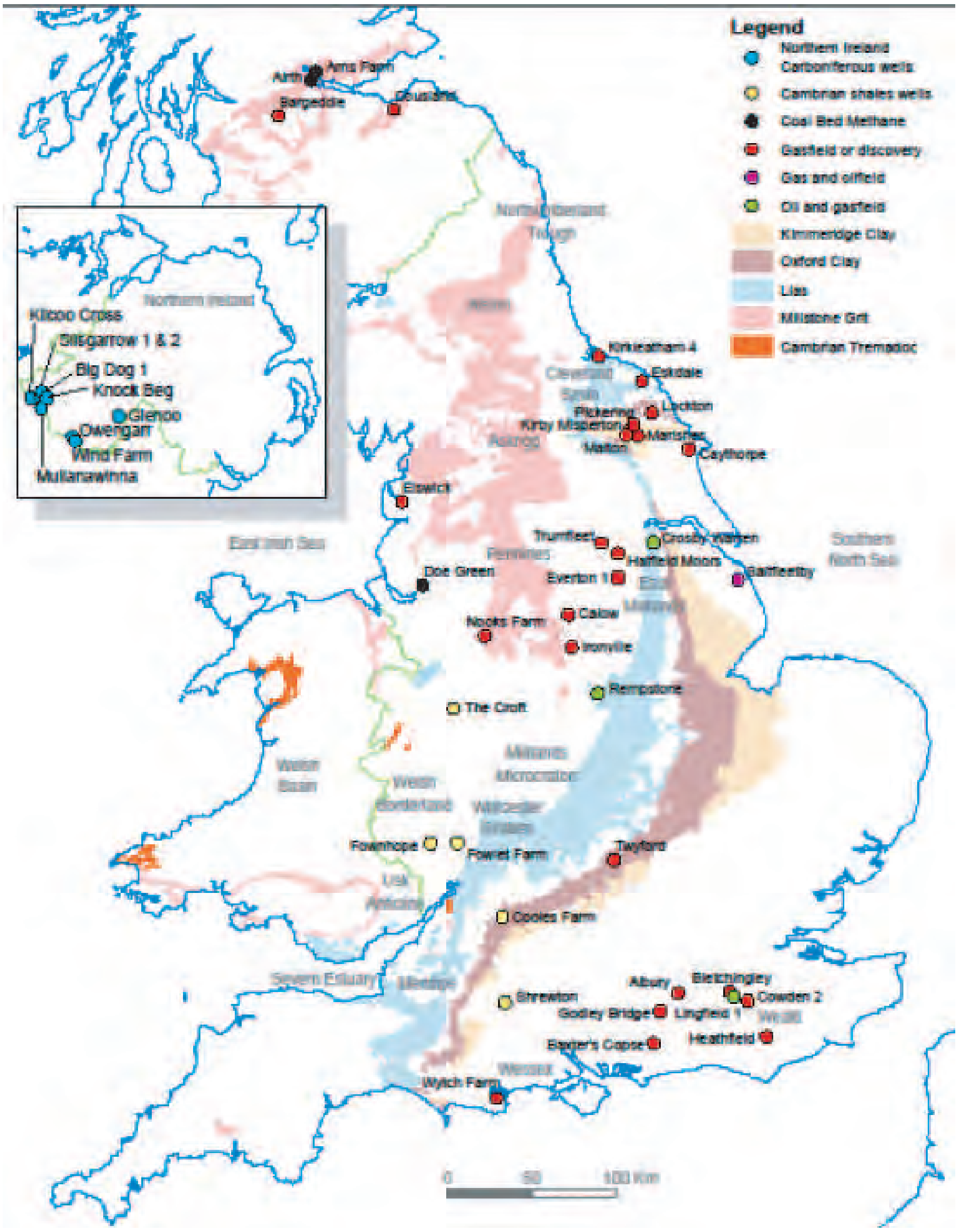
[11] Unconventional gas is largely made up of methane, i.e. the same as conventional gas. However, it is harder and/or less economic to extract than conventional gas. Gas that is currently considered unconventional could become conventional as technology develops and costs fall. CBM is found in coal seams and is methane gas that has either been absorbed onto the coal or is dispersed into pore spaces around the coal seam. Tight gas is gas trapped in usually impermeable and non-porous rock.



Source: IEA

It took around 20 years of development to reach current levels of shale gas production in the US, with production increasing from 7bcm in 2000 to 87bcm in 2009 (14% of consumption) and is forecast to rise to 368bcm in 2035 or around 55% of current consumption (recently the EIA has doubled its forecasts of US shale resources from 13.6tcm to 23.4tcm). Replicating this level of increase in other markets is likely to be challenging although, the know-how and technology developed during this period can be utilised in other markets. However, other barriers exist in reaching similar levels of production (see below).

In Western Europe the key areas that are thought to contain unconventional gas deposits are Poland, Germany, Hungary, Turkey and parts of the UK. The chart on the next page shows the most promising areas for shale gas exploration in the UK.



Source: British Geological Survey

3. Technology

This section outlines a range of technological factors important in producing unconventional gas. Shale gas is extracted using a process known as hydraulic fracturing or "fracking" where water/chemicals are injected at high pressure into a well to fracture rocks to release trapped gas.

Typically around 15–16 wells have to be drilled before finding the "sweet spot" (an area within a shale gas region that contains a high concentration of gas). Average extractions rates are between 4–6% as shale gas is not evenly distributed across a given area (based on US experience). This means that a greater number of wells are required compared to conventional gas production.

Extraction rates and cost of production depend on a range of factors such as the quality of the play (an area containing shale gas resource), the technology employed and the quality of the well operator. For instance:

— Production is significantly higher in dry gas areas than oil/wet gas areas (wet gas contains some liquids such as oil).

— Production is higher where horizontal drilling extends further out.

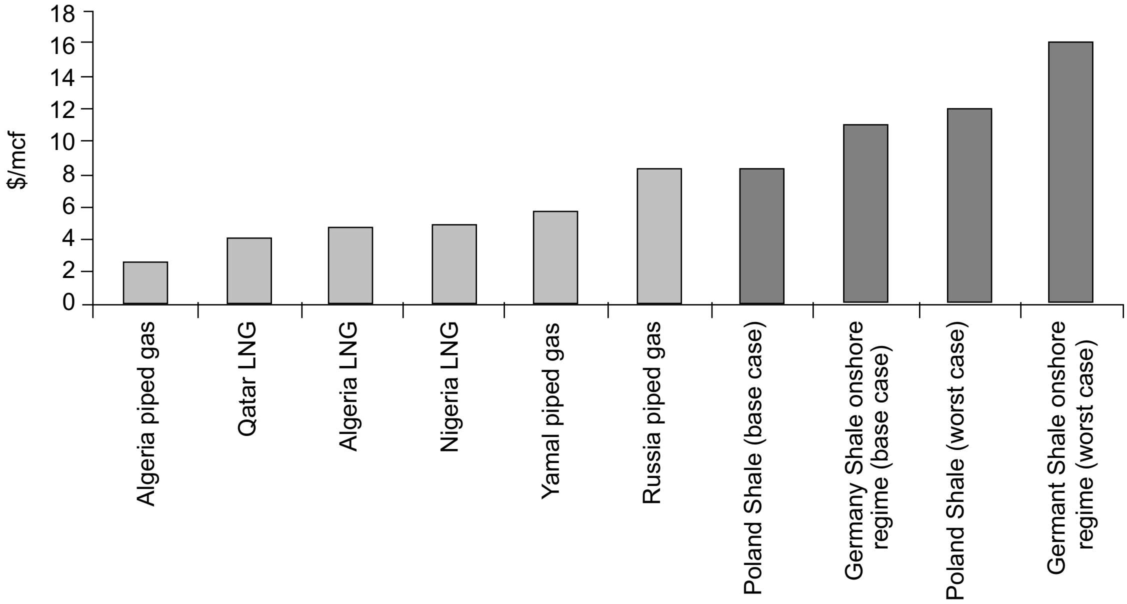
— Operator performance varies significantly, with the best operators producing significantly more than less efficient operators holding all other relevant factors constant.

— Deeper shale gas is harder to access but provides better flow rates due to higher pressure.

It is possible to apply horizontal drilling techniques used in unconventional gas extraction in improving flow rates from poorly performing conventional gas wells. For example, using this technology in Saudi Arabia has increased volumes from a conventional gas well from 0.5mcf/d to 30mcf/d. This could improve the economics of existing conventional gas wells that are either currently uneconomic and/or are coming to the end of their useful lives. It is also possible to improve/maintain extraction rates from existing unconventional gas production wells by further re-fracturing wells.

4. Economics of Shale Gas

Global gas prices play an important role in determining the economics and hence overall levels of unconventional gas production. The chart below shows estimated costs of European shale gas production versus other new sources of supply in 2020.



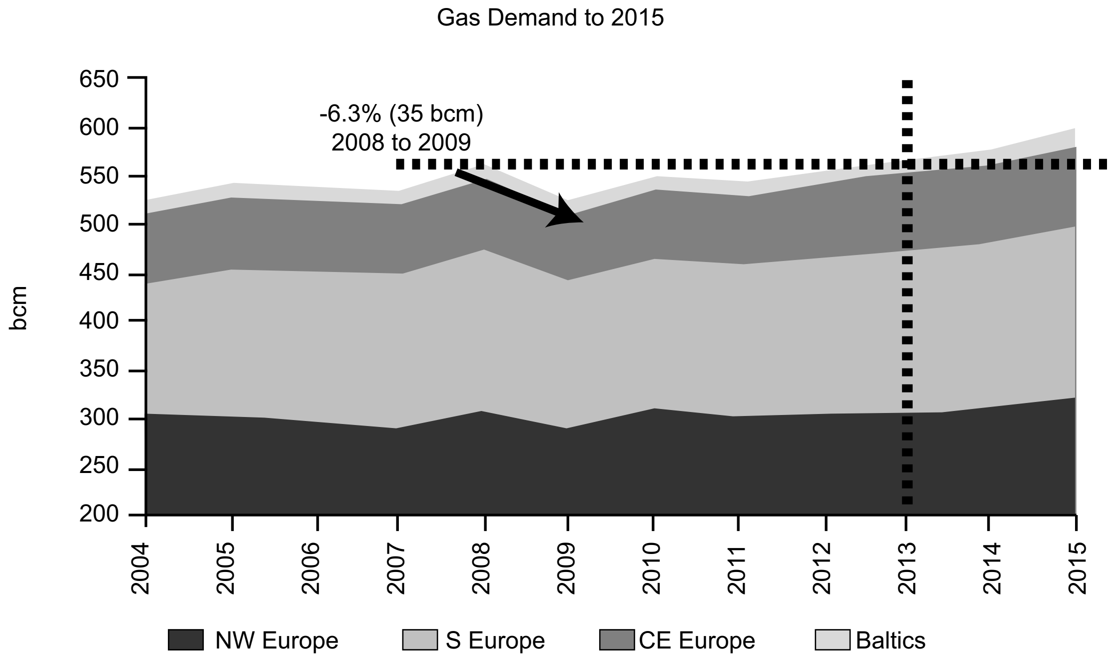
Source: Oxford Institute for Energy Studies. The current $/£ exchange rate is 1.55 and the cf to cm conversion factor is 0.028. This gives a p/therm for Poland Shale (base case) of 56p/therm.

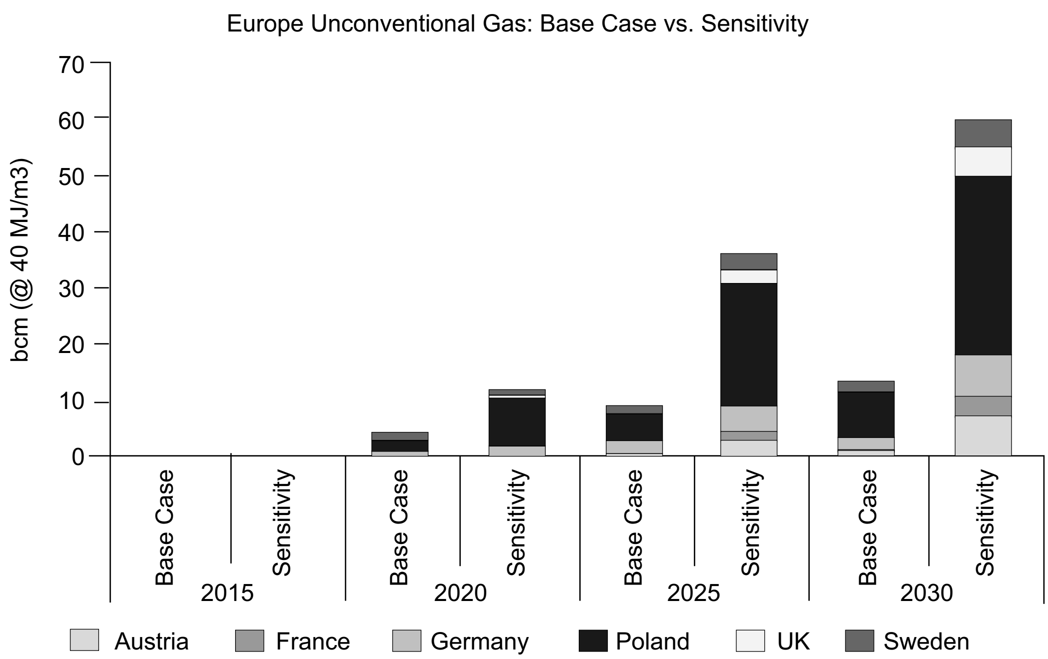
The chart shows that European shale gas is likely to have a higher cost of production compared to other gas supply sources. The long run cost for current shale gas projects in the US have been estimated to range from 12.5p/therm to 40p/therm. Current Henry Hub (a pricing point for gas trading in the US based in Louisiana) prices are around 25p/therm whilst GB prices are around 65p/therm.

In North America, government has provided assistance to unconventional producers. This has included tax breaks (eg the crude oil windfall profit tax act) and R&D support. The US is also offering to help other countries realise their unconventional gas resources through their Global Shale Gas Initiative launched in April 2010.

5. Forecasts of European and UK Unconventional Gas Production

The charts on the next page show that European gas demand is unlikely to recover to 2008 levels until 2013. The second chart shows that unconventional gas is unlikely to make a significant contribution in meeting gas demand in UK by 2020 (in both base and high case scenarios) although other European countries have the potential to produce around 5–10bcm by 2020 (in the high case scenario).





Source: Woodmac

Cuadrilla Resources, the first company to drill for shale gas in the UK, have recently obtained promising results from the UK's first shale gas well in Lancashire. Based on this data they estimate that shale gas could ultimately meet 5–10% of UK gas demand although they do not give a time frame for this view. They are hoping to start the extraction process in early 2011.

In terms of coal bed methane, according to Reach CSG, the UK has potentially large deposits that could be exploited. They estimate that CBM has the potential to provide up to 20% of UK gas production in 2020.

6. Factors That May Restrict the Development of Unconventional Gas in Europe

A number of factors may restrict the extent to which unconventional gas resources can be exploited in UK/ Europe compared to volumes observed in North America. These include:

— **Availability of sites.** Some sites containing potential unconventional resource are protected by national or European law.

— **Geology of sites.** Many European sites are smaller, with shale gas deposits deeper and further away from each other.

- **Service sector.** A lack of a flexible, readily available service sector in Europe to support unconventional gas operators. However, current operators in North America are commercial firms and as such are likely to offer their services in other markets where demand exists.
- **Local opposition.** Concerns about the impact of drilling on the local community, in particular concerns over drinking water contamination.
- **Water utilisation/scarcity.** Concern whether there is adequate infrastructure to transport water to the drilling sites, disposing of waste water and competition with other uses, eg drinking. Some positive developments in this area including using saline water for fracking (rather than drinking water) and recycling a high proportion of the water used.
- **Environmental restrictions.** These are often more stringent in Europe than in the US (particularly when compared to the large shale gas producing states).
- **Less uninhabited/available land.** Population density in Europe is 100 to 200hab/km2 compared to just 30hab/km2 in the US. The US model of "factory drilling", where hundreds of wells are drilled across a specific play to indentify a "sweet spot", is therefore unlikely to be appropriate for most European markets. Instead a target approach is more suitable, where detailed R&D takes places to identify sweet spots more accurately. This method is consistent with the traditional exploration and production method that the large European energy firms are familiar with. In the US drilling is often in sparsely populated areas but even where it is in more heavily populated areas, the public is accustom to drilling activity due to a history of onshore oil drilling.
- **Getting gas to market.** Grid density varies considerably, with a gas grid (km)/area (1000km2) of 62 and 45 in the US and UK respectively but only one in Sweden. One solution could be to convert extracted unconventional gas into electricity and transmit the power where electricity transmission is more readily available than gas.
- **Compensation to land owners.** In the US legislation provides owners of above ground land rights over underground resources. In almost all European countries underground resources is owned by the state. However, European drilling companies have said that they have not found it difficult to obtain access by negotiating directly with land owners. However, this may change as the level of drilling increases.
- **Lower prices in 2009/10**, due in part to high levels of production of unconventional gas in the US, reducing the NPV of European projects, although gas prices are currently rising in Europe.

Whilst European players are less experienced than their North American counterparts there is a greater preference for partnerships and joint ventures in Europe, with energy majors with unconventional gas extraction experience partnering up with smaller outfits. This is due in part to higher costs of developing European plays (~£200 million from development to production).

7. Questions Posed by the Committee

What are the prospects for shale gas in the UK, and what are the risks of rapid depletion of shale gas resources?

As the analysis above shows, there is considerable uncertainty over the likely levels of unconventional gas production (including shale gas) in the UK and across Europe more generally. There are a number of barriers that need to be overcome before significant production levels can be achieved. Based on current forecasts, significant volumes of UK unconventional gas production are unlikely before 2020.

The level of recoverable gas from an unconventional gas play sets the overall production limit. As noted above various factors including geological and technical determine the level of recoverable gas. In terms of the rate of depletion of shale gas wells, experience from the US indicates that although unconventional gas wells deplete faster than conventional wells production levels can be improved by re-fracturing of wells.

What are the implications of large discoveries of shale gas around the world for UK energy and climate change policy?

Large scale discoveries of shale gas resources do not necessarily mean large scale production will follow due to technical and economic factors, particularly in Europe. However, if we assume large scale production occurs this will increase overall gas supply, which is equivalent to large discoveries of conventional gas. Thus, an increase in shale gas production is likely to have the same impact on energy policy as an increase in gas production from conventional sources.

Large scale unconventional gas production in the US has already had a significant impact on global, European and UK energy prices. The significant rise in US indigenous production has reduced its LNG import requirement freeing up cargoes for alternative destinations. It is difficult to isolate the impact of increasing shale production on global gas prices from other factors such as demand reduction due to the recession and the increase in LNG liquefaction capacity. However, it is likely to have played a role in reducing gas prices.

Large unconventional gas production (as with any increase in gas supply) is likely to have an impact on the UK energy policy. For instance, everything else equal, it is likely to improve the security of supply outlook, both if large scale UK indigenous unconventional production is realised which then displaces imported gas or if large scale unconventional gas production in other countries occurs freeing up gas for international markets. Our view is that impact on security of supply for the UK is likely to be neutral to positive. However, a number of factors complicate the picture, for instance how quickly global demand will recover, in particular the speed of energy demand growth in China and India.

Finally, it may be new regulations, particularly environmental, may be need to manage the environmental impact of unconventional gas drilling, in particularly relating to usage and disposal of water.

How does the carbon footprint of shale gas compare to other fossil fuels?

Work on understanding the environmental impact of unconventional gas production is still at an early stage. However, environmental impacts are likely to include impact on water resources, concerns on contamination of the water table and the possible leakage of methane.

The Environmental Protection Agency in the US has launched a study into the impact of hydraulic fracturing, used in shale gas production, on the environment including drinking water. The study will publish its results in 2012 (please see the following link http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/index.cfm).

A paper published by Robert Howarth at the University of Cornell calculated that if methane leakages from hydraulic fracturing are including, along with emissions from forest clearing and water transport the carbon footprint of shale gas is slightly worse than coal. However, the paper notes that the assessment is highly uncertain and the numbers should be treated with caution (www.damascuscitizens.org/GHGemissions_Cornell.pdf).

I hope that you consider this information useful.

January 2011

Memorandum submitted by Shell

Executive Summary and Introduction

(i) Following the success seen in Unconventional Gas (UCG) production in North America, Shell also sees potential for UCG development across the globe, and particularly in Europe, China, Australia and Southern Africa, although it is not expected that the growth will be uniform. The estimated recoverable global resource base in unconventional gas is equivalent to 123 years of current global production.

(ii) In Europe, Shell believes the biggest untapped potential is found in France, Germany, UK, Hungary, Poland, Romania and Sweden. However, more extensive exploration programmes over the next 2–4 years are needed to better assess the resource. At the moment it is difficult to see shale and tight gas having the same, game-changing impact in Europe as in North America and certainly not before 2020. It could still however help lift production levels and further diversify Europe's supplies.

(iii) The development of UCG resources outside of North America will depend on domestic gas price developments in different countries and regions, local gas infrastructure, government and community support, and the extent to which environmental issues can be effectively addressed. The Shell experience in producing UCG in North America, where the implementation of new technologies has significantly reduced the environmental footprint of UCG activities, demonstrates that if sufficient amounts of gas are found, it is possible to extract UCG in an economically, environmentally and socially acceptable way.

(iv) Locally and globally, a greater abundance of gas could encourage a move from coal-fired electricity generation to gas-fired generation. Coal-fired power is currently responsible for the fastest sector growth in CO_2 emissions worldwide. Modern gas-fired plants emit between 50% and 70% less CO_2 than coal plants per kilowatt hour of electricity generated. Hence replacing coal with natural gas is the surest, fastest and cheapest way to reduce CO_2 emissions over the next ten vital years. For example, Shell analysis shows that for the UK, replacing existing coal with gas power plants would lead to a 20% cumulative reduction in UK CO_2 emissions by 2050. Unconventional gas production in countries such as China could encourage an increase in the use of gas for electricity generation in these regions, with potentially significant positive impacts in reducing global CO2 emissions.

Where and how great are unconventional gas resources?

1. The Shell view of global unconventional gas resources is in line with that put forward by the International Energy Agency in its extensive look at gas markets in 2009. The IEA estimate recoverable resources of UCG globally (tight gas, shale gas and coalbed methane) to be more than 380 tcm (13,700 tcf), out of a total estimate resource base of 920 tcm (33,100 tcf). This is equivalent to 123 years of current global production, which when added to recoverable conventional gas resources, is estimated to be equivalent to **over 250 years of current global production. Unconventional gas resources are more widely dispersed compared with**

conventional. The regions with the largest share of these UCG resources are North America (25%), Asia-Pacific (30%) and the FSU (17%). The IEA estimate Europe as having 35 tcm (= 1,260 tcf) of gas resources in place. Both the US and China have similar unconventional gas resources and the estimates of technically recoverable gas in both countries is greater than 1000 tcf. However, the type of gas resources differs between the two countries with resources in the US split roughly between 60% shale gas, 33% tight gas and 7% coal bed methane (CBM). Resources in China on the other hand are split roughly between 47% shale, 34% tight gas and 19% CBM.

2. As well as the success seen in UCG production in North America, Shell also sees potential for UCG development across the globe, and particularly in Europe, China, Australia and Southern Africa, although it is not expected that the growth will be uniform. This growth will heavily depend on domestic gas price developments in different countries and regions, local gas infrastructure, government and community support, and the extent to which environmental issues can be effectively addressed. If sufficient amounts of gas are found, Shell's view is that it is possible to extract UCG in an economically, environmentally and socially acceptable way.

Unconventional Gas in Europe

3. There is currently no commercial UCG production in Europe. European geological history is complex, and unlike North America, suffers from a paucity of critical data to assess accurately whether UCG can ultimately be developed commercially.

4. The **key geological components appear to be present** in many sedimentary basins, but **simple extrapolation from North American analogues is difficult**. At this time, it is not evident which areas of Europe will ultimately host commercial UCG production. Better assessment of UCG potential will first require early (one to four years) investment in seismic operations, exploration drilling and geological studies across many potential areas, followed by significant investment in appraisal drilling and production testing (two to five years). It is estimated that 20–40 wells (exploration, appraisal, pilot) are required to prove commerciality in many basins. Exploration and production companies with diversified portfolios and revenues are better able to absorb this exposure, but to succeed they will also need positive government support (eg the right fiscal framework and permitting and other regulatory conditions).

5. The potential is nevertheless there. Chart 1 below from WoodMackenzie gives an indication of how resources could be distributed across Europe. In Europe, Shell believes the biggest untapped potential is found in France, Germany, UK, Hungary, Poland, Romania and Sweden. However, more extensive exploration programmes over the next 2–4 years are needed to better assess the resource. At present, the estimates on potential resource size have a large range of uncertainty. So although the potential could be substantial (WoodMackenzie's optimistic view is that by 2025 Europe could produce 5,000 mmcfd), at the moment it is difficult to see shale and tight gas having the same, game-changing impact in Europe as in North America and certainly not before 2020. It could still however help lift production levels and further diversify Europe's supplies.

Chart 1

DISTRIBUTION OF UCG IN EUROPE

Source: WoodMackenzie

6. One of the promising signs in Europe is the increase in the number of companies participating in UCG exploration across Europe. As Chart 2 below shows, less than five years ago there were only a few companies active in UCG in Europe. For Europe, from the beginning of 2008, almost all onshore basins with speculative UCG potential are now leased or under application, from a broad competitor base—Majors, Independents, Small Players and NOCs.

7. The key indicators that unconventional gas in Europe could be material would be:

— Successful exploration wells proving the presence of unconventional gas resources.

— Successful pilot projects proving commercial gas production is possible from unconventional reservoirs.

— Examples of developments scaling up to material commercial projects.

— Government and local authority/community support—regulatory and environmental.

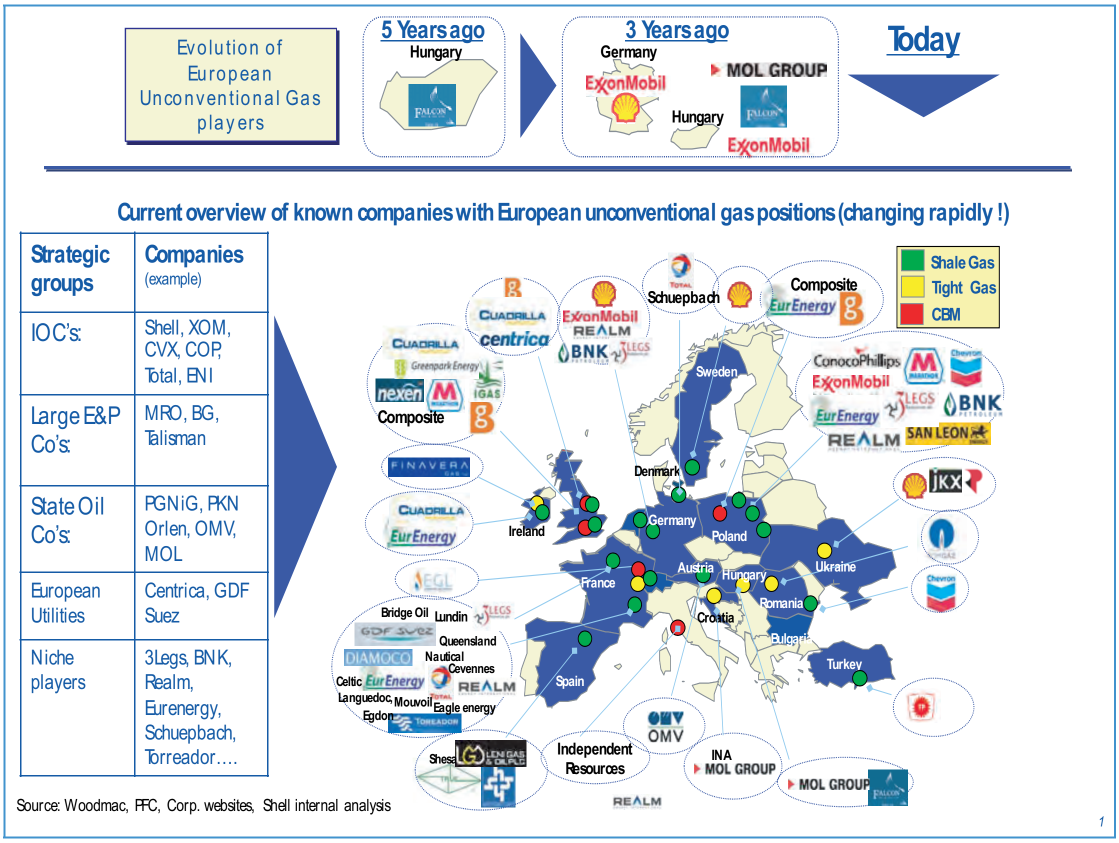
— Supply chain/contractor development with competition driving down costs.

— Sustained interest and investment by oil & gas majors.

— Development of a Mergers and Acquisitions market in unconventional projects.

Chart 2

OVERVIEW OF KNOWN COMPANIES WITH UCG POSITIONS IN EUROPE.



Unconventional Gas in the UK

8. Current activity on UCG in the UK is exploration focused and there is no commercial production at this time. There is potential for CBM production across the legacy UK coal basins. There is potential for shale gas in Bowland near Blackpool (where a small start-up called Cuadrilla is currently drilling) and in the Weald Basin of SE England.

9. Many UK areas of interest are relatively small (especially by comparison with North America) and there are no reliable estimates of reserves potential at this time. The non-technical risks in the UK are similar to those in the rest of Europe and are highlighted below. As UCG activity requires many more wells to be drilled (even if drilled from a single well pad) and more activity than conventional exploration and production, regulators will need to review whether they have the appropriate framework and resources available to deal with the increased level of well permitting, environmental permitting and legislation, production license permitting etc that will be required.

10. In terms of the implications for the UK of global UCG development, unconventional gas resources are more geographically diverse therefore their development could enhance the diversity of gas supplies to Europe and the UK, with the consequent benefits for gas security of supply.

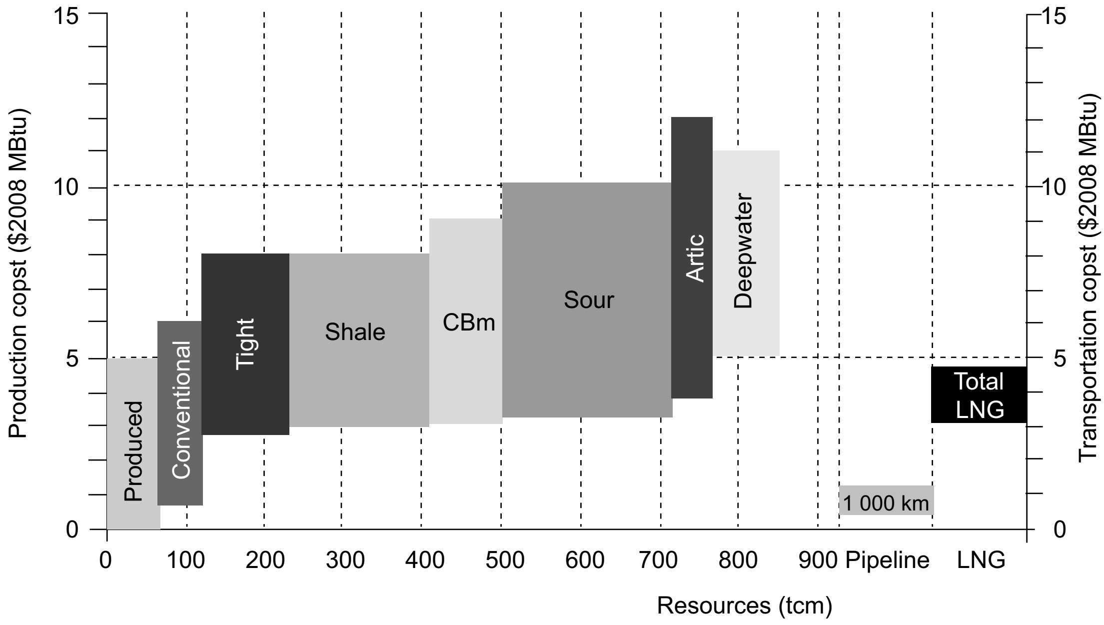
What do the economics of developing unconventional gas look like?

11. The IEA have estimated that the recoverable unconventional gas reserves cost between $2.70/MBtu and $9/MBtu to produce (Chart 3 below). In North America, production costs have declined significantly over time and are now towards the lower end of the IEA's range, and hence are competitive with conventional supplies. In Europe, WoodMackenzie have estimated that the costs of developing unconventional gas would have to fall by a minimum of 20% for European gas shale to be economical with current European gas pricing. In Shell's operations in North America, better wells are being drilled much more cheaply than and twice as fast as in the early days, and have continuously improved over time. For example, since acquiring the Pinedale tight gas field in Wyoming in 2002, Shell has used multiple new technologies including micro-seismic mapping and underbalanced drilling to treble production, while reducing well costs and delivery times by over 25%, despite the surge in industry costs. This expected moderate cost of supply compared to current global gas prices—in combination with a sustained improvement in costs as technology continues to improve—creates positive prospects for further development of this resource globally.

12. Key drivers in bringing costs down are continual development and implementation of new technologies, efficient business models and scaling, and importantly, competitive supply chain/contractor companies able to support and resource development of unconventional gas resources.

Chart 3

LONG-TERM GAS SUPPLY COST-CURVE



Source: IEA World Energy Outlook 2009

What are the challenges to the development of unconventional gas?

13. The development of UCG comes with many challenges, particularly environmental, and addressing these challenges is key to gaining public acceptance for UCG exploration. Shell is tackling these concerns and is focussed on integrating transparent constructive community engagement, advancing efficient resource development and developing technical and engineering solutions to help reduce the environmental and community impact. For example, improving well performance and surface engineering can aid the development of UCG in a sustainable manner. At Pinedale, Shell is limiting the environmental impact of the facility by using directional drilling with fit-for-purpose rigs to reduce operational footprint; and improving and monitoring drill rig engines to decrease NOx emissions and expedite reclamation of drilling sites.

14. One of the key public concerns around UCG development is that some of the techniques used to produce UCG, such as hydraulic fracturing, could affect **local water resources**. Hydraulic fracturing is a common practice to stimulate tight or low permeability natural gas (and sometimes oil) wells to increase the production rate. It is a safe, environmentally sound engineering practice that involves pumping fluid and a proppant into oil and natural gas wells to fracture resource-rich rock beds increasing production. Hydraulic fracturing fluid is typically composed of 99.5% water and sand. The other half percent contains small amounts of chemical components, most of which are also used in household products. Fracturing typically takes place thousands of

feet below the water table, well bores are encased in concrete and well design incorporates several barriers to help ensure nothing contaminates water supplies.

15. Fracturing can require the use of large volumes of water, with the actual volumes varying substantially between wells (though in relative terms, more water is used in other parts of the energy sector such as in nuclear generation or for other purposes such as agriculture). To mitigate these impacts, Shell is pursuing solutions for water usage and disposal. At the Pinedale site Shell has committed to install a Liquids Gathering System (LGS) that will:

- Cut the water usage and need for disposal.
- Increase the ability to re-use water.
- Reduce truck trips and dust associated with water removal/hauling.

16. In addition, a water recycling/reuse program in place for completions is lowering the water usage and reducing disposal issues. Shell has reduced its use of fresh water by about 50% by reusing treated fracturing water.

Europe

17. Commercial development in Continental Europe will ultimately depend largely on:

- Gas prices.
- Geology.
- Continued technological advances to supplement those that are already in place.
- Environmental and social considerations.
- Fiscal and regulatory regimes.
- Wider governmental energy policies.
- Transmission infrastructure.
- Industry competition.

18. Importantly for Europe, key technologies will be those that help deliver solutions to environmental challenges and community concerns, for example; drilling of multiple (eg > 20 wells) long horizontal wells (>1.5 km) from a single well pad that significantly reduce overall well density and allow for efficient modularisation of other development facilities (eg water ponds to support formation hydraulic fracturing (or "fraccing"); facilities to 100% recycle fluids used in formation fraccing; and more efficient fraccing techniques that employ less equipment and fluids.

19. Many European countries have strong gas demand, and successful development is likely to first meet **local market demand**, thus potentially freeing up supply to other parts of Europe. Once UCG systems are proven to be commercially viable, it is possible that UCG production growth could be accelerated with concomitant significant increases in supply chain capability, requiring delivery of new drilling rigs, fraccing equipment, drilling tools, development facilities and training of personnel. Rapid growth of UCG production is also likely to require new investment in European gas transport infrastructure and transparent commercial structures to facilitate pan-Europe gas sales.

20. One of the challenges in developing unconventional gas in Europe is that some of the reserves are located within proximity of **densely populated areas**. The industry is developing methods to limit the environmental footprint by minimising the area required for drilling. Shell development planning for Europe at this time incorporates drilling of multiple horizontal wells from a single well pad as the base case scenario. Wells of this type are at the forefront of drilling technology. By providing more efficient access to small or multiple isolated pockets of oil and gas they bring down the cost of development and, most significantly, avoid the impact of constructing multiple production sites or surface tie-backs, with obvious benefits for resource demand and environmental impact. In addition, the **advances made in drilling horizontal wells** over distances of 1,500 metres and more mean that horizontal wells can replace many vertical wells, reducing the surface area disturbed.

21. One of the key successes of UCG in North America has been the **rapid development of the supply chain** to support the increase in UCG development. Although an onshore drilling industry of comparable magnitude does not exist in many regions outside North America, should profitable projects appear in other regions, the oil and gas industry is capable of responding to take advantage of developments in new geographical locations—though this may take time. Similarly, a lack of transmission infrastructure in areas where there has not traditionally been any gas production could also challenge the development of UCG in these areas. Putting a regulatory regime in place to support the development of UCG could facilitate a more rapid development of both the supply chain and distribution capacity.

China

22. In China, key factors for the development of UCG will include favourable gas prices, technologies that work, and the know-how to apply the right technology mix to make the production of unconventional gas

economically viable. China has put in place a number of policies to facilitate the development of unconventional gas such as encouragement for foreign cooperation, supportive fiscal terms and measures to build up local capability.

What are Shell's unconventional gas activities?

North America

23. Shell has developed a strong position in unconventional gas in North America. The recent addition of further acreage will enhance the growth potential, bringing Shell's total North American unconventional gas position to some 3.6 million acres, and resource potential of over 40 tcfe (>7.1 Bboe). Shell is active in 6 key Tight Gas plays in North America:

- Groundbirch and Deep Basin in Western Canada.
- Pinedale in Wyoming.
- The Haynesville Shale play of northwest Louisiana.
- The Rio Grand Valley (Wilcox and Vicksburg plays).
- New positions: about 250,000 acres in the Eagle Ford shale play, which complements Shell's existing South Texas operations.
- More than 650,000 acres in the Marcellus Shale play, with the recent acquisition of East Resources in Pennsylvania.

Asia-Pacific

24. Building on its experience in North America, Shell is building tight gas positions globally including the Sichuan and Ordos Basins in China, and is in the early stage of shale gas exploration in Sweden, the Lower Saxony Basin of Germany (operated by XOM), Ukraine, South Africa and the Sichuan Basin in China. Shell has recently acquired together with PetroChina the Arrow CBM assets in Eastern Australia where there is both exploration and production. Shell is also exploring for CBM in the North Shiloh permit, as well as in the Ordos Basin in China. Unconventional gas is going to be one of the largest opportunities for growth in Shell's Upstream business in China and holds the potential of making China one of Shell's key Upstream countries.

25. Shell's broad global exposure to many UCG systems has demonstrated that there are substantial differences among UCG plays. Each UCG play offers different technical and non-technical challenges for which solutions must be developed to achieve commercial success. Meeting these challenges requires expertise, innovation and investment, and those companies that can rapidly learn from diversified exposure are best placed to deliver success when exploring new areas.

January 2011

Memorandum submitted by Professor Paul Stevens, Chatham House

The Shale Gas Revolution—The Key Questions

1. The "Shale Gas Revolution" in the USA is part of significant recent developments in unconventional gas. In addition to shale gas this also includes tight gas, coal bed methane and also hydrates and biogenic gas. Unconventional gas refers to the fact that simply drilling is not sufficient to produce the gas as is the case for conventional gas. Further "activity" is required and thus unconventional gas more resembles a manufacturing process. The developments in shale gas have been achieved by the application of horizontal drilling and hydraulic fracturing. Neither are particularly new technologies to oil and gas but they have been combined to good effect in recent years in the USA. The results have been spectacular. In 2000, less than 1% of domestic gas production in the USA came from shale; the latest figures suggest it is now getting close to 20%. However, even more important has been the impact on expectations. Up to 2005, the general view in the USA was that domestic gas production in the Lower 48 States would be in terminal decline. Given the continued strength in gas demand, this implied growing imports of gas both by pipeline but above all by the use of liquefied natural gas (LNG). To that end a great deal of money was invested in the USA in regasification capacity in the form of either taking regas capacity out of mothballs or new build. Since 2000, such capacity has increased ten-fold.

2. The "Shale Gas Revolution" has had a huge impact in the USA. Gas prices have collapsed although this has also been driven by lower gas demand as a result of the economic recession. Thus based on data from the US Energy Information Agency the average well-head gas price in 2005 was $7.33 per thousand cubic feet (mcf) while the average for 2010 to October was $4.25 per mcf. Furthermore, LNG imports to the USA have collapsed and in 2009 capacity utilization on regasification plants was less than 10%. To put it crudely, a great many investors in LNG in the USA have lost their proverbial shirts.

3. There can be no doubt that shale gas has the potential to transform the global energy scene and is clearly a possible "game changer". However, to determine whether this potential can be realized requires the answer to two key questions:—Can the "Shale Gas Revolution" continue in the US? Can it be replicated elsewhere in the world?

Can the "Shale Gas Revolution" continue in the US?

4. For the US there are several concerns. The current low prices of domestic gas are threatening the economics of many existing shale gas projects and future investment may well be compromised. There are also the possible negative environmental consequences of hydraulic fracturing. This involves injecting water and chemicals at very high pressure into the gas plays. The 2005 Energy Act explicitly excluded hydraulic fracturing from the Environmental Protection Agency's Clean Water Regulations—the so-called "Halliburton Loophole". As concerns grow, drilling moratoria have been called on some shale plays while environmental impact studies are completed. Interestingly when in 2009 ExxonMobil bought XTO, the third largest gas producer in the USA (mainly unconventional) for $41 billion, the deal had a special clause that would invalidate the purchase if the government (State or Federal) introduced legislation that was unfavourable to hydraulic fracturing.

5. On balance it seems unlikely that the "Shale Gas Revolution" can be halted in the USA. In particular, in the last couple of years, the major international oil companies have become increasingly involved. Such companies have much deeper pockets and much greater influence with government than the smaller companies who originally pioneered the "Shale Gas Revolution" before 2008.

6. The answer to the second question about replication elsewhere attracts much greater concerns, especially in the context of Western Europe.

Can the "Shale Gas Revolution" be replicated elsewhere?

7. Potentially global unconventional gas resources (coal bed methane, tight gas, and shale gas) are significant. A National Petroleum Council Report in 2007 estimated unconventional gas resources at five times conventional gas reserves. However, the "Shale Gas Revolution" in the USA was triggered by a number of favourable factors. It is useful to list these and then consider in each case how likely replication might be generally in a European context and specifically in the UK.

1. Geology

8.The shale plays in the US are larger, shallower and more material than those in Europe. Furthermore there are very large core samples available from earlier conventional drilling in the USA. This creates much greater knowledge of the immediate geology. There has been relatively little such drilling onshore in Europe and hence the data are not available. A related problem is that traditionally, exploration acreage being licensed in Europe has tended to involve relatively small areas with fairly rigid associated work programmes. Shale plays need larger areas and greater flexibility to tease out the best prospects.

2. Tax Breaks

9. In 1980, the Crude Oil Windfall Profit Tax Act in the USA introduced an alternative (non-conventional) fuel production tax credit of $3 per BTU oil barrel. This was equivalent to 53 cents per thousand cubic feet (tcf). It remained in force until 2002 and was a significant incentive to attempt to develop unconventional gas given that after 1980, the wellhead price rarely exceeded $2 tcf. In Europe, only Hungary has any form of tax advantage for unconventional gas.

3. Widely Dispersed Populations

10. Even ignoring environmental considerations, shale gas operations are potentially very disruptive to local communities. For example, on the Barnett Play in North Texas the average wellhead density is 12 per sq km. In the USA, population density is very much lower than is the case in Europe—27 per sq km in the USA compared to 383 in England. Furthermore, the population in the USA has long experience (and acceptance of) oil and gas operations in their "back yard". In large part this is because property rights in the USA mean that shale gas operations (and indeed any oil and gas operations) directly benefit the local landowners. In New York State for example, some residents are offered up to $5,500 per acre with 20% royalties on any gas produced. In Europe, where subsoil hydrocarbons are the property of the state, this is not the case. There is no reason for the local population to accept the disruptions. This is reinforced because given the capital intensive and specialist nature of shale gas operations, there are few local employment benefits.

4. Easy Access to the Gas Grid

11. In the USA, access to the gas grid is based upon "common carriage". This means any gas supplier can gain access to the grid even if it is already operating at full capacity. Other users must reduce their throughput on a pro-rata basis. In Europe, access is based upon "third part access" which means if the system is operating a full capacity there is no access unless dedicated new pipelines are built.

5. Limited Environmental Control

12. In the USA, environmental controls in the context of hydraulic fracturing were (very surprisingly) lax. In Europe this is not the case and satisfying environmental impact assessment criteria is likely to prove difficult

and controversial. Already local groups within the UK opposed to shale gas operations are beginning to form as my Email inbox can attest. There is another regulatory problem in Europe. European petroleum legislation has no mention of unconventional gas which means it is not at all clear how the industry will be regulated and on what basis. My understanding is that, for example in Germany, unconventional gas comes under coal mining legislation. A further difference concerns access to water. This is key to being able to mount hydraulic fracturing operations. In the USA access is generally very good in the shale play areas. However, in parts of Europe (notably in Central Europe where much of the European shale gas resources are located) water access is constrained.

6. Service Industry Capability

13. Small entrepreneurial companies with the help of an already vibrant and competitive service industry drove developments in shale gas in the USA. For example, at the peak of the recent boom in the Barnett Shale Play in 2008, 199 rigs were in action. However, as of July 2010, there appeared to be only around 34 land rigs in the whole of Western Europe, compared with some 2,515 active land rigs in the United States in 2008, of which 379 were in oil and 1,491 in gas. Putting it simply, the infrastructure in Europe does not currently exist to mount enough unconventional gas projects to make a difference. Of course this can change if the projects appear profitable, but it will take time. However, a further problem is that the service industry in Europe is an oligopoly dominated by a few (largely American) companies. This is not conducive to the rapid development of a service industry capability.

14. For all of these reasons, the replication of the "Shale Gas Revolution" in Europe and indeed the UK faces a great many barriers. Of course, these are by no means insurmountable but it will take time to manage them. Outside of Europe, the story may be different. In particular, there are parts of the world such as China were local opposition, which forms the major source of barriers to shale gas development in Western Europe, is likely to be "managed" quite easily.

15. There are many uncertainties associated with the answers to the two key questions—can the "Shale Gas Revolution" in the USA continue and can it be replicated elsewhere. This is extremely important for the future not just of gas markets but also the global energy scene. Uncertainties over the answers to the questions will inhibit future investment in gas supplies. There are already signs of the cancelation or postponement of gas export projects such as the giant Shtokman field in the Barents Sea north of the Kola Peninsula—a joint venture between Gazprom, Statoil and Total. There are also serious questions over the prospects of other gas projects such as Nabucco.

16. If the "revolution" does continue and extend to the rest of the world, consumers can anticipate a future floating on large clouds of very cheap gas. However, if it falters, in the medium term, the world will face serious gas shortages given these current investment uncertainties. As the world recovers from global recession and as earlier constraints on gas use erode, gas demand will grow. The UK provides an excellent example of what happens to energy markets when previous constraints on gas use are removed. In 1990 when the constraints began to weaken, natural gas accounted for 20% of the UK's primary energy mix. Only ten years later in 2000, gas accounted for 40% of primary energy in the UK.

17. However, given the investor uncertainty described above, future gas supplies will be lower than required had the "Shale Gas Revolution" and its current hype not happened. If unconventional gas fails to deliver on current expectations—and we will not be sure of this for some time into the future—in ten years or so, gas supplies will face serious constraints. Markets will eventually solve the problem as higher prices encourage a revival of investment. However, given the long lead times on gas projects, consumers could face high prices for some considerable time.

18. A related problem concerns investments in renewables. There is general agreement that the world must move to a low carbon economy if climate change is to be managed. Among other things, this requires much greater investment in renewables. In a world where there is the serious possibility of cheap, relatively low carbon gas which could be seen as a "transition fuel", who will commit large sums of money to expensive renewables to lower carbon emissions? Again, if shale gas fails to deliver, it condemns us to a higher carbon future than would otherwise have been the case.[12]

The Role of the UK Government in the Story

19. A key issue for the UK government is therefore what might be done to try and reduce the current uncertainties and thereby encourage greater investment in gas supplies generally and shale gas in particular? Before providing an answer it is necessary to argue why government should intervene at all? Why not simply leave it to the market? This has been the European Commission's position. On 19 July 2010, the European Commission's Michael Schuetz of the Directorate-General for Energy was asked how the European Union might assist in the development of shale gas in Europe. He replied that it was not the EU's job to nurture the technology, adding that *"the industry has to develop this business"*. The conventional argument for government intervention is to manage market failure. Market failure arises from a number of causes. These are conventionally listed as: imperfect competition; inadequate information; the existence of externalities; and

[12] *For further information on all of the preceding discussion see my report:* The "Shale Gas Revolution" Hype and Reality. http://www.chathamhouse.org.uk/research/eedp/papers/view/-/id/947/

finally the presence of public goods. Gas markets in Europe are riddled with externalities most obviously in the context of security of supply and monopoly tendencies. However, for shale gas two specific issues stand out which justify government intervention—the nature of the learning curve and the issue of contestable markets.

The Nature of the Learning Curve

20. A major problem with shale gas is that the plays and indeed the wells on the same play are all very different in terms of geology, well behaviour and reservoir characteristics. Thus unlike many other activities, there is a very limited aggregate learning curve. Thus research and development (R & D) are essential ingredients to develop shale operations, as is the sharing of information between operators. In the USA this process has been going on over the last 10 years and has helped to reduce shale gas production costs by moving down the learning curve. However, because of the heterogeneity of shale operations this experience cannot necessarily be applied in Europe without adjustments. Traditionally, government should intervene to encourage and promote R & D and the exchange of operating experiencing within the limits of what is feasible given competitive advantage and commercial confidentiality.

Contestable Markets

21. In the theory of contestable markets, market power such as monopoly can be controlled if there is threat of entry. Actual entry of competing suppliers is not necessary; simply the threat that the market might be contestable and new suppliers might enter is sufficient to enforce behaviour associated with competitive markets. Western Europe at the moment looks as though it will become increasingly dependent upon gas imports. If there are real prospects of significant gas supplies from domestic shale sources, this could have a very powerful influence on the behaviour of Europe's current external gas suppliers forcing them away from seeking higher prices. Thus even if the UK government and the EU only spout rhetoric about encouraging shale gas, this might be sufficient to create a contestable market to contain suppliers' behaviour over prices and contracts.

There are a number of actions that could be taken by the UK government to encourage the development of shale gas both here and in Western Europe more generally:

22. First would be to persuade/pressure the EU to take a more positive proactive role in encouraging shale gas developments. Western Europe is a regional gas market of which the UK is an integral part. Therefore anything that increases supply and reduces price will benefit the UK. The current EU position on shale gas of "leave it to the market" is a serious mistake that ignores the externality dimensions involved. At the very least this pressure could involve looking at the myriad of European regulations which might inhibit shale gas developments.

23. The government could do much to encourage R & D into shale gas. This could range from the funding of research and a research centre to ensuring operating experiences are shared between companies to try and create an aggregate learning curve.

24. Something must be done to sort out the regulatory uncertainty with respect to shale gas. There needs to be explicit regulation to bring shale gas operations into the general petroleum legislation. In particular, to allow for much more flexible terms for licensing acreage such that the work programme associated with shale plays can be better managed.

25. Given the positive externalities associated with shale gas in the context of security of supply—mainly the contestable market argument developed above- there may be a case for subsidy or at least some form of tax break/credit on shale gas operations.

26. Clarify the environmental position on hydraulic fracturing by ensuring the results of the current studies underway in the USA are disseminated. At the same time it will be necessary to carry out environmental impact assessments of shale gas developments in the UK to consider the relevance of the operating conditions to the experience in the USA.

27. Introduce financial mechanisms such that local communities can be compensated for disruption by some sort of fund drawn from the operators. This could be some form of compulsory corporate social responsibility fund. Something is required to provide incentives for landowners to allow access and communities to accept disruption.

28. Tax breaks for drillers building new rigs could also encourage the development of a European service industry that would make a shale gas revolution in Europe a more likely possibility. At the very least, there should be efforts to ensure that importing shale gas technology from the USA—software and hardware—is not constrained although the encouragement of a home grown service industry is preferred.

January 2011

Memorandum submitted by CNG Services Ltd

What are the implications of large discoveries of shale gas around the world for uk energy and climate change policy?

1. The UK economy was converted to natural gas in the 1970's on the back of North Sea reserves. The use of oil in British industry was dramatically reduced in the period 1970—1990 as industry converted to gas and as a result oil is now predominately used for transport.

2. Around 85% of domestic consumers have gas for heating with appliance efficiencies of around 90%.

3. British Gas were generally reluctant to promote the use of natural gas as a fuel for power generation because a combined cycle gas turbine (CCGT) generation plant will only operate at around 50% efficient.

4. However, in the period 1993–2010 there has been dramatic growth in CCGTs and now around 50% of UK electricity is generated by gas, with a large build programme now underway as a number of coal plants are being closed down. Reference 1 gives details of CCGT generation in the National Grid 2010 Ten Year Statement

5. British Gas were world leaders in the development of natural gas vehicles in the early 1990's. However, the NGV programme in the UK failed for a number of reasons. First, the compressed natural gas (CNG) filling stations were located on gas-holder sites were British gas had lots of vans. This was a major mistake in that the gas was generally "wet" which damaged engines.

6. In addition, the vehicles were conversions of petrol vehicles. They were not reliable, had no standby fuel and the CNG storage tanks took up significant space and reduced payload. They were also poor to drive, with low acceleration. Reference 2 gives an indication of British Gas NGV activity in the 1990's.

7. The privatized British Gas has spawned three world class companies, Centrica, BG Group and National Grid. In the UK it has helped to develop a highly advanced gas grid (connecting around 95% of population centres) which has broader coverage then any other major economy.

8. Overseas BG Group is making investment in relation to NGVs (Brazil, Argentina, India, Kazakhstan) as the world sees huge growth in NGVs. When British Gas worked on it in 1992 there were around 10,000 vehicles in the world running on natural gas. By 2002 this had grown towards 1 million. But by 2012 there is forecast to be 15 million, this is significant growth.

9. In the US, National Grid are also involved in the growing NGV market there. This is partly driven by the political drive to reduce reliance on oil but the key driver is the low price of natural gas caused by shale gas production. Reference 3 shows National Grid NGV activity in the US.

10. The German Government fixed CNG fuel duty in 2001 at the CEU minimum level (6 p/kg) for 20 years on the basis that the gas industry would build CNG filling stations and the car industry will develop CNG cars (note—in the same period duty in the UK has risen from 9 p/kg to 28 p/kg today). Reference 4 shows EU and Worldwide NGV Statistics.

11. This strategy has been successful in that in Germany there are now 900 CNG filling stations and around 100,000 cars and vans running on CNG from the grid.

12. The new cars and vans have been designed to run on CNG and have none of the drawbacks that the British Gas developed vehicles had 20 years ago. The VW Passat Ecofuel has a 1.4 litre engine with twin supercharger and turbocharger. It can go 0–60 mph in 9.5 seconds but has CO_2/km of less than 120 g/km. It can also run on petrol and has a combined range on CNG and then petrol of around 700 miles. The Mercedes Benz Sprinter NGT is similarly excellent in terms of range (1,100 km) and performance as is the VW Caddy. Reference 5 shows that the Passat Ecofuel has been voted the Greenest Car in the world.

13. By designing from first principles cars and vans to run on CNG there is excellent performance and utility and low CO_2.

14. But what of the UK? In 2002 there were around 20 CNG filling stations operational in the UK but now there are no grid connected public access stations that are capable of "fast filling" a vehicle.

15. In terms of vehicles there are estimated to be around 50 vehicles running on CNG and 200 running on natural gas stored on board as LNG, with fuel mostly provided at a small number of depot-based filling stations.

16. There is no case for large scale investment in installing CNG at petrol stations. Diesel and petrol hybrid cars are very good in terms of CO_2/km and whilst CNG emissions are lower than a normal petrol they are comparable to many diesel and hybrids. There is not believed to be any investors looking at the UK car market for natural gas and, with the development of electric vehicles, this situation is unlikely to change. We can reasonably assume that CNG will not be made available at petrol stations in the UK. Home refueling with CNG is possible and attractive but will be a niche market.

17. The sector of interest for natural gas is the commercial vehicle sector. There are around 700,000 vans, rigid trucks and tractors operating in the UK and a large proportion of these operate from depots. As such, they are well suited to running on natural gas as the gas grid is invariably close by. The most significant

technological development is in relation to the engine and fuel combination. Reference 6 shows that 18% of transport emissions come from trucks.

18. If air quality is the driver (nitrous oxides and particulates) then having an engine that runs on 100% natural gas gives exceptional performance. This is why most Los Angeles buses run on CNG (9,000) and all 670 refuse trucks in Madrid run on CNG. There are now no longer any diesel buses operating in LA City nor any diesel refuse trucks in Madrid. CNG is the fuel of choice where air quality is a major issue. Whilst air quality is an issue in the UK, the driver for change is now reduction in CO_2. Reference 7 shows LA buses and Reference 8 shows the benefits of the CNG refuse trucks in Madrid.

19. Diesel is a mix of hydrocarbons, typically in the C9H20 to C12H26 range. Compared to a molecule of CH4 (methane, which is >90% of natural gas), burning diesel gives rise to greater CO_2. However, the buses in Los Angeles and refuse trucks in Madrid and 99.9% of the 13 million NGVs on the road today use a "spark ignition" engine. This is similar to a petrol engine and not as efficient as a diesel engine. It can be said that the price for improved air quality and longer life is achieved by a reduction in efficiency of conversion of hydrocarbons to vehicle movement.

20. The development of dual-fuel diesel-natural gas engines in transformational. The vehicle starts on 100% diesel, but after 30 seconds it becomes 80% natural gas, 20% diesel. This gives the advantage of lower CO2 from burning methane instead of C12, but maintains the advantage of the diesel cycle. The engine thinks it is still a diesel engine and if the gas runs out it is still a diesel engine. No range anxiety there then. Reference 9 shows Volvo dual fuel trucks.

21. There are also reductions in emissions of Nox and particulates by the displacement of 80% of the diesel.

22. Volvo and Mercedes Benz are both selling diesel-natural gas trucks and they say that the reduction in CO_2 is around 20% compared to 100% diesel. This is highly significant when it is compared with the reduction possible from biofuels. Even if 10% of diesel is replaced with biodiesel this will not give a 10% reduction in CO_2 because of the energy cost of making biodiesel, then there are the food versus fuel issues.

23. There is a further good news element. There are three companies in the world that lead in relation to dual fuel truck technology. One is Canadian (Westport), the others are based in Leyland (Clean Air Power, CAP) and Nottingham (Hardstaff).

24. My grandfather worked at Leyland Motors in the inter-war years and it is encouraging for UK manufacturing industry that CAP are now providing their dual fuel technology to the likes of Volvo Trucks (as an aside, the name Leyland lives on in the truck industry but not in the UK—Ashok Leyland make trucks and buses in India including CNG versions). Reference 10 shows CAP technology.

25. Hardstaff are also very successful with their technology which is being sold in Mercedes Benz trucks. Hardstaff also hold the patents for a system that allows CNG storage to be on the trailer with an umbilical connection to the tractor unit—this means that as much CNG storage as required can be on the vehicle. A leading UK logistics company Tenens Environment are using this system. Reference 11 shows Hardstaff Dual Fuel technology, Reference 12 shows Hardstaff Umbilical technology and Reference 13 shows Tenens Environment and CNG.

26. What other vehicle technology is there with 2/3rds of the world's best technology in the UK?

27. So, we have the vehicles, we have the technology, we have the truck manufacturers, we have the CO_2 saving, what about the fuel?

28. When there have been "Well to Wheel" studies that have looked at natural gas they have used data from the 1990's gas industry. The assumption has been that the gas is taken out of the low pressure grid (same as around gasholders).

29. First, it requires 30% more electricity to drive a compressor using gas at 0.5 bar than if the gas was at 4 bar. Going forward, CNG should be taken out of the grid at pressures from 4—50 bar, giving up to a 75% reduction in electricity consumption.

30. Second, a substantial part of the gas pipeline grid was developed in the period 1890–1930 when towns gas (made from coal) was the fuel. These pipelines were made from cast iron and have leaking joints, around 0.5% of the gas leaks out of the low pressure tiers. Even though around £1 billion a year is invested replacing these pipelines it will take until 2030 until the grid is substantially leakage free. Hence, if gas it taken for CNG at these low pressures, it was assumed that around 0.5% of it would have leaked out. With the global warming effect of methane around 20 times worse than CO_2, this 0.5% translates to around 10% CO_2. By taking gas out of high pressure grids (4 bar and above) there is negligible leakage and hence there is a further 10% benefit.

31. There is also a new advantage of CNG that is aligned with wind generation. It makes sense to run compressors at times when renewable electricity is in surplus. In this way, the CNG will further reduce its carbon footprint. The alternatives of compressing air or pumping water up-hill to use "surplus" electricity are both highly wasteful of energy, because something is being done that no-one wants to be done Compressing gas however, is a required activity, why not do it at night? Overseas it is already seen as a complement to wind generation.

32. There are also positive developments in relation to the energy footprint of bringing natural gas to the UK. At the Isle of Grain, National Grid uses waste heat from an EON CCGT to warm the LNG and make it into natural gas for injection into the gas grid. This is estimated to give around a 5% CO_2 benefit which is also significant. Reference 14 shows the benefits from the efficient scheme at Isle of Grain.

33. Paragraphs 28—32 have considered CNG made from gas within the grid. There is also liquefied natural gas, LNG. The Hardstaff and CAP technology uses gas in gaseous form at low pressure. Whether the gas is stored on the truck in compressed form (CNG) or liquid form (LNG) is neither here nor there. So, let us look at the LNG supply chain.

34. There is a major prize possible in relation to "Well to Wheel" CO_2. The UK now has major LNG importation facilities at Isle of Grain and Milford Haven. It is low cost and technically straightforward to load 20 tonne road tankers with LNG at these facilities by installing an LNG road tanker loading bay (cost around £3 Million). Fluxys has done this in Zeebrugge and already LNG is imported by ferry and road to UK from Zeebrugge to serve the new dual fuel trucks that are coming to market.

35. We do not know if the owners of the LNG importation terminals at Isle of Grain and Milford Haven are considering LNG road tanker loading but we hope they are. Importing LNG in containers by ferry and road is not a great idea when we have Isle of Grain and Milford Haven and there should be jobs in UK not in Belgium for this activity. Reference 15 shows the Fluxys LNG Road Tanker Loading system.

36. If LNG is made in Qatar (for example), transported by ship to UK, loaded into an LNG road tanker, transported to a depot LNG storage tank, then decanted into the LNG storage on board a truck, there are very low CO_2 emissions in that supply chain. The LNG stored on board uses waste engine heat to become gas again. We estimate that there is around 10% saving in CO_2 from this.

37. So, LNG in dual fuel may be able to deliver a 30% reduction in CO2, with CNG a similar saving.

38. In terms of climate change, the reduction from dual fuel trucks is material within that sector and material overall and is worthy of independent analysis. It would be very helpful if The Committee on Climate Change reviewed the data and gave an opinion.

39. Separately, the reason British Industry switched from oil to gas was because gas cost around half price in energy terms. It is around half price again today and so the logic of switching haulage from diesel to (part) gas is a sound one, We estimate that UK balance of payments would take a hit of around £40 billion a year compared to 2010 as a result of importing oil. If we can reduce oil imports by 15% as a result of dual fuel then we would save £6 billion of oil at a cost of £3 billion gas.

40. Security of Supply is going to be an oil issue by 2020 and anything to reduce reliance on Middle East oil imports by then has to be considered attractive.

41. For a 44 tonne truck to run on electricity, it has been estimated that around 50 tonnes of batteries would be required. So there is clearly not going to be a material electricity option for trucks.

42. If the shale gas reserves are as big as the promoters say, and if they can be developed economically, then the logical response for UK plc is to start to switch haulage to natural gas-diesel dual fuel.

43. The final point, if the shale gas is real, what can the Government do. It could ask the owners of Milford Haven and Isle of Grain to install LNG road tanker loading buys. It could ask the Technology Strategy Board to support Hardstaff and CAP in developing their dual fuel natural gas—diesel technologies. The Government can also support cities like Sheffield that are taking significant steps to move along the LA and Madrid paths by introducing natural gas for refuse trucks and other commercial vehicles as the best way to improve air quality. Reference 16 shows Sheffield/Veolia and CNG.

44. Crucially, however, the Government can also support investment in infrastructure and vehicle development by giving a longer period of confidence on natural gas fuel duty (at present only fixed relative to diesel for 3 years). The regimes to promote investment in offshore wind or ground source heat pumps or anaerobic digesters rely on a long term guarantee of income support. An equivalent level of confidence in duty level is required if we are to capture the CO2 reduction prize offered by dual fuel. This will also offer a duty reduction to hauliers who are prepared to invest in the natural gas refueling infrastructure and vehicles.

45. Once the depot based filling stations are built and depreciated, the Government can look forward to increasing duty on natural gas without it killing the market, but this is 15 years away.

46. The Energy Networks Association commissioned a report by Redpoint published in November 2010 ("Gas Future Scenarios Project—Final") which makes the case that natural gas for commercial vehicles is an attractive option. See Reference 17.

47. One final point, the Government is preparing to announce the level of the Renewable Heat Incentive which includes the renewable premium paid to biomethane (renewable natural gas made from organic material). If set at an appropriate level this will encourage waste to be converted into biomethane, injected into the gas grid and taken out at existing truck depots. In this way, the duel fuel CNG-diesel development is aligned with the move towards a fossil free economy. National Grid forecast in January 2009, that biomethane could supply

around 50% of the gas used by domestic gas consumers. The same resource would supply much more than the 80% of gas required to move haulage to dual fuel. Reference 18.

January 2011

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Memorandum submitted by The Co-operative Group

INTRODUCTION

1. The Co-operative is a unique family of businesses, jointly owned and democratically controlled by over 6 million members. We are the fifth largest food retailer, the third largest retail pharmacy chain and the number one provider of funeral services in the UK. We also have strong market positions in banking and insurance. The Co-operative employs 120,000 people, and has around 4,800 retail outlets and branches.

2. Taking a responsible approach to business has been a guiding principle of The Co-operative since its inception. We are proud to have led UK business in our approach to combating climate change.

3. The Co-operative's approach to addressing the issue of climate change is five-fold, embracing: energy efficiency, support for renewable energy, carbon offsetting, the provision of finance, and influencing public policy. This begins with ensuring sustainable business operations:

- Between 2006 and 2009 (the latest year for which data is available). The Co-operative achieved an absolute reduction of 21% in its operational greenhouse gas emissions.
- By 2012, we will generate 15% of our energy requirements from sustainable sources, including from our wind farm at Coldham in Cambridgeshire and other schemes under development.
- During 2009, over 98% of our electricity was sourced from good quality renewable sources.
- We've made combating climate change a community investment priority. For example, we've invested £2 million in our Green Energy for Schools programme and we're supporting the development and financing of community owned renewables across the length and breadth of the UK.

4. Strong business credentials in the UK have allowed The Co-operative to lead on public policy initiatives to combat climate change. This includes involvement in campaigns, such as the Big Ask in 2007, which resulted in the Climate Change Act 2008 becoming law. We are also currently campaigning against tar sands development in Alberta, Canada.

5. In order to inform its position on shale gas, The Co-operative commissioned The Tyndall Centre to investigate issues including its carbon footprint relative to conventional gas, scenarios for shale gas exploitation (and resulting greenhouse gas emissions) for global and UK development, and other environmental impacts potentially associated with the extraction process. The report, entitled "*Shale gas: a provisional assessment of climate change and environmental impacts"*, can be downloaded from www.tyndall.ac.uk/shalegasreport. The contents of this submission are based on the findings of this report.

6. While, currently, information on the shale gas extraction process and its associated potential environmental impacts is patchy, a number of issues of concern were raised within the report:

- At a global level, shale gas represents a potentially very significant new fossil fuel source, that in the absence of a global emissions cap is likely to lead to increased greenhouse gas (GHG) emissions.
- Within the UK, the expansion of the shale gas industry is, at best, not in the spirit of UK climate change policy and, at worst, may act as a disincentive to investment in zero carbon energy sources such as renewables.
- At the local level, research from the United States (US) has revealed a number of chemicals involved in, and mobilised by, the hydraulic fracturing extraction process that have potential human health impacts via the contamination of groundwater (e.g. toxicity or carcinogenicity).

7. **It is for the reasons stated here, and further expanded below, that The Co-operative recommends a complete and immediate moratorium on UK shale gas extraction until the risks have been properly evaluated and can be shown to be fully addressed.**

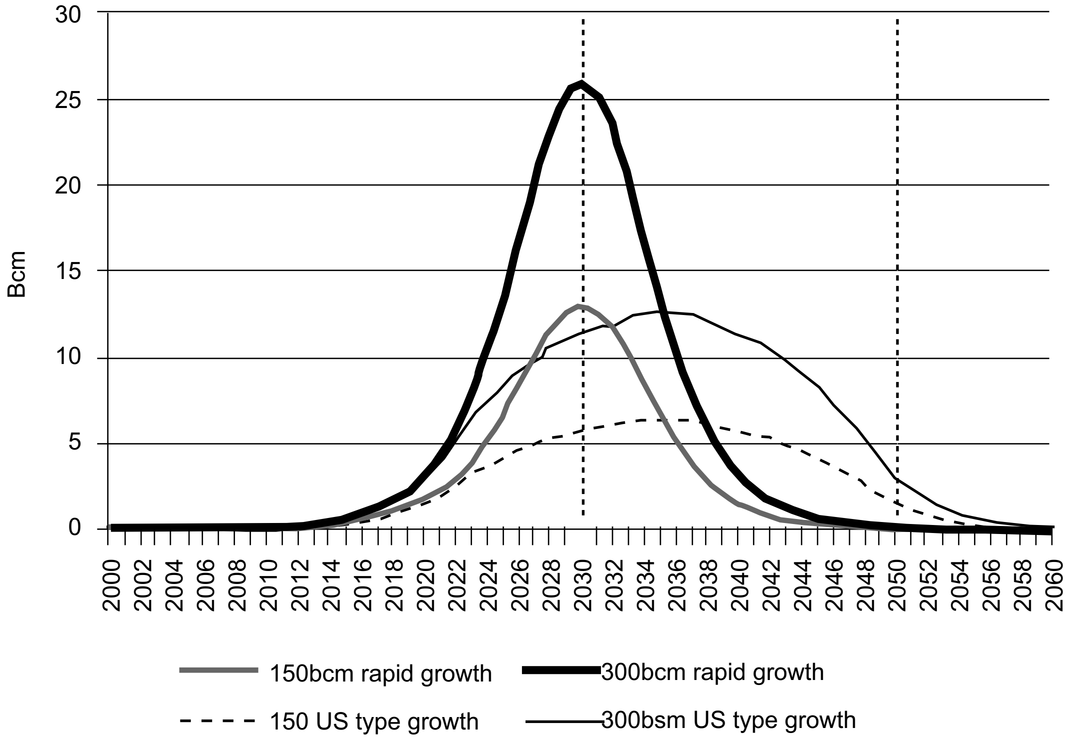
Question 1: *What are the prospects for shale gas in the UK, and what are the risks of rapid depletion of shale gas resources?*

8. In order to examine the potential impact of shale gas in the UK, four scenarios were developed in the research: two assuming the amount of shale gas produced correlates with the figure provided by DECC (2010)—150 billion cubic metres (bcm); and two that assumed double this (300bcm). The two 300bcm scenarios reflect the experience in the US where shale gas estimates have been revised upwards year on year (for example in 2008, the US Energy Information Administration (EIA) estimated the US technically recoverable shale gas resource at 3,539bcm and then revised this upwards in each of the successive years, with the latest 2010 assessment at 23,427bcm (EIA 2010b)).

9. For both the 150 and 300 bcm scenarios, two different rates of extraction were used: one based on a Hubbert type curve (a bell curve) that is often used as an approximation for resource extraction, which sees a rapid increase in production followed by a rapid drop in production; the other based on the kind of growth rates that are predicted for the US by the EIA (EIA, 2010b). The four scenarios are plotted below in Figure 1.

Figure 1

SHALE GAS PRODUCTION IN THE UK UNDER FOUR SCENARIOS



10. All four scenarios see the majority of shale gas being exploited before 2050 and the cumulative emissions associated with the use of this shale gas ranged from 284–609 $MTCO_2$ over the period 2010 to 2050. To give this some context this amounts to between 2.0 to 4.3% of the total emissions for the UK under the intended budget proposed by the UK Committee on Climate Change. Assuming that the carbon budget is adhered to, this should not result in additional emissions in the UK. For example, it is possible that UK produced shale gas could substitute for imported gas, although it would not negate the need for imports.

11. It is also possible that extracting additional fossil fuel resources could put pressure on efforts to adhere to our carbon budget by reducing gas prices and directing investment away from renewables and other low or zero carbon energy sources. It is also important to note that in a market led global energy system where energy demand worldwide is growing rapidly, even if shale gas were to substitute for imported gas in the UK, leading to no rise in domestic emissions, it is likely that this gas would just be used elsewhere, resulting in a global increase in emissions.

12. Within the UK, shale gas could theoretically substitute for coal and thereby reduce emissions. However, with a carbon budget in place, coal (without Carbon Capture and Storage (CCS)), is likely to be phased out anyway—shale gas is not required to make this happen. Given the radical reduction in emissions required and the need for a decarbonised electricity supply by the mid-2030's.[13] Developing shale gas would risk being a major distraction from transitioning to a genuine zero-carbon grid. Given the investment in infrastructure required to exploit these resources there is the danger of locking the UK into a number of years of additional gas use, leaving unproven CCS, as the only option for lower carbon electricity. Consequently, this investment would be better made in real zero-carbon technologies that would provide more effective long-term options for decarbonising electricity supply.

Question 2: *What are the implications of large discoveries of shale gas around the world for UK energy and climate change policy?*

13. In order to examine the potential impact of shale gas on global GHG emissions, three scenarios were developed in the research. The starting point for the global scenarios is an estimate for the global reserves of shale gas taken from a report by the US National Petroleum Council (NPC, 2007). Three scenarios were then developed assuming that differing proportions of the total resource are actually exploited (10%, 20% and 40%). Assuming that 50% of this resource is exploited by 2050, these scenarios give additional cumulative emissions associated with the shale gas of 46–183 $GTCO_2$, resulting in an additional atmospheric CO_2 concentration of 3–11ppmv.

[13] The Committee on Climate Change has suggested that electricity will need to be effectively decarbonised by 2035 (Committee on Climate Change, 2010).

14. The argument that shale gas should be exploited as a transitional fuel in the move to a low carbon economy seems tenuous at best. If we look at the US, there is little evidence that shale gas is currently, or expected, to substitute for coal (see for example projections within "change in US primary energy sources 2008 to 2035" within EIA (2010a)). It is possible that some level of substitution may occur in other countries but, globally energy use is growing and, without a meaningful constraint on carbon emissions, there is little price incentive to substitute for lower carbon fuels. It is difficult to envisage any situation other than shale gas largely being used *in addition* to other fossil fuel reserves and adding a further carbon burden. This could lead to an additional 11ppmv of CO_2 over and above expected levels without shale gas—a figure that could rise if more than 50% of the total shale gas resource were to be exploited.

15. The idea that we need transitional fossil fuels is itself open to question. For example, in the International Energy Agency scenario that outlines a path to 50% reduction in carbon emissions by 2050, fuel switching coupled with power generation efficiency only accounts for 5% of the required reductions (IEA, 2010). If globally we are to achieve the considerable reductions in carbon emissions that are required then it is energy efficiency, CCS, and renewable energy that will make the difference.

16. At the global level, against a backdrop of energy growth matching, if not outstripping, that of global GDP and where there is currently no carbon constraint, the exploitation of shale gas will most likely lead to increased energy use and increased emissions resulting in an even greater chance of dangerous climate change. While for individual countries that have a carbon cap, for example in the UK, there may be an incentive to substitute shale gas for coal, the likely result would be a fall in the price of globally-traded fossil fuels leading to an increase in demand. Consequently, there is no guarantee that the use of shale gas in a nation with a carbon cap would result in an absolute reduction in emissions and may even lead to an overall increase.

Question 3: *What are the risks and hazards associated with drilling for shale gas?*

Groundwater pollution

17. A key risk associated with shale gas extraction is the potential for contamination of groundwater. From the limited evidence available from the US, it appears that the fluid used in hydraulic fracturing contains numerous chemical additives, many of which are toxic to humans and/or fauna. Concerns that the fracturing process could impact on water quality and threaten human health and the environment have prompted the US Environmental Protection Agency (EPA) to instigate a comprehensive research study into the issue, within initial findings expected by the end of 2012. While awaiting the results of this study, New York State has introduced a moratorium on any new wells.

18. Groundwater pollution could occur if there is a catastrophic failure or loss of integrity of the wellbore, or if contaminants travel from the target fracture through subsurface pathways. The risks of such pollution were seen as minimal in a study by ICF International (INGAA, 2008); however, this assessment was based on an analysis of risk from properly constructed wells. History tells us that it is rarely the case in complex projects that mistakes are never made and the risk of groundwater pollution from improperly constructed wells also needs to be considered.

19. The dismissal of any risk as insignificant is hard to justify given the documented examples that have occurred in the US, seemingly due to poor construction and/or operator error. These examples have seen high levels of pollutants, such as benzene, iron and manganese, in groundwater, and a number of explosions resulting from accumulation of gas in groundwater.

Surface pollution

20. While it may not always be possible to pinpoint the exact cause of groundwater contamination, identifying the source for land and surface water pollution is more straightforward. There are a number of potential sources of pollution including: well cuttings and drilling mud; chemical additives for the fracturing liquid; and flowback fluid—the liquid containing toxic chemicals that returns to the surface after fracturing. There are numerous routes by which these potential sources can cause pollution incidents including failure of equipment and operator error. Unsurprisingly, a number of incidents have been reported in the US.

Water consumption

21. Shale gas extraction requires significant amounts of water. Analysis provided by the Tyndall Centre suggests that to carry out all fracturing operations on a six well pad takes between 54–174 million litres of water over its lifetime, which is equivalent to about 22–69 Olympic size swimming pools of water. If the UK were to produce 9bcm of shale gas each year for 20 years (approximately 10% of annual consumption) this would equate to an average annual water demand of 1,300–5,600 million litres. This compares with current levels of abstraction by industry (excluding electricity generation) of 905,000 million litres. Shale gas exploitation at this level would therefore increase abstraction by up to 0.6%. While this appears to be a small additional level of abstraction, a number of points need to be made:

- This assumes the water demand is spread evenly over the whole country. Clearly actual water requirements will be focused in the areas where shale gas is being extracted and this could add a significant additional burden in those areas;

— Water resources in many parts of the UK are already under a great deal of pressure, making additional abstraction difficult; and
— The impacts of climate change may put even greater pressure on water resources in the UK.

22. Given that the water is mainly used over a short period of time during initial fracturing, the most likely means of getting this water to the site in the UK would probably be by truck or abstraction.

Other issues

23. For the UK, high population density and the likely proximity of wells to population centres could result in exacerbation of impacts such as noise pollution, traffic, and landscape degradation. Further information on assessment of these potential impacts is contained within the Tyndall Centre report on pages 69 and 70.

Question 4: *How does the carbon footprint of shale gas compare to other fossil fuels?*

24. It is assumed that the direct GHG emissions associated with the combustion of shale gas will be the same as gas from conventional sources. In considering the UK, the distribution of shale gas would be the same as conventional gas and therefore subject to the same losses. This means that the main difference between shale and conventional gas is likely to be from emissions that arise from the differing extraction processes. The limited verifiable data available makes assessment of these extraction emissions problematic. However, it was possible, using data on expected emissions from the Marcellus Shale in the US, to estimate the likely emissions associated with the different processes that occur in extracting shale gas compared to natural gas.

25. Estimated emissions are associated with a number of processes:
— Horizontal drilling;
— Hydraulic fracturing and flowback;
— Production of chemicals used in hydraulic fracturing (these emissions are unknown and have not been included);
— Fugitive methane emissions during fracturing (these emissions are unknown and have not been included);
— Transportation of water;
— Transportation of brine; and
— Waste water treatment.

26. The combination of emissions from these processes gave an estimate per well of 348–438tonnes CO_2e. This figure will increase if the well is refractured, something which could happen up to 5 times, the DECC (2010) report suggests that refracturing could happen every four to five years for successful wells.

27. The significance of these emissions is dependent on the rate of return for the well—something which is site specific. Looking at examples of expected total production for shale basins in the US it has been estimated that, on average, the additional CO_2e emissions associated with the processes above account for between 0.14–1.63tonnes CO_2e/TJ of gas energy extracted. The value depends on the total amount of gas that is extracted per well and the number of times it is refractured. Examining the UK in particular, although the rate of return per well is not quoted for UK basins, it is thought that additional CO_2e emissions per well would be at the higher end of estimates compared to the US, as economies of scale are against UK wells.

28. Given that during combustion, 1TJ gas would produce around 57tonnes CO_2, the additional emissions from the shale gas extraction processes identified represent only 0.2–2.9% of combustion emissions. However, similar to conventional gas there will be some further emissions associated with processing, cleanup and distribution.

29. These relatively low levels of additional emissions suggest that there would be benefits in terms of reduced carbon emissions if shale gas were to substitute for coal. Combustion of coal produces around 93tonnes CO_2/TJ. Clearly even with additional emissions associated with shale gas, the emissions from gas would be considerably lower. The benefits increase when the higher efficiencies of gas fired power stations compared to coal fired power stations are considered.

30. **However, as noted above in our responses to questions one and two, there are concerns that at a UK level, shale gas could displace investment in renewables, and at a global level could simply lead to increased greenhouse gas emissions. Therefore, the straightforward comparison of the carbon footprint of shale gas relative to coal is not the appropriate way to analyse the issue.**

January 2011

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Memorandum submitted by Philip Mitchell

Introduction

This submission is an individual comment, although much of the work has been done as part of a campaign by the Blackpool and Fylde Green party, it is not an official submission of The Green Party of England and Wales.

This account offers a case that a fully commercial consideration of the exploitation of Shale gas reserves would be unacceptable to the UK, using as an example, an area of Lancashire that may be a commercial shale gas area, and has already seen the beginning of a proposed roll-out of the industry in Europe. It offers an opportunity for the committee to consider alternatives that will prevent the human and environmental costs, before this industry becomes entrenched in the UK.

Limitations of the Committee

I urge members to carefully consider the limitations that the timeframe of the committee has placed them under. There is currently a Moratorium of Shale Gas in US states producing Shale Gas from the Marcellus Shale Field, these States include New York State and Pennsylvania. Written Submissions would not be possible in time to fully consider the findings from these State Investigations, but I urge members to study carefully the related documents on the website www.delawareriverwatcher.org This organisation conducts high quality research into the implications of the industry in these areas and particularly the Delaware River Basin. The quality of New York has been compromised as a result of the Shale Gas Industry.

I would also like to remind the members that the Oil and Gas industry has very poor reputation for taking into account the public interest, and that business plans of current operators in the UK, for example Cuidrilla Resources Limited In the North West, depend completely on their ability to exploit UK and European Shale Gas Deposits [Attachments—1 and 2 Press release from major shareholder AJ Lucas—operations are only in UK and Europe].

I also feel very restricted as, although I have given submissions to the DECC on shale gas, I was not contacted regarding the Inquiry until one week before close.

I have made the point to the DECC that the SEA to the 14th Onshore Licensing round seriously downplays the risks and hazards and I would like to add that the extent of the areas covered by potential shale gas is misleading in their map provided as Shalegas productivity test programs are already well advanced in weeton (Preese Hall) and Singleton (Grange Road) which is South of the area suggested in their maps [Attachment5]. I suggest the committee seeks full information on the location of previous drilling which has shown gas samples in Shale as this would been likely to have been more extensive than the current production test sites.

Risks and Hazards

A good summary can be viewed at the Delaware River Keeper website location: http://www.delawareriverkeeper.org/resources/Factsheets/Drilling_and_Production.pdf—please submit this complete location. This states that 2 to 9 million gallons of water are needed for each well and that many harmful chemicals including arsenic and benzene are added to this water. The fluids used for drilling are also very harmful, and in great quantities due to multiple horizontal as well as vertical drilling each of up to one mile. [Attachment3—extract from above location]

The extent of the public response to the Shale Gas Industry in the Eastern United States has been enormous and the Delaware River keeper organisation had at time of the press release concerned collected 8000 Letters including submissions from 1700 businesses affected, and has support from the New York Mayor.

In Lancashire it has been reported that the Shale Gas field potentially reached from Blackpool to Pendle Hill, and in the DECC map includes the Forest of Bowland and extends to the West side of the Yorkshire Dales. This itself suggests a field of approximately 400 square miles, and on a purely commercial consideration would mean 100 gas wells extracting gas from a well 2 miles apart (the approximate distance of the first three test wells in the Fylde). THIS IS A TINY PROPORTION OF THE POTENTIAL FIELD across the UK.

The main risk and source of public outcry in the US has been the contamination of drinking water. In Lancashire the aquifers used in drinking cover this likely area of drilling and in the AJ Lucas press release [Attachments—1 and 2 Press release from major shareholder AJ Lucas—Preese Hall, Grange Hill, Singleton], appears to be in the location of the Aquifer [Attachment4—Location of Groundwater Abstractions, including aquifers] and Carbonate Rock. Purely commercial Interest would also mean many of the wells would be in the area of the aquifers.

The committee should also consider the risk of extracting 1 billion gallons of water from the surface water of the potential gas field in Lancashire.

The routes to pollution are multiple, and include leakage from the well, spillage from the site and handling of thousands of gallons of liquid which flows back from the well after fracking. The control mechanisms cannot be relied upon alone**. I would also urge the committee to seriously consider the long term risks of deterioration of control mechanisms of the vertical well linings meant to protect the well from leakage.**

When the liquid used for fracking leaks it has natural gas dissolved in it, this entering the water table has caused wells to explode and domestic water drawn from the aquifer to be inflammable and explosive. In 1990 there were still wells in Lancashire which may be still the main source of water a affected in this way.

There is a need to dispose of the millions of gallons of highly toxic liquid flow-back following fracking and the committee needs to consider the **risks of inadequate numbers of treatment centres to process this waste, for example in Lancashire on the basis of using up to 1 billion gallons of water for fracking. Contamination of water supplies and Rivers would be considered disastrous. This is already a huge problem in New York State and Pennsylvania.**

The risk to locally produced food is serious. Contamination with the chemicals involved through any of the many routes of pollution will pose a threat to the farming and local food retail industry as well as the consumers.

The risk to wildlife and animals is huge. ***See attachment 6—Non-protected wildlife sites in Lancashire (1996).***

There is also a risk of a well blowout which in a reported case spewed out explosive gas and polluting liquid 75 feet into the air and onto the ground for 16 hours. The area around for one square mile had to be evacuated and flight routes diverted.

Experiences in the Fylde

Experiences in the Fylde of the first three production test sites (Weeton—Preese Hall, Singleton and Lytham Moss Anna's Road) Cuadrilla Resources. Cuadrilla Resources Limited gives its postal address in Lichfield, Leicestershire, UK. AJLucas describe their activities as only in the UK and Europe and that this has been the first time they have carried out "true" shale gas extraction methods (attachments 1 and 2).

At Weeton , Preese Hall, the drilling is through "Clitheroe Limestone"[Attachment1]whereas the Delaware River Keeper network wishes to ban drilling through" Karst Geology and Carbonate Rock"- I urge the committee to question Geologists on the significance of drilling through the rock quoted in the AJLucas press release e.g. to contamination of aquifers. The site is close to residences and also close (approximately 1 mile) to a busy railway line which would be at risk in the event of a "blowout", previously referred to. [Attachment 13—map of Preese Hall with respect to Weeton residences and railway line]

At Singleton, the current site is flush and adjacent to a field of brassica crops, of the type used for human consumption, animal feed or retaining minerals into the soil. The field is downward sloping, so any of the dangerous chemicals used would flow down, in the event of a moderate spillage. Arsenic salts in released fracking fluids or a direct chemical spill, for example would be taken up and retained in these crops and either consumed or retained in the soil. Many of the chemicals used in fracking and drilling are very harmful.

The planning permission for Singleton drilling does not include specific details of the chemicals used or any risk assessment, and no suggestion that they could be harmful. Fluids and storm water runoff from storage sites can run into the road. *[See attachment 14 for written component of Cuadrilla account of operations]*

The Singleton planning permission states that the borehole passes through an important aquifer, the Sherwood Sandstone.

The Cuadrilla site at Anna's Road is on Lytham Moss, near the town of Lytham St Anne's, and is an important ecological site bordering the Marton Mere wetlands. Swans routinely winter at the site, Great Crested Newts have been recorded only 220m from this site and a water body which "comprises potential great crested newt breeding habitat" is located approximately 220m to the south. Water voles have been recorded in the wider area. A chemical spill or other polluting event would easily contaminate the area of where these protected animals live and threaten the protected wetlands of Marton Mere, which hosts a Wildfowl and Wetlands Trust Centre. There are also many domestic animals, such as horses nearby and a popular animal sanctuary.

Extracting groundwater for the fracking would also threaten these wetland ecologies, and residents of Lytham St Anne's have questioned the effect of reduced water table on the stability of their properties. Diversion of water courses is already taking place.

Economic Considerations

In the 40 square miles of Lancashire I've considered, the farming and tourist industry are predominant. Millions of visitors enjoy the countryside and appreciate the wildlife that exists there. The Local food industry is important to the many restaurants and country hotels as well as the Northwest generally.

The farming industry is struggling and a transition to shale gas a economy will lead to much higher rates of long term unemployment amongst its workers.

The cost of the processes involved in fracking, disposal of waste and of infrastructure, including new roads and treatment centres, will add to energy prices and government expenditure, placing a burden on the economy. The reduction in land and house prices, in villages such as Singleton and Elswick in which properties are sought after and which dot the landscape of the area I've considered will fall, and I've attached a petition from Singleton Village residents which shows the very strong feeling against their local developments in the village. This petition was carried out over four days, at the start of which very few residents understood what the development was and was facilitated by networking through cascading through the village. Please understand that this was inadequate time to conduct a full petition, and that a proportion of villagers had an interest in the "Singleton Trust" land which would have been paid for, for the facilities built. Petitions (mostly residents and singleton school parents (where labelled)) are *attachments 7 to 12* inclusively. Only a small part of the parish of Singleton (population 877, *2001 census*) is included in the village itself.

Alternatives

The need for Shale gas as an energy resource is overstated by an industry that relies on this case. These resources are not renewable and will eventually be depleted leaving behind a highly questionable legacy.

Gas resources are likely to be linked across Europe, and large-scale gas storage in, for example, Morecambe Bay Gas fields would ensure a constant supply.

The renewable energy industry can be expanded instead and investing in switching to this, rather than unconventional hydrocarbon extraction, can provide a large part of our future energy needs. Scientists made a presentation at the House of Commons in June 2009 arguing that an electricity "supergrid" across Europe and North Africa could solve the problem of the intermittency of wind turbines and solar power. [Ref: "Green" supergrid could plug Europe into renewable power by 2030, say scientists].

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The following attachments were included with the submission but have not been printed:

1	ASX media release, Cuadrilla Activity Update Report, 7 December 2010
2	Page 2 of above
3	Extract from www.delawareriverkeeper.org/resources/Factsheets/Drilling_and_Production.pdf
4	Location of Groundwater Abstractions in Lancashire, 1990 [map]
5	Unconventional Hydrocarbon Resources of Britain's Onshore Basins (DECC) [map]
6	Non-protected wildlife sites in Lancashire (1996) [map]
7–12	Petitions against shale gas exploration and extraction
13	Map of Preese Hall
14	Cuadrilla account of operations—February 2010

Memorandum submitted by Friends of the Earth

Friends of the Earth primarily approaches the question of whether shale gas is a good or bad energy supply option to exploit from a climate change perspective, although we recognise that there are other important considerations, such as groundwater pollution from the chemicals associated with hydraulic fracturing.

In December we published research[i] into global carbon budgets that identified that 1,100 $GtCO_2e$ is the size of a global carbon budgets for a 70% chance of avoiding a global average temperature increase of two degrees or more. If this budget is to be shared equally between nations based on average population between now and 2050 then the UK would need to reduce emissions by 80% by 2030 from 1990 levels, the EU by 83% and the USA by 95%. China would need to peak its emissions by 2013 and then decline by 5% per annum. These reductions rates assume no "negative emissions" or other geoengineering techniques are deployed, which is clearly an issue for debate. The implication of our research is that we need a very fast transition away from a fossil fuel based economy towards a low carbon economy. It is within this context that we judge the utility or otherwise of shale gas.

We are aware from research by Chatham House that there are in theory very substantial reserves of shale gas, far greater than conventional gas.[ii] Although the majority of this is in North America, Middle-East and

China the quantities in Western Europe are not insignificant and may be greater than proven reserves of conventional gas. As the Chatham House report makes clear, shale gas has the potential to be a "game changer" by opening up huge new sources of gas but whether and how much of the potential can be realised is not yet clear.

Friends of the Earth has concerns about the exploitation of these resources.

— Large amounts of shale gas could undermine investment in renewable energy in the UK and elsewhere. The UK has a 2020 target for renewable energy but no targets after 2020. Investors could be very nervous of investing significant money in offshore wind or other renewable power projects if it is not clear that there will be a guaranteed market for the energy after 2020.

— The Government's draft National Policy Statements say there is only need for 18 GW of new non-renewable capacity. But there is however at least 14 GW of new gas either with consent, being built or in the pre-Infrastructure Planning Control (IPC) regime. On top of that there is already 20 GW of gas and nuclear applications in the current IPC system. This is 34 GW—way over the "needed" 18 GW, and a potential massive over-supply, which is likely to come at the expense of renewables. Gas is already threatening renewables investment, even before shale gas is considered.

— If the Government intends renewable energy to play a significant role in meeting its Climate Change Act obligations, and if it wants to build a world leading marine renewables industry, then it needs to set out clear expectations for offshore wind and other renewables over the next 30 years, and clear policies to ensure it is not swamped by investment in other types of capacity. It also needs to put in place the appropriate long-term support framework to enable investor confidence. A well-funded Green Investment Bank is a clear priority.

— Friends of the Earth recognises that available data suggests that the carbon footprint of shale gas is smaller than that of coal used in electricity production, although it is higher than that of conventional gas.[iii] Therefore if shale gas was to displace existing coal electricity generation then there would be a net carbon reduction. However, as some coal is being displaced anyway via the LCPD, new shale gas would more than likely be displacing other types of electricity generation such as renewables.

— The emissions reduction rates required to meet the Climate Change Act are very significant. The Committee on Climate Change has suggested that the carbon intensity of electricity generation should be reduced to 50gCO_2/KWh. The Government has said that any emissions performance standard would apply to coal-fired power stations and not to gas. Without a clear policy requirement to achieve the 50gCO_2/KWh target there is a risk that shale gas exploitation could lead to the development of many more gas-fired power plants and jeopardise the meeting of the target recommended by the Commꞁttee on Climate Change.

Friends of the Earth therefore recommends that the Government put in place the following policies before any shale gas projects are considered:

Within its National Policy Statements:

— Accept the Committee on Climate Change recommendation that electricity generation by 2030 must have a carbon intensity of no greater than 50gCO_2/KWh.

— Set a limit for GW of consented new fossil fuel-fired generation compatible with this target.

— Provide a clear expectations for renewable energy generation in 2025, 2030 and 2040.

— Rule out all new coal-fired power stations regardless of whether they have CCS, and set a date for the closure of existing plant.

— Within its Market Reform work:

— Put the 2030 decarbonisation target centre-stage

— Put in place the appropriate long-term support framework to build investor confidence in renewables

— Put in place a stronger Emissions Performance Standard to cover gas-fired power plants at a date necessary to achieve the 50gCO_2/KWh target.

Once these policy measures are clear then the role of gas in future energy needs will be clearer. Shale gas should only be part of the supply if need is clearly proven and if extraction can meet high environmental standards, such as no contamination of groundwater and low local environmental impacts. Until then there should be a presumption against shale gas exploitation.

January 2010

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[i] Friends of the Earth (2010), Reckless Gamblers: how politicians' inaction is ramping up the risk of dangerous climate change.

[ii] Stevens (2010), The shale gas revolution: hype or reality, Chatham House.

(iii) Tyndall Centre, University of Manchester (2011), Shale gas, a provisional assessment of climate change and environmental impacts.

Memorandum submitted by ExxonMobil

As discussed, ExxonMobil is developing new tools and techniques for finding and producing gas resources, both conventional and unconventional, in Europe. We believe that unconventional resources will increasingly contribute to European supply, expecting to grow to ~5 BCFD or about 10% of total supply by 2030.

ExxonMobil has been steadily increasing our position in unconventional gas resources by focusing on securing access to high-quality opportunities worldwide. Following the completion of ExxonMobil's merger with XTO, the company is moving forward with the creation of a new organization to focus on global development and production of unconventional resources.

In Poland ExxonMobil Exploration and Production Poland (EMEPP) has now safely completed drilling the Krupe-1 shale gas well in the Chelm concession in southeast of the country. The well spudded on 3 December 2010 and reached a target depth of 3,807 meters. On 20 February 2011 drilling commenced on the Siennica-1 well, and is expected to last for 10 weeks.

Further operations at both wells, including a decision if fracing will be conducted, are dependent upon an analysis of drilling results.

EMEPP has also safely completed 3D seismic surveys in the Mińsk Mazowiecki, Wolomin and Chelm areas. We have commenced shooting seismic in the Werbkowice concession. 3D seismic acquisition is a low environmental-impact, temporary activity and all activities are conducted in a way to respect and protect the local communities, wildlife and the environment. The programs incorporate ExxonMobil's global best practices to ensure the environmental footprint is minimal and temporary, and complies with our permits.

With regard to your question on regulatory regime, ExxonMobil supports stable and sensible policies that will allow unconventional gas to compete on a level playing field. This will help increase production and secure supplies of reliable, affordable energy to help boost the economy. Due to the relative lack of equipment and personnel in Europe for large-scale unconventional exploration and development, it will be important that there are no undue restrictions on the import of equipment and/or services into the EU, or the ability to move these quickly from one country to another within the EU.

Operators are likely to ask for larger, unproven development areas in their production licenses than for conventional resources, due to the inherent nature of unconventional resource basins. Regulatory amendments will need to take this into account. Environmental regulations may need to be amended to account for issues associated with accessing large tracts of land with large volumes of equipment, as well as to manage water use during operations in an environmentally responsible manner.

Extended pilot phases (potentially lasting years, not months) that produce gas on a smaller scale than full development are distinct possibilities.

These pilots may require innovative local solutions, such as supplying local communities through small, newly built distribution systems or using portable gas-fired electrical generation stations to supply local communities directly through the existing grid. All of this may require regulatory amendments.

As previously offered, we would be delighted to meet with Chairman Yeo to discuss both shale gas regulation and our activities in Poland.

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