Department for Environment, Food and Rural Affairs

Draft Shale Gas Rural Economy Impacts paper

Covering Note

This paper is an early draft of an internal document; it is not analytically robust. Work on it has since been discontinued.

The draft paper was intended as a review of existing literature. It includes early, often vague, assumptions which are not supported by appropriate evidence. These were never intended as considered Defra positions or as statements of fact.

Containing no new evidence, the paper simply refers to data from overseas studies which cannot be used to predict impacts in the UK with any degree of reliability. The author of the paper was not asked to consider, and did not have an in-depth knowledge of, the UK regulatory framework.

In June 2012, the Royal Society and Royal Academy of Engineering report concluded that environmental (and health and safety) risks can be managed effectively in the UK if operational best practices are enforced through regulation. The UK has a rigorous and robust regulatory regime which is fully capable of preventing and managing any risks.

This paper has been released further to a Decision Notice issued by the Information Commissioner's Office (ICO) on 8 June 2015. The ICO accepted that the paper was an incomplete draft.

Security

The document shows the security markings at the time of the request (Draft Restricted); the document has been declassified for release.

Redaction

The name of the paper's author has been redacted under section 40(2) and (3)(a)(i) of the Freedom of Information Act (2000) as agreed previously with the complainant and the Commissioner.   No other material has been removed.

The full report follows below and is made up of twenty-three (23) pages.

01 July 2015

Shale Gas
Rural Economy Impacts

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March 2014

Contents

Executive summary

The analysis in this report has examined the economic, social and environmental impacts associated with shale gas exploration following a rapid literature review. Much of the international evidence is based on the experience in the USA which has seen a significant expansion of shale gas fracking over the past few years.

Whilst this evidence is useful it is important to note that the USA experience is not directly transferrable to the UK context for a number of reasons. For example, the USA have a different regulatory regime for the treatment of waste water which is not the same in the UK, where there are tighter environmental permit controls that will reduce the risks of ground and surface water pollution. In addition property rights for mineral extraction are owned by landowners in the USA creating a financial incentive for private owners to allow the disruptions associated with shale operations. Whereas in the UK property rights reside with the state and landowners receive no compensation or reward. These regulatory control and incentive differences are likely to lead to different scenarios in the expansion and impact of shale gas operations in the UK. Despite these differences it is still useful to learn lessons from the USA experience and consider how applicable they are in the UK context.

In assessing the impact of Shale Gas exploration and drilling it is important to differentiate between short and long-term impacts on rural communities. In order to do this there is a need to understand what will drive the pace and scale of drilling and associated boom and bust cycle as operators enter and exit the market. This will have implications for the potential benefits, costs, job creation and longer term economic development prospects for rural communities where shale gas drilling is taking place. Overall there will be positive and negative impacts on different groups within rural communities that need to be considered.

Unfortunately none of the international reports reviewed contained any robust quantitative assessment of the cost and benefits or impacts from shale gas on rural communities. However, they did include qualitative information that described (rather than measured) the effects with a general discussion. The main high level findings from the report are summarised in the tables below which consider the economic, social and environmental impacts specifically for rural communities rather than the wider economy.

ECONOMIC IMPACTS			
Jobs	**Services**	**Energy**	**Tourism**
Likely to be positive but uncertain impact as higher skilled jobs may be awarded to workers from outside local area. Although some supply chain businesses may recruit locally boosting rural employment	**Positive** if council rebates and company contributions are invested in local services and infrastructure. This could be a major benefit for rural communities using these services.	**Positive outlook** for energy security which will benefit rural communities following increased domestic production rather than relying on foreign imports of gas and vulnerability to political or exchange rate uncertainty.	**Broadly neutral.** Losses from tourists avoiding area due to shale gas operations may be off-set by increased hospitality to new workers

SOCIAL IMPACTS		
Congestion	**Housing impacts**	**Services**
Negative but localised. Additional volume of lorries and vehicles using local rural roads, but depends on location as some may be situated near national highways.	**Negative but localised**. House prices in close proximity to the drilling operations are likely to fall. However, rents may increase due to additional demand from site workers and supply chain.	**Broadly neutral.** Depends if new workers at shale gas operations and supply chains create additional demand on schools, doctors and other local rural services that cannot be met by existing services.

ENVIRONMENTAL IMPACTS			
Water resources	**Noise**	**Air Quality**	**Landscape**
Low impact if properly regulated but risks need to be managed effectively on site.	**Localised impact** on rural communities living within close proximity of shale gas fracking operations	**Low impact** If properly regulated but risks need to be managed effectively	**Low impact** that is site specific, although will have localised impact on businesses reliant on tranquil environment

An assessment of the significant environmental and economic impacts for the UK has been undertaken by DECC along with another study by the Institute of Directors that estimated the job creation potential associated with shale gas operations. The Environment Agency have also recently commissioned Ricardo-AEA consultants to undertake an assessment on what the future industry in shale gas and coal bed methane may look like, if and when it moves to commercial production. It describes the processes involved and the infrastructure required, although it does not consider environmental impact. The results from these studies is contained in the summary findings from the literature review, however, these do not breakdown the impacts at a rural community level. Further work could be undertaken to examine the numbers of communities (residents and businesses) that are likely to be affected from shale gas exploration. However, due to uncertainties on specific license locations at present time we have not undertaken any new research at this stage.

Section 1: Findings from literature review

DECC Environmental Impact Assessment for Shale Gas Exploration and Drilling

DECC commissioned AMEC to undertake an EIA that examined the likely significant environmental effects of further onshore oil and gas licensing to comply with the requirements of the Strategic Environmental Assessment Directive (2001/42/EC). Consideration was given to all the stages in the oil and gas production and development lifecycle, under high and low activity scenarios for both conventional and unconventional oil and gas.

	Likely significant effects of shale gas drilling for the UK
Employment	Could create 16,000 – 32,000 new full time equivalent positions (including direct, indirect and induced jobs). Increase of up to 7% in the level of employment supported by the UK oil and gas industry sector. The extent to which these jobs might directly benefit local communities would depend on the availability of skills and experience in the local labour market.

Hydrocarbon reserves

The high activity scenario could generate in total some 0.12 to 0.24 trillion cubic metres (4.32 to 8.64 trillion cubic feet) of gas, more than six times the 0.037 trillion cubic metres (1.31 trillion cubic feet) of gas produced in the UK in 2012 or more than twice the approximate 0.1 trillion cubic metres (3.52 trillion cubic feet) of gas consumed in the UK per annum.

Climate Change

Domestic shale gas production could help to reduce net greenhouse gas emissions associated with imports of liquefied natural gas (LNG) in particular; however, if LNG or other fossil fuel displaced from the UK is used elsewhere, that could lead to an increase in global GHG emissions.

Waste Water

Depending on where wastewater is treated, the additional volume could place a burden on existing wastewater treatment infrastructure capacity, and require further or new investment. However, if on-site treatment and recycling could occur, wastewater volumes could be reduced.

Likely significant effects for Local Communities

Community economic contributions

Under the commitments of the United Kingdom Onshore Operators' Group (2013) Community Engagement Charter, shale gas exploration could provide a community contribution of £100,000 per hydraulically fractured site as an initial benefit, equivalent to total UK payments of between £3 million and £12 million. A further £2.4 to £4.8 million per site (or nearly £0.6 billion in total) could be generated in a production phase, reflecting the 1% contribution from revenue over the lifetime of each well.

Other local effects

It is estimated that there will be approximately 14 to 51 vehicle movements to a site each day during exploration and site preparation over a 32 to 145 week period. This could have an adverse impact on traffic congestion, noise or air quality depending on existing roads, traffic and air quality. It could have a more sustained and locally significant effect on communities adjacent to the development sites, or adjacent to the routes to the sites, during exploration and site preparation.

Water use

The potential impacts are on water resource availability, aquatic habitats and ecosystems and water quality. Water would typically be sourced from a mains water supply which would need agreement from the relevant water company, or could be abstracted from groundwater or surface water which would need an abstraction licence; in either case, any addition to demand would only be granted where assessed by the regulator as sustainable. Demand could however be substantially reduced if it could be met from recycling and reuse of flow back water.

Institute of Directors report: Getting Shale Gas working

IOD report examines the potential impact of Shale Gas which it argues could represent a multi-billion pound investment, create tens of thousands of jobs, reduce imports, generate significant tax revenue and support British manufacturing. It could potentially meet a third of the UK's gas demand with a very small surface footprint, benefitting the environment at the same time. The table below provides estimates of the potential gas exploration reserves and applies a number of different recovery rates. At the low end, a recovery rate of 5% who equate to a recoverable resource of 15.5 trillion cubic feef (tcf) of gas which is more than five years of total UK consumption. At the high end, a recovery rate of 25% of the gas in place would imply a recoverable resource of 77.3 tcf which is over 25 years of total UK consumption. They expect that a recovery rate of 10% may be more realistic as a conservative assumption. This would equate to a recoverable resource of 30.9 tcf based on the findings of the exploration companies.

Potential UK shale gas recoverable resources based on various recovery rates

	Recovery rate 5%	10%	15%	20%	25%
Gas in place (tcf) – total of exploration company estimates	309	309	309	309	309
Recoverable resource (tcf)	15.5	30.9	46.4	61.8	77.3
Years of total UK consumption (3 tcf a year)	5.2	10.3	15.5	20.6	25.8
Percentage of potentially recoverable conventional gas resources	30%	60%	90%	119%	149%

Economic and environmental benefits of Shale Gas

Investment and job creation

Investment could reach £3.7 billion a year, supporting 74,000 jobs. Geologists, engineers, construction workers, business analysts, truck drivers and public relations staff are examples of the people needed by the industry. Cement and steel manufacturers, equipment manufacturers, drilling services companies and water treatment specialists would form important parts of the supply chain. Spending by the employees of the industry and its supply chain would benefit local businesses, including restaurants, shops, pubs, theatres and hotels.

Environmental benefits

According to the Committee on Climate Change, if production is well regulated, shale gas can have lower emissions than imported LNG. A recent report for the European Commission also reached the same conclusion. To the extent that UK shale gas supports the production of chemicals and other goods in the UK rather than overseas, emissions will be lower, as UK industry is more energy efficient than in most countries.

Cuadrilla report by Regneris consultants:
Economic Impact of Shale Gas Exploration & Production in Lancashire and the UK

Cuadrilla Resources Ltd are exploring the potential for commercial shale gas extraction in the Lancashire area via a series of test wells. Exploration commenced in mid-2010. Regeneris Consulting were appointed by Cuadrilla to quantify the economic impact of both the current exploration phase and the likely economic impact of a subsequent and far more extensive phase of commercial extraction. This modelled the impact for both the county of Lancashire and the UK as a whole.

Economic benefits of Shale Gas exploration in Lancashire

Jobs in 1st year of operation

Regeneris estimate the test well activity will support some 250 FTE jobs over a 12 month period across the UK. Half of the jobs will occur within Cuadrilla and its extensive range of 1st tier suppliers. Over a tenth of the jobs result from the expenditure patterns of employees across the wider UK economy. Just over 15% of the jobs (circa 40) are estimated to be taken by Lancashire residents.

Economic Impacts of Commercial Extraction

At the UK Level, the FTE employment impact peaks at some 5,600 FTE jobs in the period 2016 through to 2019 with a build-up in the years from 2013 onwards. At the peak some 4,000 jobs are directly within the eventual lead producer and within both first and subsequent tier suppliers. 610 FTE jobs (direct and indirect) are required for the installation of the conversion infrastructure. Induced jobs resulting from the expenditure of staff account for 850 FTEs nationally, although this estimate does not appear to take any account of displacement or crowding out.

At a Lancashire level, the FTE employment impact peaks at 1,700 FTE jobs in the period 2016 through to 2019. Evidence from the US, measured at the State level, puts the FTE per well ratio at between 32 to 58 FTEs per well. The scale of these operations will lead to substantial new clustering of a supplier base in Lancashire and some attraction of specialist overseas suppliers to other UK locations.

Ricardo AEA report commissioned by the Environment Agency:
Unconventional Gas in England, description of infrastructure and future scenarios

The Environment Agency commissioned Ricardo AEA to undertake an analysis of how the unconventional gas industry in England may grow from the exploration phase. It used three future scenarios to outline a range of possibilities for the future scale of the industry, designed to represent low growth, medium growth and high growth. The scenarios are a current best estimate, based on experience from the US. Although it recognises that the situation in the UK is likely to vary from the US due to differences in planning rules, property rights, tax and financial incentives etc.

Results of analysis – numbers of wells drilled

High scenario

It was estimated that under the high US-style scenario, the total number of wells drilled would be about 12,500 with a peak of 1,100 wells drilled per year. Under this scenario, UK shale gas production at its peak could potentially reach 80 billion m3 per year, approximately 89% of the UK's current gas consumption. However, differences between the US market, regulatory, environmental and geological conditions mean that this scenario is highly unlikely to occur.

Mid scenario

In the mid case scenario, production would peak at around 9.8 billion m^3 per year, around 11% of the UK's current demand for natural gas.

Low Scenario

In the low case scenario, total cumulative production would reach 12 billion m^3 from a total of about 580 wells. Under this scenario, production would peak at about 1 billion m^3 per year, about 1.1% of the UK's current consumption.

Consideration of gas price predictions indicates that the high and mid case scenarios could potentially be commercially viable, whereas the low case scenario seems unlikely to be viable.

Comparison of findings

The tables below show the total jobs and production estimates with assumptions (where available) used as basis for the calculations in the various reports. The numerous assumptions make it difficult to disentangle the basis for variation between these estimates. However, differences in the expected number of wells and variation in drilling processes that affect the maximum level of shale gas production are likely to be key factors that explain the differences. Despite this there is a degree of consistency in the peak level of production expected around 2020 and that overall it will lead to a positive impact on employment and greater energy security.

Jobs comparison

	DECC	IOD	Ricardo	Cuadrilla
Jobs created	16,000 – 32,000 FTEs in UK	74,000 FTEs	Na	5,600 FTEs
Assumptions	Based on evidence from USA with adjustments made for UK context. Unclear how these have been derived from tables in report.	Assume that each £1 million of capex and opex leads to the creation of 20 jobs in UK	na	Estimate the test well activity will support some 250 FTE jobs over a 12 month period across the UK.

Production comparison

	DECC	IOD	Ricardo	Cuadrilla
Peak in production	2020	2019	2020	2020
Number of wells	360 wells at maximum production	At peak, 50 rigs would be drilling 400 laterals a year. This equates to a recoverable resource of 0.9 billion m3 per annum	580 wells in low growth scenario, 3,095 medium growth scenario and 12,478 in a high 'US-style' scenario.	190 wells drilled in low growth scenario over 6 years. The higher end scenario = 800 wells drilled over a period of 16 years.
Assumptions	Assumes the high activity scenario would generate between 120 billion m3 and 240 billion m3 of gas cumulatively in total.	Assume an initial production rate of 0.07 million m3 per day in the central scenario 0.06 million m3 per day in the low scenario and 0.09 million m3 per day in the high scenario.	Cumulative gas production could range from 11.8 billion m3 (low growth), 133 billion m3 (medium growth) to 1,040 billion (high 'US style' growth).	na

Environment Agency comparative analysis

The Environment Agency has also undertaken a comparative analysis between the Ricardo study and the DECC (AMEC) SEA. This stressed that both sets of scenarios are illustrative only. Neither provides a forecast of future activity. Little drilling or testing has taken place and therefore it is not possible to make meaningful estimates at this stage. The DECC SEA notes that a series of assumptions have been made, that these assumptions do not represent any definitive view but rather a representative view based on present knowledge.

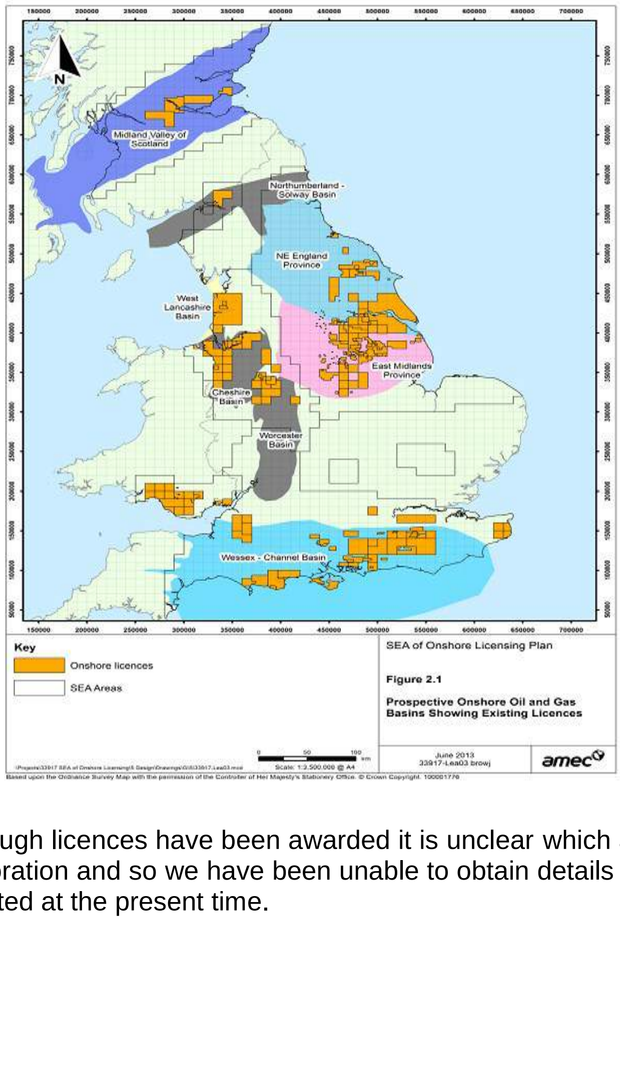
The Ricardo AEA reports that there are significant uncertainties facing the unconventional gas industry. These include knowledge about the geology, potential impacts to planning, the economy, taxation and future benefits. The scenarios represent a best estimate only, based on US experience, which may differ in key respects from the UK. As a result the approach was to develop a range of illustrative future scenarios, rather than to develop forecasts for industry growth.

The scenarios are based on different methodologies. For shale gas, both draw heavily on experience in the USA. The DECC SEA Scenarios are based primarily on past activity in previous licensing rounds for conventional oil and gas and coal bed methane (CBM). Shale gas predictions are based on evidence from literature, much of which is based on the US experience, and applied to the UK. The Ricardo-AEA report scenarios are based on expected future growth, based on US experience. It develops separate scenarios for shale gas and coal bed methane. The high growth level represents growth in the UK similar to that experienced in the USA, which it recognises is highly unlikely to occur given the different market, regulatory, environmental and geological conditions. The medium case is based on industry well drilling forecasts and the low case draws on UK experience of new energy infrastructure.

Both reports do not expect production to be at full tilt until the 2020s. The SEA report assumes that all of the wells granted licences under the 14th round will be drilled and completed within the first 12 years. Wells are expected to have a 20 year life span. The Ricardo AEA report expects production to start no earlier than 2016/7, based on the Institute of Directors report. It presents estimates of well growth scenarios up to 2035, peaking in the 2020s. Neither report gives the precise locations of where unconventional sites may be in the future. The SEA outlines the broad areas under consideration and thinks that most activity is likely to be close to existing licensed areas. The Ricardo AEA report uses statistics on resources in prospective areas in its methodology but the end results are not broken down geographically.

Section 2: Areas likely to be effected by Shale Gas licensing

Shale gas is now regulated by DECC through the office for unconventional gas and oil. The main areas that have been identified for exploration are illustrated in the diagram below which shows the extent of the reserves and current licences that have been awarded. This indicates that large numbers of rural communities may be affected by the expansion of shale gas activities in the North East, West and Southern regions of England.



Although licences have been awarded it is unclear which are operational in relation to shale gas exploration and so we have been unable to obtain details of which specific rural locations will be affected at the present time.

Section 3: Impacts on rural communities from Shale Gas drilling

3.1 Economic Impacts

To fully assess the economic impacts of shale gas drilling on rural communities it is important to consider a wide set of questions:

- Who will get the jobs that are created?
- What are the externality costs (pollution, waste, noise) associated with shale gas production and the extent these will be borne by local rural communities?
- How will the costs and benefits be distributed?
- How will other regional industries, such as tourism, be affected?
- Where will the tax revenue or rebates given to Local Authorities be spent?
- Will local communities benefit from skills and training?
- How do the short-term impacts compare to the longer term impacts?

It is often claimed that the overall effect of shale gas operations will be positive with benefits such as lower energy prices that are more secure and tax revenues that can compensate communities for the impact of externalities. Indeed the government recently announced that English councils which give the go-ahead to shale gas developments will be allowed to keep 100 per cent of the business rates they collect from consented sites[1]. This is estimated to be worth up to £1.7m a year for a typical site. In 2013 the industry also announced that local communities would receive £100,000 when a test well is fracked – and a further one per cent of revenues if shale gas is discovered. This could be worth £5m-10m for a typical producing site over its lifetime. The industry will consult further on how this money can best be shared with the local community, with options including direct cash payments to people living near the site, plus the setting up of local funds directly managed by local communities.

Energy Minister Michael Fallon said: "We already knew that the development of shale gas could bring growth, jobs and energy security to the country, and now local councils and people will benefit from millions of pounds of additional investment." For example, the IOD estimate that a two-hectare site could potentially support a 10-well pad of 40 laterals, representing an investment of £514 million and supporting 1,104 jobs at peak. It could produce 126.2 bcf of gas and, at peak, power 747,000 homes. It could use 544,000 m3 of water and see 11,155-31,288 truck movements over 20 years.

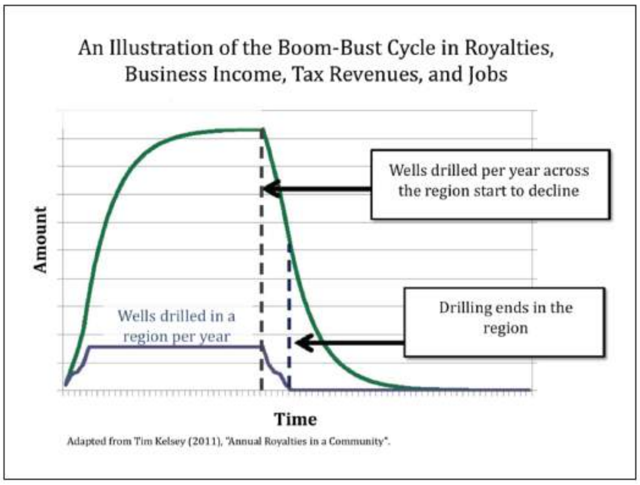
At a national level the IOD estimate that shale gas investment could reach £3.7 billion a year, supporting 74,000 jobs. Geologists, engineers, construction workers, business analysts, truck drivers and public relations staff are examples of the people needed by the industry. Cement and steel manufacturers, equipment manufacturers, drilling services companies and water treatment specialists would form important parts of the supply chain. Spending by the employees of the industry and its supply chain would benefit local businesses, including restaurants, shops, pubs, theatres and hotels.

What is less clear is how sustainable the shale gas investments will be in the future and whether rural communities have the right mix of skills to take advantage of the new jobs and wider benefits on offer. Evidence from the USA suggests this is not necessarily the case, with a high proportion of expenditures associated with drilling being made outside of the local rural economy. The majority of local jobs created are therefore likely to be indirect (supply side) jobs that support the sector rather than directly related to the extraction process. These are likely to be small, on a per well basis, and of lower value than the more highly skilled jobs created within the energy industry.

[1] https://www.gov.uk/government/news/local-councils-to-receive-millions-in-business-rates-from-shale-gas-developments

There will also be sectors that gain from the expansion of drilling activity but others that may lose business due to increased congestion or perceptions about the region. These behavioural responses may reduce the number of visitors and tourists to the rural area, with an associated reduction in spend in the local tourism economy. It is recognised that this loss may partially be offset by the rise in new workers and other suppliers entering the area particularly if they rent accommodation or book hotels and use restaurants/hospitality in the area that benefits local rural community business.

The longer term economic impacts to rural communities is uncertain and will largely depend upon how revenue raised during the shale gas boom is reinvested within the local economy to create sustainable jobs for the future that do not rely on the shale gas sector. The international evidence on this is weak but there are some positive examples in Australia where shale gas funds have been used to improve human capital (via skills training) which has reduced rural decline. Research in the US that examined the Marcellus shale gas exploration (Cornell University) highlighted the potential boom and bust scenario in which an expansion of economic activity is followed by a significant contraction as drilling ends and income falls. The timing of the cycle will depend on geological factors such as the quantity of shale gas and the technologies being used in the drilling and extraction processes.



The literature review that has been undertaken did not contain any robust quantitative assessment of the cost and benefits or impacts from shale gas on rural communities. Most of the reports included qualitative information that described (rather than measured) the effects with a general discussion. Further work will therefore be needed to monitor and assess the net economic impact of shale gas on rural communities, particularly if as expected this sector expands significantly over the next few years. The table below provides a summary of the key economic variables with an indication of the expected significance of impact.

Table 1: Summary of economic impact of shale gas on rural communities

Jobs	Services	Energy	Tourism
Likely to be positive but uncertain impact as higher skilled jobs may be awarded to workers from outside local area. Although some supply chain businesses may recruit locally boosting rural employment	**Positive** if council rebates and company contributions are invested in local services and infrastructure. This could be a major benefit for rural communities using these services.	**Positive outlook** for energy security which will benefit rural communities following increased domestic production rather than relying on foreign imports of gas and vulnerability to political or exchange rate uncertainty.	**Broadly neutral.** Losses from tourists avoiding area due to shale gas operations may be off-set by increased hospitality to new workers

Case study – Blackpool

Cuadrilla Resources Ltd are currently exploring the potential for commercial shale gas extraction in the Lancashire area via a series of test wells. Exploration commenced in mid 2010. Regeneris Consulting[2] were appointed by Cuadrilla to quantify the economic impact of both the current exploration phase and the likely economic impact of a subsequent and far more extensive phase of commercial extraction. This modelled the impact for both the county of Lancashire and the UK as a whole. Key findings from this research are summarised below:

Lancashire represents a large and complex economic area spanning urban areas exhibiting strong economic growth, towns with very weak historic performance and a substantial rural economy. Economic strategies for the county call for considerable diversification away from declining and lower value sectors, and prioritise actions that will attract higher value industries with strong growth potential. In the Fylde Coast sub-region – an area within which future drilling activity will be concentrated – the challenges and diversification needs are even more acute. GVA growth has been minimal, the second lowest of all areas across the North West, and there is considerable reliance on a visitor economy that has been in long term decline. Blackpool, the main town within the Fylde Coast is the 3rd most deprived local authority in England.

Regeneris estimate the test well activity will support some 250 FTE jobs over a 12 month period across the UK, although it is unclear from the report whether these estimates take account of displacement and crowding out effects. Half of the jobs will occur within Cuadrilla and its extensive range of 1st tier suppliers. Over a tenth of the jobs result from the expenditure patterns of employees across the wider UK economy with just over 15% of the jobs (circa 40) estimated to be taken by Lancashire residents

Table 7.5 : Bowland Shale FTE jobs generated by three test wells

	Lancashire	Rest of UK	All of UK total
Jobs within Cuadrilla/1st Round Suppliers	17	108	125
Jobs due to subsistence expenditure	19	4	23
Jobs within the rest of the Supply Chain	4	68	72
Jobs from Induced Impacts	3	27	30
TOTAL	43	207	250
Implied Jobs per Well			83

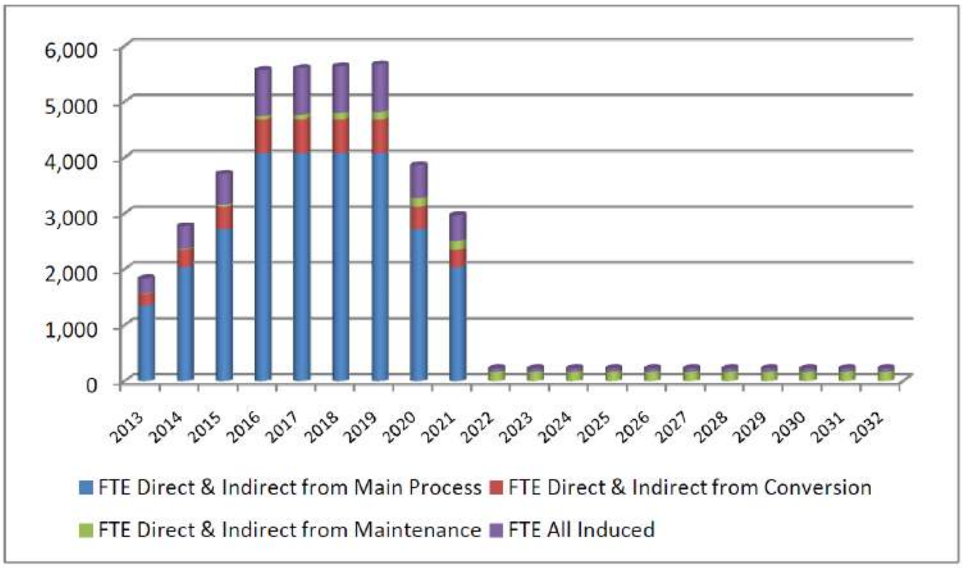
Source : Regeneris Consulting

At the UK Level, the FTE employment impact peaks at some 5,600 FTE jobs in the period 2016 through to 2019 with a build-up in the years from 2013 onwards. At the peak some 4,000 jobs are directly within the eventual lead producer and within both first and subsequent tier suppliers. 610 FTE jobs (direct and indirect) are required for the installation of the conversion infrastructure. Induced jobs resulting from the expenditure of staff account for 850 FTEs nationally. At a Lancashire level, the FTE employment impact peaks at 1,700 FTE jobs in the period 2016 through to 2019. At the peak the implied FTE per well ratio stands at 95 FTEs per well at the UK level, reducing to 30 FTEs per well at the Lancashire level. Evidence from the US, measured at the State level, puts the FTE per well ratio at between 32 to 58 FTEs per well. The scale of these operations will lead to substantial new clustering of a supplier base in Lancashire and some attraction of specialist overseas suppliers to other UK locations.

[2] Details of the Cuadrilla report with assumptions used in the analysis can be found at this link

http://www.cuadrillaresources.com/wp-content/uploads/2012/02/Full_Report_Economic_Impact_of_Shale_Gas_14_Sept.pdf

Figure 9-1 : Bowland Shale Central Case Extraction Scenario – FTEs at UK level



Source : Regeneris Consulting

3.2 Social Impacts

Evidence from the literature review suggests that rural communities face three major social impacts associated with shale gas drilling activities, which are set out below.

a) Increased congestion on roads and noise

The nature of the drilling work will involve trucks and other heavy vehicles hauling equipment and transporting staff to and from the operation. This is expected to have a higher impact on those communities living within a 5 mile radius of the site, although road congestion may spread wider but will depend on infrastructure and maintenance levels. These externalities can be managed to a certain extent by the operator being considerate of residents and planning efficient transport usage to minimise disruption.

Results from the literature review shows that the total vehicle movements per well pad are broadly similar. The SEA report breaks down vehicle movements for low and high activity scenarios. 4950-17,600 vehicle movements are assumed for the low activity and 10290-36735 vehicle movements for the high activity. The Ricardo AEA report does not break vehicle figures down according to scenarios. It quotes figures from the USA of 7,000 to 11,000 vehicle movements for a single ten well pad. This figure would be reduced substantially if water and flowback fluid could be transferred by pipeline. The Ricardo AEA report is consistent with the Institute of Directors estimate of 870 truck movements per well.

Calculations on the number of vehicle movements per day differ. The SEA report assumes 16-51 vehicle movements per day during the production development phase, which covers well construction and hydraulic fracturing. The Ricardo AEA report does not give a daily average figure. It suggests there could be 5000 truck movements for the drilling phase for a ten well pad. The temporal distribution of these activities would be uneven so it suggests the total number of trips during the heaviest period could be as high as 250 per day.

b) Impact on housing demand and property prices

As operations expand and new workers arrive into rural locations there may be a modest increase in demand for accommodation that could raise rents and cause affordability issues for rural residents seeking accommodation. For example, the Cuadrilla research quotes a figure of 83 FTE jobs being created on average for each drilled well in the UK, of which a % may seek accommodation in rural areas. On the other hand, those residents owning property close to the drilling site may suffer from lower resale prices due to the negative perception being located near the facility and potential risks. However, these effects will depend on a range of wider factors that influence rents and house prices such as planning policy, growth and investment from wider sectors, schools, flooding and insurance etc. Evidence from the US experience is listed below.

A 2010 study in Texas[3] concluded that houses valued at more than $250,000 and within 1,000 feet of a well site saw their values decrease by 3 to 14 percent. Boxall et al. (2005) looked at the impact of property prices in Alberta Canada near sour gas wells and flaring oil batteries. They found a reduction in house prices of between 4% to 7% within 4 km of the wells. The results are statistically significant and robust. However, the use of a small dataset, sample of 532 observations, make disentangling impacts difficult in the presence of confounding variables and the study considered sour gas wells alongside other gas wells, which may not be comparable in a UK context.

Gopalakrishnan and Klaiber (2013) looked at the impact on property prices in Pittsburgh, US, between 2008 and 2010 within a mile of a well pad with 7 wells. Property prices for households dependent on well water within a mile of the gas wells are found to be reduced by 5.6% on average. The sample data included 4,123 housing transactions in the period. The results are statistically significant and robust. However, the following limitations are worth highlighting: impacts relate to houses dependent on well water which may not be comparable to a UK setting; the period covered is relatively short term; and the authors also acknowledge that the lack of data to control for variables like higher property demand for working near wells and other factors, means that it's difficult to eliminate other factors explaining the results.

Muehlenbachs et al. (2012) looked at the impact of property prices in Pennsylvania, US, within 2km of gas wells. They used a sample of 19,055 property transaction between 2004 and 2009. They find a positive price effect with living near a well on homes dependent on commercially piped water supply. Whilst they also find a reduction in property prices of up to 12.9% for groundwater dependent homes, this is not statistically significant result. The study is robust. However there are a number of limitations worth highlighting: there is not enough data to disentangle positive impacts (ie lease payments to homeowners living near wells, higher rental prices and other economic activity) from the negative impacts (drilling activity and noise impacts, increased traffic, and air and light pollution); and local impacts that determine the results may not be the same in UK setting.

Overall the evidence on impact on property prices in the literature is quite thin and the results are not conclusive. There could potentially be a range of 0 to 7% reductions in property values within 1 mile of an extraction site to reflect the impacts, where the high range reflects the top end of the Boxall et al (2005) estimate for the price fall.

Properties located within a 1 - 5 mile radius of the fracking operation may also incur an additional cost of insurance to cover losses in case of explosion on the site. Such an event would clearly have social impacts, although the probability is expected to be low if the regulator and company manage these risks effectively.

c) Local Services

As new workers arrive to commence jobs within the shale gas sector there is likely to a proportion that prefer to live in rural areas, particularly if this is close to the operation site. Some of the workers will also bring families and children with them into the area who will require school and access to other local services (doctors, dentists, libraries). This may create additional pressures on local services if insufficient capacity is available to cope with the increase in demand.

[3] http://www.environmentamerica.org/reports/ame/costs-fracking

Unfortunately only qualitative evidence is available from the international literature, which is not directly comparable to the situation in England. For example, the USA and Australia often have shale gas operations being sited in rural areas which had previously experienced significant depopulation and so had capacity to meet additional demand from existing local services.

The government has announced that local authorities will benefit by receiving a tax rebate from business rates which can be invested in local services. However, it is unclear whether this level of investment will be sufficient to meet the additional demand if new schools or hospitals are needed to ensure service provision for existing rural communities is maintained. The table below provides a summary of the main social impacts on rural communities that are expected from the expansion of shale gas activities.

Table 2: Summary of social impact of shale gas on rural communities

Congestion	Housing impacts	Services
Negative but localised. Additional volume of lorries and vehicles using local rural roads, but depends on location as some may be situated near national highways.	**Negative but localised**. House prices in close proximity to the drilling operations are likely to fall. However, rents may increase due to additional demand from site workers and supply chain.	**Broadly neutral.** Depends if new workers at shale gas operations and supply chains create additional demand on schools, doctors and other local rural services that cannot be met by existing services.

3.3 Environmental Impacts

a) Water

Impacts on water quality and quantity are the most highly publicised environmental effects associated with shale gas fracking, with potential human health consequences for local rural communities. Hydraulic fracking increases the amount of fresh water used by each shale gas well by as much as 100 times the quantity used in conventional drilling. The IOD estimate that water use for shale gas could reach 5.4 million m^3 a year, around 0.05% of the total. This would equate to 27,000 four people households using 200 m^3 of water per year. It is also a similar amount of water that is currently being used on existing mining/quarrying operations which is estimated by WRAP[4] at 7 million m^3 a year.

In the US the chemicals that are added to the water have raised public health concerns related to surface water and groundwater quality. Although chemical additives used in fracturing fluids typically make up less than 2 percent by weight of the total fluid they do include biocides, surfactants, viscosity modifiers, and emulsifiers which vary in toxicity.

A proportion of the fluids used in drilling returns to the surface; these “flowback” or “produced” fluids may contain hydraulic fracturing chemicals, as well as heavy metals, salts, and naturally occurring radioactive material from below ground. This water must be treated, recycled, or disposed of safely otherwise surface water may be contaminated by leaking on-site storage ponds, surface runoff, spills, or flood events. There is a risk that even if contaminated surface water does not directly impact drinking water supplies, it can affect human health indirectly through consumption of contaminated wildlife, livestock, or agricultural products.

Experience from the US indicates that leakage of waste fluids from the drilling and fracking processes has resulted in environmental damage. Although it is unlikely that contamination will occur via the artificially created fractures in the rock, leaks can potentially occur through faulty

[4] http://www.wrap.org.uk/sites/files/wrap/PAD101-201%20-%20Freshwater%20data%20report%20-%20FINAL%20APPROVED%20for%20publication%20vs2-%2005,04,12.pdf

well construction or from surface spillage of drilling and fracking related fluids (IEA, 2012; The Royal Society, 2012). Royal Society[5] research shows that the majority of incidents of contamination in the US occurred under historically weaker environmental standards than are currently adhered to and that the UK regulatory environment is likely to be more robust. For instance, waste fluids will need to be stored in sealed steel tanks rather than open ponds, which reduce the risk of leakage.

The Environmental Impact Assessment commissioned by DECC identified that the additional volume of waste water could place a significant burden on existing treatment infrastructure capacity, and require further or new investment. Overall the potential impacts on water resource availability, aquatic habitats and ecosystems and water quality is uncertain. Water would typically be sourced from a mains water supply which would need agreement from the relevant water company, or could be abstracted from groundwater or surface water which would need an abstraction licence; in either case, any addition to demand would only be granted where assessed by the regulator as sustainable. Demand could however be substantially reduced if it could be met from recycling and reuse of flow back water.

b) Noise and Light

Noise and light have also been cited in the US as environmental and health concerns for residents and animals living near drilling operations. Excessive and/or continuous noise, such as that typically experienced near drilling sites, has documented health impacts. According to community reports near these sites, some residents may experience deafening noise; light pollution that affects sleeping patterns. Noxious odours from venting gases can also impact on air quality for local residents.

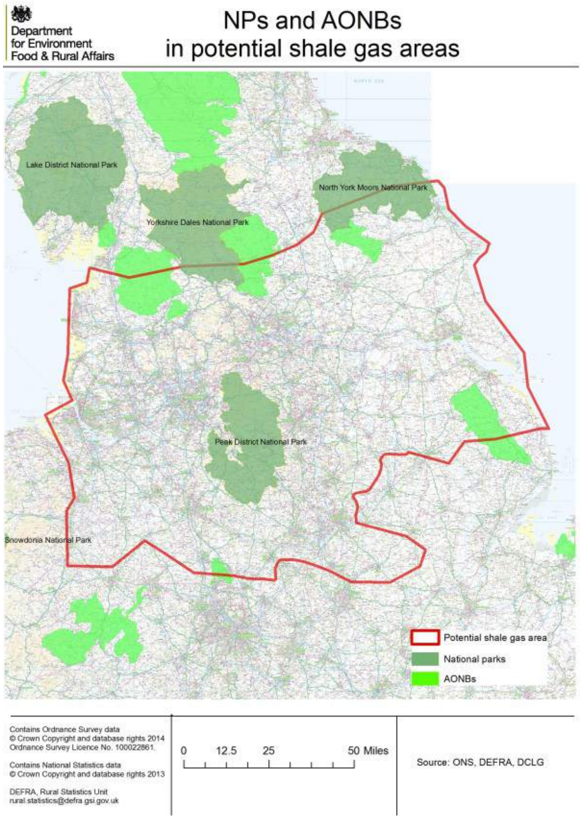
NYSDEC (2011) reports that noise impacts can be felt close to distance to the extraction site. There is also the potential for hydraulic fracturing to cause earthquakes and seismic activity. According to de Pater and Baisch (2011) and Green et al. (2012), hydraulic fracturing can cause noticeable seismic activity. Also, pressure in disposal wells can build up over time, inducing seismicity (The Royal Society, 2012). These risks would need to be properly regulated and managed to minimise the impacts.

c) Landscape

Environmental impacts on the landscape are another consideration. Shale gas development may transform a previously pristine and quiet natural region, bringing increased industrialization. As a result rural community businesses that rely on clean air, land, water, and/or a tranquil environment may suffer losses from this change such as agriculture, tourism, organic farming, hunting, fishing, and outdoor recreation.

The map in the diagram below illustrates the potential impact of the Bowland shale gas exploration area which cuts across a number of National Parks and Areas of Outstanding Natural Beauty, including the entire Peak District National Park. However, the size of the extraction pads will be small relative to the potential area. Various sources give estimates of the land area taken up by an extraction pad, which may include multiple wells. The IEA (2012) estimate a typical size of one hectare, while Tyndall Centre (2011) estimates a size of between 0.4 and 2 hectares. The largest estimate is from Cooley and Donnelly (2012) at 3 hectares. MacKay and Stone (2013) estimate the potential size of a pad in the UK, at 0.7 hectares. The SEA report assumes each well pad will cover 2 to 3 hectares. The Ricardo AEA report gives a range of areas, based on US experience from 2 to 3.6 hectares.

[5] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/256359/Publication_RoyalSociety_2012-06-28-Shale-gas.pdf



The SEA report suggests the total area covered by well pads will be between 60-90 hectares (low scenario) and 240-360 hectares (high scenario). It assumes 6-12 wells per pad (low scenario) and 12-24 wells per pad (high scenario). The Ricardo-AEA scenarios produce a total land take of 200 hectares (low growth), 1080 hectares (medium growth) and 4400 hectares (high 'US style' growth). These figures are based on land requirements for well pad development, drilling hydraulic fracturing and completion stages only. During the operational phase the landtake would be lower. Overall the results suggest that the landscape impacts will be relatively low in comparison to other extractive industries such as quarrying.

d) Waste

A typical fracking site will produce waste liquids from both drilling the well and the fracking process itself (IEA, 2012). Treatment of some waste fluids may produce solids that would typically be disposed of via landfill (The Royal Society, 2012). Any products sent to landfill would attract the landfill tax and, as such, the impact will be incorporated into the calculation of operational costs already. No other evidence was identified to support any suggestion that this impact could be significant.

e) Air Quality

Some studies have found evidence of Volatile Organic Compounds (VOCs), such as benzene, near shale gas extraction sites in the US, particularly during uncontrolled flowback of fracking fluid (McKenzie et. al., 2012; Colborn et. al., 2011). VOCs contribute to ozone and smog formation and can result in adverse health effects. However, the literature is limited and uncontrolled flowback and open storage of fracking fluids on site would not materialise in the UK due to the regulatory regime in place (The Royal Society, 2012).The combustion of natural gas produces a number of air pollutants, including particulate matter (PM), oxides of nitrogen (NOx), sulphur dioxide (SO2) and ammonia (NH3). However, levels of pollutants released from shale gas production are relatively low, and when valued represent a negligible cost.

Table 3: Summary of environmental impact of shale gas on rural communities

Water resources	Noise	Air Quality	Landscape
Low impact if properly regulated but risks need to be managed effectively on site.	**Localised impact** on rural communities living within close proximity of shale gas fracking operations	**Low impact** If properly regulated but risks need to be managed effectively	**Low impact** that is site specific, although will have localised impact on businesses reliant on tranquil environment

Section 4: Conclusion

This report has examined the potential economic, social and environmental impacts that are likely to be associated with an expansion in shale gas exploration. Overall the impacts are likely to be mixed with short-term positive economic gains from employment and energy that need to be balanced against the costs that may affect certain groups, such as businesses involved in tourism, local house price impacts and increased congestion.

To a large extent these effects are already experienced by those rural communities located near established extraction activities e.g. quarrying, mining and conventional gas extraction. This report has not considered whether existing regulations for these activities will be sufficient to cover the expansion of shale gas and limit the impacts for rural communities. These issues are expected to be covered in the other regulatory reviews that have been commissioned.

However, there may be some important lessons to be learnt from experiences of these other extraction sectors. For example, a report from the quarrying industry[6] suggested that a way of further localising the positive economic benefits is to foster the development of the vertical and horizontal economic linkages between the proposed quarry and the existing community. This can be facilitated, for example, by encouraging prospective quarry operators to adopt a policy of favouring the procurement of materials, equipment and services from local suppliers and distributors or giving better rates to local buyers. In addition, the economic and social development of a local area affected by quarrying activities has sometimes been enhanced through seed funding donated by the operator, which is administered by the local authority, but made available to the community for projects.

HMT also introduced an aggregates levy[7] in 2002 that was aimed at reducing the environmental externality costs associated with quarrying aggregate material. Part of the revenue was used to reduce National Insurance contributions to promote employment and some was used in a Sustainability Fund for local projects.

Current proposals from both government and operators appear to be following a similar approach. Under the commitments of the UK Onshore Operators' Group (2013), shale gas exploration could provide a community contribution of £100,000 per hydraulically fractured site as an initial benefit, equivalent to total UK payments of between £3 and £12 million. Meanwhile, the government recently announced that English councils which give the go-ahead to shale gas developments will be allowed to keep 100 per cent of the business rates they collect from consented sites. This is estimated to be worth up to £1.7m a year for a typical site.

Although many rural communities may therefore gain in the short-term from the expansion of shale gas activity it is also important to consider the longer-term effect as companies exit the market. This will have implications for the potential benefits, costs, job creation and longer term economic development prospects for rural communities where shale gas drilling is taking place.

[6] http://www.bgs.ac.uk/planning4minerals/Economics_14.htm

[7] *www.parliament.uk/briefing-papers/SN01196.pdf*

Section 5: Recommendations

Some specific recommendations from the Royal Society report that are relevant in the context of protecting rural communities from the impact of shale gas expansion include:

i. An Environmental Risk Assessment (ERA) should be mandatory for all shale gas operations. Risks should be assessed across the entire lifecycle of shale gas extraction, including risks associated with the disposal of wastes and abandonment of wells. Seismic risks should also feature as part of the ERA.

ii. Water requirements can be managed through integrated operational practices, such as recycling and reusing wastewaters where possible. Options for disposing of wastes should be planned from the outset.

iii. Shale gas extraction in the UK is presently at a very small scale, involving only exploratory activities. Uncertainties can be addressed through robust monitoring systems. There is greater uncertainty about the scale of production activities should a future shale gas industry develop nationwide. Attention must be paid to the way in which risks scale up. Co-ordination of the numerous bodies with regulatory responsibilities for shale gas extraction must be maintained. Regulatory capacity may need to be increased.

iv. Risk assessments should be submitted to the regulators for scrutiny and then enforced through monitoring activities and inspections. It is mandatory for operators to report well failures, as well as other accidents and incidents to the UK's regulators. Mechanisms should be put in place so that reports can also be shared between operators to promote best practices across the industry.

Other recommendations could also include:

v. Ensuring that adequate provision of local infrastructure and maintenance are included within the plans for expanding shale gas drilling operations. This would ensure that roads are protected from the impact of heavy vehicles and water infrastructure has the capacity to deal with increased demand.

vi. Encouraging operators to offer employment and training opportunities to residents living in rural communities both direct and indirect via supply chain contracts so that they benefit from the increase in economic activity.

vii. Planning for the longer-term when operations are scaled back and site mediation to ensure that tourism and other local business activities have opportunities to benefit.

viii. Routine monitoring and evaluation of the impacts of shale gas drilling to ensure that negative externalities (noise, congestion, air quality etc) are kept within acceptable limits.

ix. Annex: Shale Gas reference sources

Report	What it covers	Web link
House of Commons Parliamentary report on Shale Gas and fracking.	Overview of shale gas and energy markets. Regulatory regime and environmental considerations.	http://www.parliament.uk/Templates/BriefingPapers/Pages/BPPdfDownload.aspx?bp-id=sn06073
How much shale gas do we have?	Report describes the location, depth and properties of the shale as well as the processes that lead to economic accumulations of gas.	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/226874/BGS_DECC_BowlandShaleGasReport_MAIN_REPORT.pdf
Health policy issues related to shale gas extraction	Number of articles with literature reviews, which include: The Economic Impact of Shale Gas Development on State and Local Economies: Benefits, Costs and Uncertainties	http://www.prendergastlibrary.org/wp-content/uploads/2013/03/New-Solutions-23-1-Binder.pdf
The Economic Consequences of Shale Gas Extraction: Key Issues	The Economic Impact of Marcellus Shale Gas Drilling: What Have We Learned? What are the Limitations? Explains boom and bust impacts. Also impact on tourism and environment	http://www.greenchoices.cornell.edu/downloads/development/shale/Economic_Consequences.pdf
Economic appraisal of shale gas plays in Continental Europe	This study evaluates the economic feasibility of five emergent shale gas plays on the European Continent. Well productivity estimates will become better constrained over time as geological uncertainty is reduced and as technology improves during the progressive development of the shale gas fields	http://www.alboran.com/files/2013/07/SR-7.pdf
IOD report on Shale Gas	Examines the economic and environmental benefits of shale gas production	http://www.iod.com/influencing/policy-papers/infrastructure/infrastructure-for-business-getting-shale-gas-working
Journal of Environmental and Occupational Health Policy – papers on shale gas impact	The Economic Impact of Shale Gas Development on State and Local Economies: Benefits, Costs and Uncertainties Jannette M. Barth	http://www.prendergastlibrary.org/wp-content/uploads/2013/03/New-Solutions-23-1-Binder.pdf
The Economic Consequences of Marcellus Shale Gas Extraction: Key Issues	Examines the Boom-Bust Cycle of Shale Gas Extraction Economies and impact on communities around Marcellus Shale (New York and Pennsylvania)	http://www.greenchoices.cornell.edu/downloads/development/shale/Economic_Consequences.pdf
The economic benefits of shale gas extraction in the southern Karoo, South Africa	Findings on the estimated economic impact of shale gas extraction based on the application of an economy-wide impact modelling methodology.	http://www.essa2013.org.za/fullpaper/essa2013_2484.pdf

Oxford Energy Institute report on shale gas	Examines viability of shale gas exploration in UK and some commentary	http://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/07/UK-Shale-Gas-GPC1.pdf
Institution of Gas engineers and managers, The time for shale gas is now	Overview of shale gas market and how to mitigate risks	https://www.igem.org.uk/media/312796/Shale%20Gas%20-%20the%20time%20is%20now.pdf
Impacts of unconventional gas development on rural community decline in Australia	Australian study looking at the impacts of unconventional gas, on rural decline. Rural decline is defined as comprising loss of rural youth, reduced human capital and increasing rural poverty. The results show signs of mitigating (and in some cases reversing) rural community decline.	http://www.gisera.org.au/publications/tech_reports_papers/socioeco-proj-1-rural-decline-workingpaper.pdf
Saltire projects: UK Shale Gas Development: Legal, Economic, Environmental and Political Challenges posed to the ambitious UK Shale Gas Plan	The objective of this report is to investigate the benefits that shale gas development could bring to the UK's economy drawing on the U.S paradigm. It also aims at examining the potential challenges that are likely to obstruct the advancement of shale gas and the controversies associated with shale gas activities (horizontal drilling and hydraulic fracturing or "fracking"	http://www.saltireprojects.co.uk/perch/resources/the-development-of-shale-gas-in-the-uk-2.pdf
Economic implications of unconventional gas. Report from Ohio rural development organisation	Examines short- and long term impacts of energy development. These often include increased employment, though the largest impact appears to be on local incomes of select groups. An accurate estimate of the short and long term economic impacts of shale development is essential for a community to manage its economic future. In particular, communities should take steps to mitigate the long-term effects associated with the resource curse and ensure they benefit from energy development in the long term.	http://www.nardep.info/uploads/Brief15_EconomicsFossilFuel.pdf
Cuadrilla report by Regneris consultants: Economic Impact of Shale Gas Exploration & Production in Lancashire and the UK	Regeneris Consulting were appointed by Cuadrilla to quantify the economic impact of both the current exploration phase and the likely economic impact of a subsequent and far more extensive phase of commercial extraction. This modelled the impact for both the county of Lancashire and the UK as a whole.	http://www.cuadrillaresources.com/wp-content/uploads/2012/02/Full_Report_Economic_Impact_of_Shale_Gas_14_Sept.pdf
AEA Ricardo report: Unconventional Gas in England	Description of infrastructure and future scenarios	Pending

Other sources of information

Type of source	Type of information	Web link
Planning portal	Shale gas development incentives announced	http://www.planningportal.gov.uk/general/news/stories/2014/Jan14/160114/160114_1
Gov.uk	The Prime Minister will announce that councils can keep 100 per cent of business rates they collect from shale gas sites – double the current 50 per cent figure.	https://www.gov.uk/government/news/local-councils-to-receive-millions-in-business-rates-from-shale-gas-developments
BGS	The British Geological Survey (BGS) in association with DECC has completed an estimate for the resource (gas-in-place) of shale gas in part of central Britain in an area between Wrexham and Blackpool in the west, and Nottingham and Scarborough in the east.	https://www.bgs.ac.uk/research/energy/shaleGas/home.html#ad-image-0
Daily Telegraph	Government accused of 'overhyping' shale gas benefits	http://www.telegraph.co.uk/earth/energy/10580255/Government-accused-of-overhyping-shale-gas-benefits.html
EurActiv	The EU's competition commissioner, Joaquín Almunia, has said that Brussels will investigate the UK's plans for incentivising shale gas production "if needed", as more lawmakers and NGOs call for an EU state aid probe to be launched.	http://www.euractiv.com/energy/state-aid-row-engulfs-uk-shale-g-news-532827?utm_source=EurActiv%20Newsletter&utm_campaign=a4ad7efc47-newsletter_daily_update&utm_medium=email&utm_term=0_bab5f0ea4e-a4ad7efc47-245766509
Gov.uk	The government has published a regulatory roadmap for shale oil and gas developers along with a Strategic Environmental Assessment report for consultation.	https://www.gov.uk/government/news/next-steps-for-shale-gas-production
AMEC	Understanding the potential impacts of shale gas fracking on the UK water industry commissioned by UKWIR (due March 2014)	http://www.amec.com/aboutus/projects/water/shale-gas-fracking.htm
CPRE	CPRE Policy Guidance Note on Shale Gas	http://www.cpresussex.org.uk/campaigns/fracking/item/download/650
Energy Matters	Facts about true cost of shale gas from US	http://euanmearns.com/what-is-the-real-cost-of-shale-gas/
UK onshore operators group	Community Engagement Charter Oil and Gas from Unconventional Reservoirs	http://www.ukoog.org.uk/elements/pdfs/communityengagementcharterversion6.pdf
INSEAD blog	Europe's shale gas competitiveness challenge and consequences for the petrochemical sector	http://knowledge.insead.edu/blog/insead-blog/europes-shale-gas-competitiveness-challenge-and-consequences-for-the-petrochemical-sector-2655

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