Economic Impact Assessment and scenario development of unconventional oil and gas in Scotland

A report for the Scottish Government

October 2016

kpmg.com/uk

Important notice

This report ("Report") has been prepared by KPMG LLP in accordance with specific terms of reference agreed between the Scottish Government ("Scottish Government" or "the addressee") and KPMG LLP. The Report should not therefore be regarded as suitable to be used or relied on by any other person or for any other purpose. The Report is issued to all parties on the basis that it is for information only. Should any party choose to rely on the Report they do so at their own risk. KPMG LLP will accordingly accept no responsibility or liability in respect of the Report to any party other than the Addressee.

We have indicated within this Report the sources of the information provided. We have not sought to verify independently those sources unless otherwise stated within the Report.

This Report has been prepared from publicly available documentation, such as Internet sources, published accounts, input from stakeholders, etc. All the documents which have been relied upon in preparing this Report are referenced in this Report.

The work and analysis for this Report were performed before the result of the UK's referendum on continued membership of the EU and that 'Brex-it' and Scotland's role in the EU creates significant economic uncertainty which is likely to impact our findings.

Common abbreviations

AUD	Australian Dollar
Bbl	Barrel
Bcf	Billion cubic feet
Bcm	Billion cubic metres
BGS	British Geological Survey
CBM	Coal bed methane
CCC	Committee on Climate Change
CO_2	Carbon dioxide
DECC	Department of Energy and Climate Change (incorporated into newly formed Department for Business, Energy & Industrial Strategy in July 2016)
GDP	Gross Domestic Product
GHG	Greenhouse gas
GSP	Gross State Product
GVA	Gross Value Added
IoD	Institute of Directors
LNG	Liquified natural gas
LPG	Liquified petroleum gas
m^3	Cubic metre
MMBOE	Millions of barrel of oil equivalent
MMbbl	Millions of barrels
NGLs	Natural gas liquids
ONS	Office for National Statistics
p/therm	Pence per therm
PHIA	Public Health Impact Assessment
SIMD	Scottish Index of Multiple Deprivation
Tcf	Trillion cubic feet
Tcm	Trillion cubic metres
UKCS	UK Continental Shelf
UKOOG	United Kingdom Onshore Oil and Gas
UOG	Unconventional Oil and Gas
USD	US Dollar

Definitions

Associated gas	Natural gas produced with crude oil from the same reservoir.
Barrel	A unit of volume measurement used for oil and its products.
Capex	Capital expenditure.
Casing	Metal pipe inserted into a wellbore and cemented in place to protect subsurface formations.
Completion	The installation of permanent downhole and wellhead equipment for the production of oil and gas.
Condensate	Hydrocarbons which are in the gaseous state under reservoir conditions and which become liquid when temperature or pressure is reduced.
Direct impacts	The measure of the total amount of additional expenditure within a defined geographical area, which can be directly attributed to the development of an industry.
Dry gas	Natural gas composed mainly of methane with only minor amounts of ethane, propane and butane and little or no heavier hydrocarbons in the gasoline range.
Exploration well	Drilling carried out to determine whether hydrocarbons are present in a particular area or structure.
Field	A geographical area under which an oil or gas reservoir lies.
Fracturing	A method of breaking down a formation by pumping fluid and solids/proppant at very high pressure. The objective is to increase production rates.
Gas field	A field containing natural gas but no oil.
Gas in place	An estimated measure of the total amount of gas contained in a reservoir, and, as such, a higher figure than the estimated recoverable reserves and resources of gas.
Gas-to-Liquids (GTL)	The conversion of natural gas to a liquid form so that it can be transported easily. Typically, the liquid is converted back to natural gas prior to consumption.

Definitions

Hydrocarbon	A compound containing the elements hydrogen and carbon. May exist as a solid, a liquid or a gas. The term is mainly used in a catch-all sense for oil, gas and condensate.
Indirect impacts	The inter-industry purchases as they respond to new demands from directly affected industries. Sometimes referred to as supply chain linkage effects.
Induced impacts	This is where employment or other economic benefits emerge in other sectors of the economy resulting from changes in the sector of the economy being considered.
Injection well	A well used for pumping water or gas into the reservoir.
Input-Output table	A table prepared by macroeconomists showing the sale and purchase relationships between producers and consumers in different sectors of an economy. The tables can either show flows of final and intermediate goods and services defined according to industry outputs (industry × industry tables) or according to product outputs (product × product tables).
Lateral	Deviated wells used in the extraction process of unconventional oil and gas.
Liquified Natural Gas (LNG)	Gas, chiefly methane, liquefied for transportation.
Liquified Petroleum Gas (LPG)	Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport and handling. Commercial liquefied gas consists essentially of either propane or butane, or mixtures thereof.
Mother bore	The main vertical hole drilled in the earth created when drilling a well – also known as borehole. A 'mother' bore can have multiple laterals wells. This study assumes there is only one lateral well associated with each mother bore, i.e. single lateral wells.
Natural gas liquids	The portions of gas from a reservoir that are liquified at the surface in separators, field facilities, or gas processing plants.
Non-associated gas	Natural gas produced from a reservoir that does not contain significant quantities of crude oil.
Oil	A mixture of liquid hydrocarbons of different molecular weights.
Oil field	A geographic area under which an oil reservoir lies.
Oil in place	An estimated measure of the total amount of oil contained in a reservoir, and, as such, a higher figure than the estimated recoverable reserves and resources of oil.

Operator	The company that has legal authority to drill wells and undertake production of hydrocarbons. The operator is often part of a joint venture and acts on behalf of this joint venture.
Opex	Operating expenditure.
Pad	Onshore development and production platform/area which can have multiple wells associated with it. A production phase of one well pad requires 2 hectares.
Petroleum	A generic name for hydrocarbons, including crude oil, natural gas liquids, natural gas and their products.
Proven field	An oil and/or gas field whose physical extent and estimated reserves have been determined.
Proppant	A solid material, typically sand, treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment.
Proven reserves	An estimated quantity of all hydrocarbons statistically defined as crude oil or natural gas, which geological and engineering data demonstrate an estimated probability to be recoverable in future years from known reservoirs under existing economic and operating conditions.
Recoverable reserves	That proportion of the oil and gas in a reservoir that can be commercially produced using currently available techniques.
Reservoir	The underground formation where oil and gas has accumulated. It consists of a porous rock to hold the oil or gas, and a cap rock that prevents its escape.
Unconventional oil and gas	The term 'unconventional' in UOG refers to the types of geology in which the oil and natural gas are found. For the purpose of this study, UOG includes shale gas, associated liquids and coal bed methane.
Wellhead	The equipment at the surface of a well used to control the pressure; the point at which the hydrocarbons and water exit the ground.
Wet gas	Natural gas containing significant amounts of liquifiable hydrocarbons.
Workover	Operations on a producing well to restore or increase production. A workover maybe performed to stimulate the well, remove sand or wax from the wellbore, to mechanically repair the well, or for other reasons.

Contents

1

Executive summary

1.1 Background

The development of unconventional oil and gas (UOG) – shale gas, associated liquids and Coal Bed Methane (CBM) – has been gathering pace in a number of countries around the world in recent years, including the USA, Australia and Poland. The exploitation of UOG resources has been associated with economic benefits in the USA. However, the potential environmental impacts of some of the processes used to recover UOG resources are controversial.

In the UK, a number of sites have been identified which have geological characteristics that indicate potential sources of unconventional of oil and gas. These sites include the Midland Valley of Scotland which lies between the Highland Boundary Fault and the Southern Upland Fault and the Bowland Shale area and Hodder and Weald basins (in England). The British Geological Survey (BGS) has estimated that the range of shale gas resources in place in Scotland could be between 49.4 trillion cubic feet (tcf) and 134.6 tcf with a central estimate being 80.3 tcf (British Geological Survey, 2014). The range of estimates for shale oil resources in place by BGS is between 3.2 and 11.2 billion barrels (bnbbl) with the central estimate for resource being 6.0 bnbbl.

The most recent report on UOG in Scotland is the 'Report on Unconventional Oil and Gas' by the Independent Expert Scientific Panel (2014) on behalf of the Scottish Government. The Independent Expert Scientific Panel study assessed the scientific evidence relating to UOG and included summaries of the geological and seismic evidence. It also considers at length the regulatory requirements for the development of the UOG sector in Scotland as well as the technical, environmental and societal challenges associated with the development of UOG. The Independent Expert Scientific Panel conclude that there could be potential for positive economic impacts in terms of jobs created, taxes paid and gross value added from developing the UOG sector in Scotland. The report also identifies that there are environmental or societal impacts such as concerns around water contamination, public health, seismicity, climate impacts and wider social impacts that will need to be carefully considered, and recommends that communities are consulted regarding those impacts.

Some UOG-related exploration activity has taken place in England, for example Cuadrilla Resources' exploration activities in Lancashire. In Scotland, while two licences for areas in the Midland Valley have been granted, a moratorium on giving planning consents for UOG development was put in place in January 2015 while full consideration was given to the impacts of UOG exploitation.

To support the Scottish Government's assessment of the benefits and challenges of UOG development, a number of research projects were commissioned by the Scottish Government including:

- Understanding and monitoring induced seismic activity;
- Decommissioning, site restoration and aftercare – Obligations and treatment of financial liabilities;
- Understanding and mitigating community level impacts on transport;
- Economic impacts and scenario development;
- Climate change impacts; and
- Separately, a Public Health Impact Assessment (PHIA) of UOG development is also being evaluated.

This KPMG Report presents the findings of the economic impact assessment and scenarios development. Reports regarding the other matters listed above were prepared by other parties retained by the Scottish Government.

1.2 The scope of this Report

This Report is an independent KPMG assessment of the potential economic impacts of the development of UOG resources in Scotland. Our independent view has been based on a range of sources including: stakeholder input gathered during stakeholder workshops run as part of this research project (see Appendix D.1 for details of stakeholders that participated in the workshops) and their written input submissions to us, publicly available information and our analysis of that information. The scope of work that this Report covers is:

- Identification of the potential aggregate impact of UOG development on the Scottish economy under a range of scenarios;
- Consideration of the specific impacts of the development of UOG in Scotland and, in particular, the key sectors and groups likely to be affected; and
- Consideration of the potential nature and extent of any community benefit payments.

For the purposes of this study, UOG activities are limited to shale gas with liquids being developed as an associated product using hydraulic fracturing and Coal Bed Methane

(CBM) developments. KPMG understands that Underground Coal Gasification is subject to a separate review process and is not within the scope of this study.

Given this scope of work we have used the following approach:

- **Defined the economic impacts** of UOG development in Scotland to be evaluated as part of the study;
- **Prepared a range of scenarios,** in consultation with stakeholders, for the nature and timing of potential development of UOG in Scotland and for how that development may impact business and the Scottish economy;
- **Evaluated how the potential development of UOG may impact other parts of the Scottish economy.** To do this we use the concept of Gross Value Added (GVA) which shows the economic contribution to the economy of a sector or industry. We considered direct, indirect and induced impacts. These effects are often described as 'trickle down' or multiplier effects. We consider two multiplier effects:
  - **Indirect effects** generated in the UOG supply chain; and
  - **Induced effects** arising from the spending of those employed by the UOG industry and its supply chain.

  We evaluate these multipliers using an analysis of the Input-Output tables prepared by the Scottish Government[1]. The Input-Output tables demonstrate the impact one sector of the economy (in this case, UOG) has on other sectors. In the case of UOG, these impacts may be demand for materials and products from other sectors in the Scottish economy or by supplying a local source of fuel or feedstock to other sectors of the economy.
- **Assess impacts on employment and GVA in Scotland**;
- **Consider impacts on taxation receipts** in the UK.

We also include a qualitative assessment of some other factors to be considered as part of the economic impact assessment that do not lend themselves to direct quantification, specifically:

- The potential benefits of the use of indigenously produced gas as a feedstock for the Scottish petrochemicals industry. The development of UOG could generate a positive effect on the petrochemical industry and its supply chain if the Scottish UOG sector were able to provide feedstock to existing manufacturing plants (Chemical Industries Association, 2012).
- Other impacts, which are beyond the scope of formal quantification for this research project, such as the impact on house prices in UOG development areas, impacts on the environment, agriculture and the development of renewable energy.

The Scottish Government has asked us to comment on the petrochemical industry and other impacts, which we discuss in Section 5 of this Report.

1.3 Important to note

There are five key points associated with the evaluation of any benefit of UOG development that will need to be considered before any decisions regarding UOG development are made.

1) If oil and gas prices were to remain at historically low levels, it would be unlikely that UOG resources in Scotland could be developed economically. A low gas price environment for an extended period of time would mean that development of the UOG resources would be unattractive and therefore the economic benefits that could arise from UOG development identified in this report would not materialise. The estimated cost of UOG gas in the Central scenario in this report is approximately 45p/therm, the average of the Department of Energy and Climate Change (DECC)[2] projected gas prices in their low scenario for the forecast period is 43p/therm demonstrating the current economic challenge for developing UOG resources in Scotland. Commodity prices are volatile and sensitive to factors such as supply and demand, economic growth and geopolitical events and any final investment decisions in UOG development will need to consider appropriate price forecasts at the time of the decision.

2) Further exploration work is required to identify, with more accuracy, the UOG resources that are in place and the production potential of the Midland Valley in Scotland. The results of the exploration activity will determine the feasibility of successful commercial development of the UOG resources. Following exploration it is viable that commercial development is not possible in which case the cost of exploration (estimated to be £240m) would have been incurred, however the economic benefits of UOG development identified in this report would not arise.

Footnotes:
1. http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output. The most recent tables were published by the Scottish Government in 2012.
2. Throughout this report, we refer to DECC projections. It should be noted that DECC has now been absorbed into the new Department for Business, Energy and Industrial Strategy (BEIS).

3) The external costs and impacts of developing UOG such as environmental and societal impacts and impact on visual amenity are not quantified but are discussed qualitatively in Section 5.

4) Development of UOG in Scotland will also rely on an ability to obtain appropriate funding (debt and/or equity) to support exploration and extraction.

5) There is considerable uncertainty regarding trends in Scottish, UK and global energy markets and prices that are difficult to predict. Although the cost data used is the latest available, it is over two years old. This increases the level of uncertainty surrounding any conclusions we are able to draw from our analysis and should be factored into the readers' own interpretation of our findings. The uncertainty of assumptions made is also compounded by the fact that we have sought to assess the development of the UOG sector in Scotland to 2062[3], a long time period over which much may change. All of these factors would impact the conclusions presented here. The level of uncertainty is why we have considered a range of development scenarios in this Report, as described below.

1.4 Industry development scenarios

Previous research undertaken by BGS has clearly demonstrated the considerable uncertainties regarding the UOG resources that could be developed in Scotland due to the complex geology, meaning that reserves and recovery estimations are not currently possible without further drilling and testing[4]. To address this uncertainty we have developed a number of industry development scenarios, covering aspects such as:

- Resource development stages (number of pads developed and the number of wells per pad);
- Volumes of shale gas and associated liquids that are produced;
- Costs for development. The costs for development and production are based on publicly sourced data from previous studies prepared by the Institute of Directors (2013) and EY (2014). These are the latest publicly available data for UK costs and may not reflect the most up-to-date understanding of costs;
- Planning and resource development timescales;
- The share of UOG development and products spend that is in the Scottish economy; and
- Decommissioning strategies and associated costs.

Following workshops with stakeholders, UKOOG provided us with some of their members' views on UOG development in Scotland. The scenarios developed for the purposes of this study are therefore based on UKOOG's submission as well as wider information gathered from stakeholders and through the literature review – this includes the IoD report on shale gas (2013) and the EY report on shale gas and its supply chain (2014). KPMG discussed the scenarios with UKOOG and took on board their comments. As a result, the scenarios reflect a range of outcomes in the development of UOG in Scotland. We would like to thank UKOOG for their input into the development of UOG scenarios. Three production scenarios in which exploration is successful were assessed[5]:

- Central scenario – based on midpoint estimates of potential production;
- High scenario – in which significant development occurs for the next decade or so; and
- Low scenario – in which development is initially slow and does not grow significantly, for example there is a low level of production. This scenario was developed based on a suggestion from stakeholders of Scottish Environment LINK and Friends of the Earth Scotland. This does not imply any endorsement of the scenario by these stakeholders.

We also consider a scenario in which development does not take place following some exploration activity either because UOG resources prove not to be as expected or because commercial development is not feasible. In this scenario, the economic benefits identified in this analysis would not arise and operators involved in exploration would incur a loss.

It is unlikely these scenarios will cover all possible outcomes however, it is possible that detailed assessments of the UOG resource potential for Scotland reveals that the resources are not viable for economic production. A final assessment of which production scenario is most likely would depend upon detailed exploration work.

Table 1.1 presents a summary of the key parameters for each development scenario.

The cumulative costs for the three production scenarios are shown in Figure 1.3 and set out in more detail in Appendix C.

According to our estimates, the UOG industry could represent, on average, 0.1% of Scottish GDP (2015) in our Central scenario and 0.3% in our High scenario which is not a large contribution to the Scottish economy.

Footnotes:
3. We have taken a long-term view in this study to evaluate the full economic lifecycle of the industry and to consider decommissioning and after care costs.
4. The BGS articulate some of the uncertainties regarding resource levels: "The relatively complex geology and relatively limited amount of good quality constraining seismic and well data result in a higher degree of uncertainty to the Midland Valley of Scotland shale gas and shale oil resource estimation than the previous Bowland-Hodder and Weald Basin studies... Reserve and recovery estimation is not possible at this stage; in order to estimate the shale gas and oil reserves, drilling and testing of new wells will be required." (See BGS.ac.uk.)
5. The low scenario also draws on input/suggestions received from Scottish Environment LINK and Friends of the Earth Scotland. This does not imply any endorsement of the scenario by these stakeholders.

Table 1.1 The scenarios we have considered: key parameters.

	Product		Units	Central	High	Low
What could be produced	Shale gas	Cumulative output by 2062	bcf	947	2,934	316
		Lifetime production per pad	bcf	47.3	94.7	31.6
	Associated liquids	Cumulative output by 2062	MMBOE	17.8	49.7	0.5
		Lifetime production per pad	MMBOE	1.2	2.4	0.1
	CBM	Cumulative output by 2062	bcf	26.3	26.3	26.3
		Lifetime production per pad	bcf	13.1	13.1	13.1
How much would be produced (development approach)	Shale gas	Number of pads	No.	20	31	10
		Wells per pad	No.	15	30	10
		Production life of a well	Years	15	15	15
	Associated liquids	Number of shale gas pads also producing associated liquids	No.	15	23	8
		Wells per pad	No.	15	30	10
		Production life of a well	Years	15	15	15
	CBM	Number of pads	No.	2	2	2
		Wells per pad	No.	15	15	15
		Production life of a well	Years	12	12	12
How much would it cost	Shale gas and associated liquids	Capex[6]	£bn	3.0	7.2	1.0
		Opex	£bn	1.3	3.2	0.4
		Decommissioning	£bn	0.1	0.4	0.1
		Expenditure within Scotland	£bn	2.2	6.5	0.5
	CBM	Capex[7]	£bn	0.3	0.3	0.3
		Opex	£bn	0.1	0.1	0.1
		Decommissioning	£bn	~0.0	~0.0	~0.0
		Expenditure within Scotland	£bn	0.2	0.2	0.2
Community benefits payments and taxation	Shale gas, associated liquids and CBM	Community benefit payments	% of revenue	4%	4%	4%
		Taxation assumptions		Direct taxes: corporate tax payable on taxable company profits. Income tax and National Insurance contributions on salaries.		
				Indirect VAT on purchases with supply chain. Local government: business rates charged on a per pad basis.		
Estimated FTE employment per pad	Shale gas and associated liquids	Number of FTE jobs at peak[8]	FTE	80	90	55
	CBM	Number of FTE jobs at peak[9]	FTE	-	-	-

Notes: These assumptions have been development based on input from UKOOG as well as previous studies by EY and IOD

Footnotes:
6. Including the impact of cost reduction through learning.
7. Including the impact of cost reduction through learning.
8. Including capex, opex and decommissioning jobs.
9. Including capex, opex and decommissioning jobs.

1

Executive summary

Estimated benefits should UOG development proceed in Scotland

Estimated total spend to 2062

Central: £4.4 billion
of which £2.2 billion spend in Scotland

High: £10.8 billion
of which £6.5 billion spend in Scotland

Low: £1.5 billion
of which £0.5 billion spend in Scotland

Additional total tax receipts across UK to 2062

Central: £1.4 billion

High: £3.9 billion

Low: £0.5 billion

Estimated total Scottish GVA to 2062

Central: £1.2 billion

High: £4.6 billion

Low: £0.1 billion

Cost of exploration if no UOG development takes place Central Case: (£240m)

Estimated peak Scottish employment

Central: 1,400 jobs

High: 3,100 jobs

Low: 470 jobs

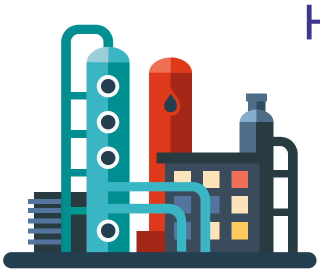
Total production to 2062, should development occur

Shale gas

Central: 950 bcf

High: 2,930 bcf

Low: 320 bcf

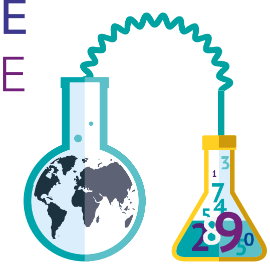


Associated liquids

Central: 18 MMBOE

High: 50 MMBOE

Low: 0.5 MMBOE



Notes: The results presented here exclude CBM development.
Estimated peak employment relate to spend in Scotland. These roles may not necessarily be taken by Scottish citizens.

Figure 1.1 Shale gas total cumulative output.

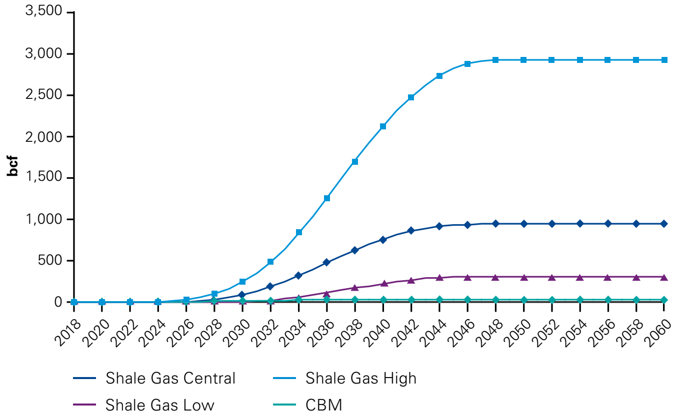


Figure 1.2 Associated liquids total cumulative output.

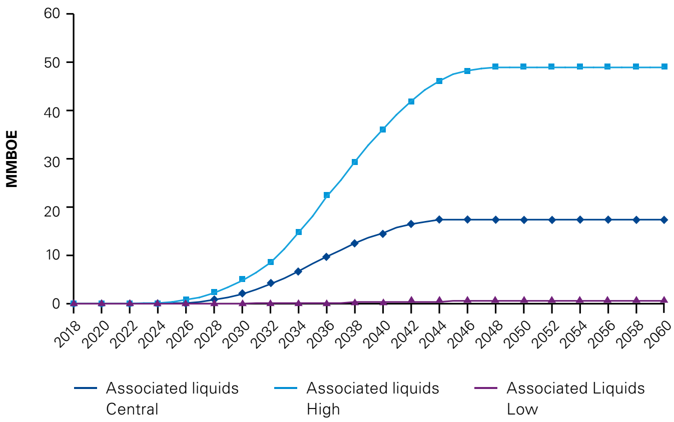
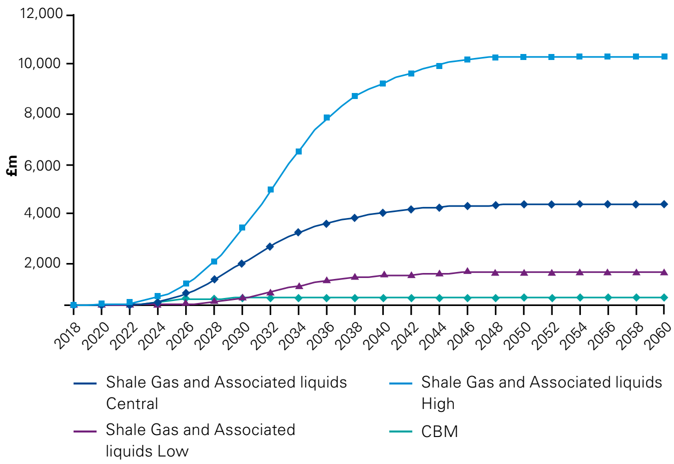


Figure 1.3 Shale gas and associated liquids total cumulative cost.



Total annual gas consumption in Scotland (2014) is estimated at 164 bcf/year[10] (The Scottish Government, 2015)[11]. With a total production of 947 bcf of gas in our Central scenario, this represents about 5.5 years of Scottish consumption. In our High scenario (2,934 bcf) this represents about 18 years of Scottish consumption.

Figure 1.1 shows that total cumulative output for gas is 947 bcf in year 2048 in the Central scenario, while it reaches, 2,934 bcf in year 2049 in the High scenario and 316 bcf in year 2047 in the Low scenario. The different peak year in the different scenarios reflects the planning and pad development timescales we have assumed. CBM reaches maximum production of 26 bcf in year 2035. Similarly, Figure 1.2 shows that total cumulative output for associated liquids is 17.8 MMBOE in year 2044 in the Central scenario, while it reaches 49.7 MMBOE in year 2048 in the High scenario and 0.5 MMBOE in year 2048 in the Low scenario.

Figure 1.3 shows that total cumulative costs are £4.4 billion in the Central scenario, £10.8 billion in the High scenario, £1.5 billion in the Low scenario and £0.4 billion for CBM in 2048.

Footnotes:
10. Converted from GWh to bcf.
11. We assume that demand for gas remains the same over the studied period, i.e. total intermediate consumption in Scotland remains unchanged.

1.5 Assessment of the economic impact on Scotland

The analysis we have undertaken demonstrates some economic benefits for the Scottish economy from UOG development if the development of the industry is in line with our Central or High scenarios. The Low scenario also demonstrates some economic benefits but to a much lower extent. The results[12] of our analysis are summarised in Table 1.2 below.

Table 1.2 Estimated cumulative economic impact from UOG development scenarios in Scotland to 2062[13].

	Central	High	Low
Total spend (£bn)	4.4	10.8	1.5
Spend in Scotland (£bn)[14]	2.2	6.5	0.5
Total additional economic impact of UOG spend in Scotland (£bn)	1.2	4.6	0.1
Additional jobs created (at peak)	1,400	3,100	470
Additional tax receipts (in UK)[15] (£bn)	1.4	3.9	0.5
Community benefits payments (£m)	217	663	63

In our Central scenario, the direct expenditure of £2.2 billion on the development of UOG to 2062 in Scotland could give supply chain benefits and other induced economic benefits of an additional £1.2bn (direct, indirect and induced) and be responsible for the creation of c1,400 jobs (at peak) in the Scottish economy, including jobs in construction, water transport, financial services, repair and maintenance, legal activities, architectural services, etc. It should be noted however that, in the Central case, £1.2bn of benefit over the life of UOG development and production equates to c£30m pa.

In effect, in the Central case, for £1 invested in the Scottish UOG sector a further 60 pence of economic benefit is secured for the economy. These benefits are increased in the High scenario in which the industry develops to a far greater degree. These benefits could be further increased if CBM could be profitably developed.

These potential benefits should be assessed in the context of a cumulative exploration spend of £240m in the Central case which could be at risk if there is no scope for economic production of UOG in Scotland or if further exploration activity demonstrates that resources are not sufficient to justify further development (i.e. operators involved in exploration would incur a loss).

1.6 Links to other Scottish Government UOG research projects

The economic impact assessment also links to some of the other work being performed as part of the programme of research being undertaken on behalf of the Scottish Government regarding UOG. Specifically:

- We have provided details of the production scenarios to the Committee on Climate Change to support its analysis of climate change impacts;
- We have provided the production and decommissioning scenarios to AECOM Ltd (the supplier appointed by the Scottish Government for the decommissioning study), to support its analysis of decommissioning, site restoration and aftercare.

1.7 Acknowledgment

As part of our preparations for this research project, we sought input from key stakeholders recommended by the Scottish Government in the development of UOG in Scotland including UKOOG (the body representing the UK onshore oil and gas industry), Friends of the Earth Scotland, Scottish Environment LINK, the Broad Alliance and COSLA. We would like to thank those stakeholders that provided input into the preparation of this study.

Footnotes:
12. On an undiscounted basis.
13. This table excludes the benefits/ disbenefits of CBM. Our analysis demonstrates that in the current context (current price of gas, cost of development, estimated well recovery rates, etc.) the development of CBM may not be economic and may therefore not materialise. As such, we have not included FTE jobs for CBM. For a summary of the analysis on CBM, please see Section 5 (Table 5.1).
14. The difference between total spend and spend in Scotland is expenditure outside Scottish borders on equipment and other requirement of UOG development.Based on total UOG spend.
15. Based on total UOG spend.

2

Introduction

2.1 Context and scope

The development of UOG has become increasingly prominent in a number of countries in the last decade. This has resulted in more focus being placed on the potential to exploit unconventional energy sources around the world.

In the UK, several companies are seeking permission to use hydraulic fracturing as an approach to recovery of resources. A large share of Scotland's UOG resource is thought to be located in the Midland Valley. Currently Scotland has a moratorium in place on granting of planning consents for the development of all UOG extraction. The moratorium is in place while the Scottish Government undertakes research and public consultation to increase understanding of the impacts for UOG development. The research will feed into a public consultation by the Scottish Government.

The Scottish Government commissioned, on behalf of the Scottish Ministers, a set of studies covering:

- Understanding and monitoring induced seismic activity;
- Decommissioning, site restoration and aftercare – Obligations and treatment of financial liabilities;
- Understanding and mitigating community level impacts of transport;
- Economic impacts and scenario development;
- Climate change impacts; and
- Separately a Public Health Impact Assessment (PHIA) of UOG development are also being undertaken.

The objective of this study is to perform an economic impact assessment of the potential development of UOG in Scotland. Our research has demonstrated that there is considerable uncertainty around the potential for development of UOG in Scotland, in particular the productivity and size of the available resources (the complex geology of the Midland Valley and the unproven nature of any UOG resources in the area mean there is considerable uncertainty as to the viability of the industry) that could be economically extracted, the associated costs of development, availability of specialist teams to develop UOG and trends in the UK and international gas markets. As a result, the economic impact assessment presented in this Report is based on a number of scenarios for UOG industry development[16].

The scope of work that this Report covers is:

- Identification of the potential aggregate impact of UOG development under a range of scenarios on the Scottish economy;
- Consideration of the specific impacts of the development of UOG in Scotland and in particular identify the key sectors and groups likely to be affected; and
- Consideration of the potential nature and extent of any community benefit payments.

For the purposes of this study, UOG activities focus on shale gas associated liquids development using hydraulic fracturing and coal bed methane (CBM) developments. KPMG understands that Underground Coal Gasification is subject to a separate review process and is therefore not within the scope of this study.

2.2 What is UOG?

2.2.1 UOG defined

The term 'unconventional' in UOG refers to the types of geology in which the oil and natural gas are found. For the purpose of this study, UOG includes shale gas, associated liquids and coal bed methane.

Shale gas is natural gas coming from unconventional sources, i.e. it is found within organic-rich shale beds, which are layers of low permeability rock rather than a conventional 'reservoir' capped by shale or other beds (White, Fell, & Smith, 2016). Similarly, shale oil is oil obtained from bituminous shale, while coal bed methane is a form of natural gas extracted from coal seams.

2.2.2 What are NGLs?

Natural gas can be characterised as dry gas or wet gas. Dry gas is natural gas composed mainly of methane with only minor amounts of ethane, propane and butane and little or no heavier hydrocarbons in the gasoline range. In contrast, wet gas is natural gas containing significant amounts of liquifiable hydrocarbons.

Natural gas liquids (NGLs) are the portions of gas from a reservoir that are liquified at the surface in separators, field facilities, or gas processing plants (Oil and Gas UK, n.d.[17]). A number of different gases are considered as NGLs

Footnotes:
16. The impacts estimated in this study are gross impacts of the development of the UOG industry.
17. n.d. – no date.

Table 2.1 NGL attribute summary.

Natural Gas Liquid	Applications	End use products	Primary sectors
Ethane	Ethylene for plastics production; petrochemical feedstock	Plastic bags; plastics; anti-freeze; detergent	Industrial
Propane	Residential and commercial heating; cooking fuel; petrochemical feedstock	Home heating; small stoves and barbeques; LPG	Industrial, residential, Commercial
Butane	Petrochemical feedstock; blending with propane or gasoline	Synthetic rubber for tyres; LPG; lighter fuel	Industrial, transportation
Isobutane	Refinery feedstock; petrochemical feedstock	Alkylate for gasoline; aerosols; refrigerant	Industrial
Pentane	Natural gasoline; blowing agent for polystyrene foam	Gasoline; polystyrene; solvent	Transportation
Pentane Plus	Blending with vehicle fuel; exported for bitumen production in oil sands	Gasoline; ethanol blends; oilsands production	Transportation

Source: U.S. Energy Information Administration (2012)

and have a number of different uses. Ethane, propane, butane, isobutane, and pentane are all NGLs. Table 2.1 shows NGLs attributes, their various applications and end use products.

NGLs are used as feedstock for petrochemical plants, used for space heat and cooking, blended into vehicle fuel, etc.

Research by the British Geological Survey indicates there are both shale oil and shale gas resources in carboniferous rocks in the Midland Valley of Scotland (British Geological Survey, 2014). Table 2.2 below shows BGS's most recent assessment.

Figure 2.1 overleaf shows how UOG differs from conventional oil and gas in terms of geology and approach to development. Section 2.2.3 provides a high-level explanation of how UOG is extracted.

2.2.3 How is UOG extracted?

The development of UOG involves four phases:

– Exploration;
– Well development (including hydraulic fracturing);
– Production; and
– Site decommissioning and post production management.

In order to exploit UOG, it is necessary for an operator to obtain a licence for exploratory drilling and production. The exploration stage involves the search for rock formations (i.e. shale beds) associated with oil or natural gas deposits. This involves geophysical analysis and/or exploratory drilling to identify whether or not there is oil or gas present. A borehole is drilled into the shale surface at a specific site. A well is drilled vertically to the depth

Table 2.2 Estimates of the potential total in-place shale oil and shale gas resource in the Carboniferous Midland Valley of Scotland study area.

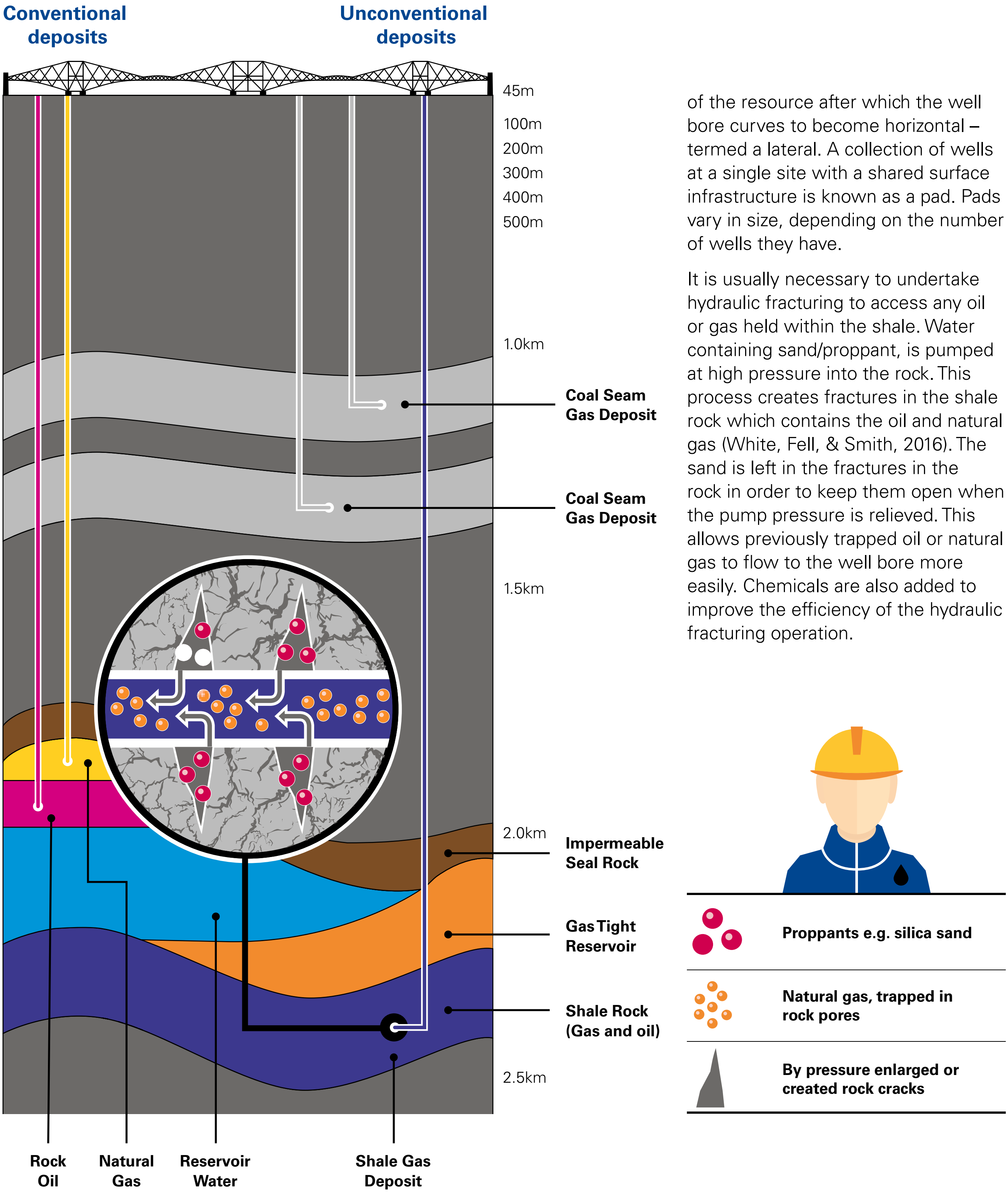
	Total potential shale gas estimates (tcf)			Total potential shale gas estimates (tcm)		
	Low	Central	High	Low	Central	High
Shale gas	49.4	80.3	134.6	1.40	2.27	3.81
	Total shale oil estimates (billion bbl)			**Total shale oil estimates (million tonnes)**		
Shale oil	3.2	6.0	11.2	421	793	1,497

Source: British Geological Survey (2014).

2

Introduction

Figure 2.1 Conventional vs unconventional deposits



of the resource after which the well bore curves to become horizontal – termed a lateral. A collection of wells at a single site with a shared surface infrastructure is known as a pad. Pads vary in size, depending on the number of wells they have.

It is usually necessary to undertake hydraulic fracturing to access any oil or gas held within the shale. Water containing sand/proppant, is pumped at high pressure into the rock. This process creates fractures in the shale rock which contains the oil and natural gas (White, Fell, & Smith, 2016). The sand is left in the fractures in the rock in order to keep them open when the pump pressure is relieved. This allows previously trapped oil or natural gas to flow to the well bore more easily. Chemicals are also added to improve the efficiency of the hydraulic fracturing operation.

The Independent Expert Scientific Expert Panel report on UOG (2014) state that: "While a simple fracturing process to increase permeability was carried out on vertical boreholes during early exploration of CBM in Airth in the mid-1990s [...], none of the coals appraised for commercial-scale CBM in Scotland to date should require hydraulic fracturing of the horizontal borehole. This is due to their distinctive physical properties compared to those found in other continents".

Well development occurs after exploration has located an economically recoverable resource. Whilst UOG can be recovered using single lateral wells, it is also possible to drill several laterals from one point on the surface pad and reach difficult to access areas. Multi-lateral wells are increasingly used in the US but it is unclear at present whether this approach would be successful in Scotland due to complex geology and thinner shales (BGS, 2014).

Once the site has been developed the production of oil or gas can proceed.

When all of the oil or natural gas that can be recovered technically and economically from a reservoir has been produced, the site can be decommissioned and restored typical decommissioning procedures include wells are blocked with cement plugs and the casing cut off 1 metre to 2 metres below ground level and the well is buried. All surface equipment is removed and the well pad is removed. The site can then be restored to its original use (e.g. pasture) or restored for other beneficial use (e.g. recreational use or as a wildlife habitat).

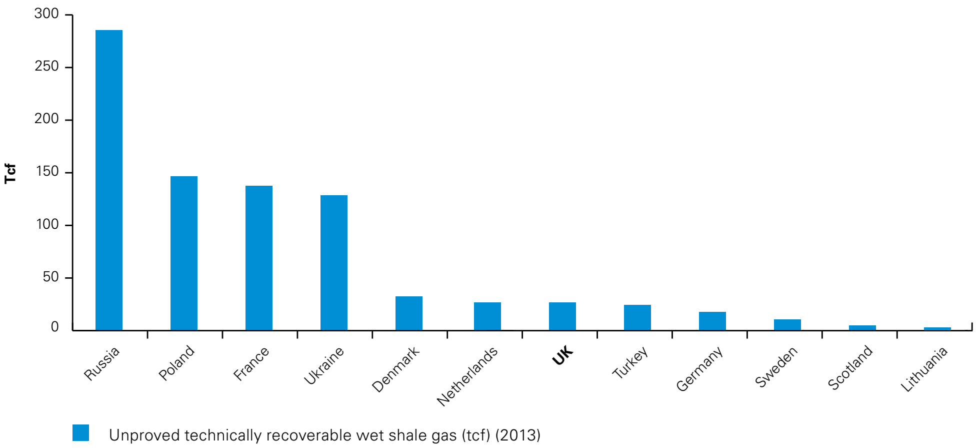
2.3 International development of UOG

2.3.1 Resource development in Europe

The consideration of UOG exploration in the UK and specifically Scotland is in the context of the development of these resources in other countries. The greatest beneficiary of UOG development to date has been the US. Within the EU, other countries are seeking to develop UOG resources further.

Published estimates show there may be opportunities to develop UOG further in countries such as Poland, France, Romania, Russia and the Ukraine. In comparison, countries such as Sweden have not shown interest to proceed while Northern Ireland has a moratorium on the development of shale gas. France has a continued ban on hydraulic fracturing since 2012 (shale gas europe, n.d.). Figure 2.2 shows the unproved technically recoverable resources of shale gas in some European countries. In the UK, Scotland is especially well positioned given its central part in the development and extraction of North Sea gas, and may have a skilled workforce available. The UK Government has shown some appetite to develop a UOG industry and this has also been demonstrated in North Yorkshire where county councillors approved the UK's first hydraulic fracturing exploration tests[18] in five years (Bounds & Stacey, 2016).

Figure 2.2 European shale gas resources.



Source: U.S. Energy Information Administration, (2015)
Note: Recoverable reserves are the proportion of gas in a reservoir that can be removed using currently available techniques (Oil and Gas UK, n.d.).

Footnotes: 18. Third Energy will need to seek further permission to produce on a large scale.

2.3.2 Resource development globally

The US has been the first country to significantly exploit UOG, specifically shale gas, which started with the drilling on Barnett shale in Texas in the late 1990s. Between 2000 and 2012 the US 'shale boom' saw annual production of shale gas rise from 0.3 tcf to 9.6 tcf making up 40% of US dry natural resource production (Independent Expert Scientific Panel, 2014). Production expanded during this period to other shale plays such as the Marcellus shale. The development of UOG in the US resulted in a decrease in its share of imports of natural gas, a drop in the domestic price of energy and the US surpassed Russia to become the world's largest natural gas producer in 2015 (International Energy Agency, 2015). Due to increasing gas production in the US and higher prices in outside markets the Energy Information Administration expects the US to become a net exporter of gas in H2 2016 (U.S. Energy Information Administration, 2016). In February 2016 the US exported its first liquefied natural gas (LNG) cargo (Reuters, 2016). The development of the UOG industry in the US has benefited from significant government funding of research and development in the early stages of the industry's development (Resources for the Future, 2013).

Similarly, Australia has also seen a rapid growth in the development of UOG, through the extraction of coal bed methane. Exploration has been ongoing since the late 1970s but since 2007 there has been rapid growth in the production of CBM and activities are expected to continue for at least several decades (Australian Government, 2015). The commercial production of CBM in Australia has seen many positive economic impacts in relation to employment numbers and gross value added in nearby regions.

2.4 UOG in Scotland

Scotland currently has a moratorium on planning consents for UOG development in place. Two companies currently hold licences for exploratory drilling, INEOS and IGas. However no drilling has taken place due to the moratorium. INEOS acquired Petroleum Exploration and Development License (PEDL) 162 in 2014 which area covers 400km^2 in the Midland Valley of Scotland next to PEDL 133 in which INEOS owns a 51% stake of the shale layer (INEOS, 2014). IGas owns PEDL 158 and 163 which are blocks in West Fife and Caithness acquired in December 2013 (iGas, n.d.).

Research conducted by the BGS suggests there could be a potential resource of between 49,400 bcf and 134,600 bcf of shale gas in Scotland (British Geological Survey, 2014). This could be enough for Scotland to reduce the country's reliance on imports for a number of years. However, there remain uncertainties around how much of this is actually technically and economically recoverable in the current economic and energy market climate of low prices.

2.5 The structure of this Report

The remainder of this document is divided into three further sections:

- Section 3 of this Report outlines our approach to the study and our methodology for the economic impact assessment;
- Section 4 describes the production scenarios considered in this study;
- Section 5 presents our findings on the economic contributions to Scotland; and
- The appendices to this Report produce supporting details for our assessment.

3

Our approach

3.1 Overview of approach

The approach we have taken to assessing the impact of UOG development in Scotland has been developed to meet the requirements of the scope of work provided to us by the Scottish Government and is consistent with similar studies undertaken to assess the impact of UOG developments in other countries (see survey of relevant research in Appendix B).

The key steps in the process are:

- To **define the economic impacts** to be evaluated as part of the study;
- To **prepare a range of scenarios** after discussion with stakeholders, for the development of UOG in Scotland and for how that development will impact business and the Scottish economy, in addition to considering the timing of those impacts as well;
- To **evaluate how the development of UOG may impact other parts of the Scottish economy.** These are often described as 'trickle down' or multiplier effects. We consider two multiplier effects:
  - › **Indirect effects**: the indirect effects generated in the UOG supply chain; and
  - › **Induced effects**: arising from the spending of those employed by the UOG industry and its supply chain.

We evaluate these multipliers using an analysis of the Input-Output tables prepared by the Scottish Government[19]. The Input-Output tables demonstrate the impact one sector of the economy (in this case UOG) has on other sectors. In the case of UOG, these impacts may be demand for materials and products from other sectors in the economy or by supplying a local source of fuel or feedstock to other sectors of the economy. Hence, we:

- Assess impacts on **employment** and GVA in Scotland;
- Consider impacts on **taxation receipts** in the UK; and
- Prepare a qualitative assessment of other factors to be considered as part of the economic impact assessment specifically:
  - › The significance of the development of UOG resources in Scotland as a feedstock for industrial facilities, e.g. petrochemical companies in the country; and
  - › Outline some of the other potential impacts that could arise from UOG development which could potentially feature in a cost-benefit assessment of UOG development in Scotland.

These steps are explained in more detail in the remainder of this section.

3.2 Defining the economic impact of UOG development in Scotland

Critical to our approach is identifying which economic impacts will be evaluated for the study. We have undertaken a broad review of recent research into approaches to Economic Impact Assessment and also studies that have been performed of economic impact of UOG in the UK and elsewhere. A bibliography of the work we have reviewed is included in Appendix A and a brief summary of the literature review is in Appendix B.

Typically, an Economic Impact Assessment is based on the costs (spend) from the sector under consideration and its benefits to the economy, Gross Domestic Product (GDP) growth, jobs created, impact on the supply chain, etc. For the purposes of this research project we have not attempted to replicate a cost-benefit analysis which aims to fully quantify costs and benefits as this was not part of the scope of work requested by the Scottish Government. A key measure of economic impact is Gross Value Added (GVA). GVA measures the difference between the total output or revenue of an industry and what it spends on intermediate inputs. Intermediate inputs are the goods and services used up in production[20]. GVA is the industry level equivalent of Gross Domestic Product (GDP), the measure used to assess the size of an economy.

Table 3.1 overleaf lists the potential economic impacts from UOG development that could be considered as part of a broader evaluation of the costs and benefits of industry. The economic impacts considered for this study are based on the scope of work for this research project provided to us by the Scottish Government and are in the top left hand corner of Table 3.1.

3.3 Preparing a range of scenarios

We considered a scenario where exploration takes place with no production either because it is uneconomic or insufficient resources are in place.

Assuming that this exploratory phase was completed, we developed production and cost profiles for potential scenarios for Scottish UOG development, based on a number of assumptions. These scenarios were based on assumptions around:

Footnotes:
19. http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output. The most recent tables were published by the Scottish Government in 2012.
20. Employee wages or dividends paid to shareholders are not intermediate inputs, but are included in GVA.

Table 3.1 Potential economic impact of UOG and how they have been conducted in this research project.

Economic impacts		Other considerations (impact not quantified as part of this research report)
– Contribution to GVA/GDP – Contribution to employment – Contribution to tax/government revenues	**Evaluated in this report**	– Impact assessment on: › Environment (externalities – impacts on water, noise, light pollution, biodiversity, landscaping, air emissions and air quality) › Visual amenity › Tourism › Agriculture – Health related costs
– Supply chain, skills, training kills, training and development	**Subject to commentary in this report**	
Local considerations		
– Community benefits payments – House price trends – Feedstock for other industries, i.e. specific facilities (petrochemical sector) – Health related costs – Renewables / power sector	**Subject to commentary in this report**	

- Recoverable resources;
- Likely production and costs profiles;
- Industry structure;
- Rates of technical/efficiency improvement;
- Gas and oil prices; and
- Inland consumption of fuels.

Based on the above assumptions, total production, total costs and total revenues were derived and formed the basis of our Central, High and Low scenarios. Section 4 presents our scenarios in more detail and our detailed assumptions are included in Appendix C.

3.4 Evaluation of impacts of UOG on the Scottish economy

Underlying our calculations is an Input-Output model, which allows us to examine the flows of goods and services between individual sectors of the Scottish economy. It also enables us to capture the economic activity generated by employees of the UOG industry and its supply chain, spending their money. The analysis utilises a series of multipliers that are applied to the direct GVA and employment of the UOG industry. As there is currently no accepted definition or industry classification (SIC codes) for UOG activities the model uses multipliers generated by KPMG using the Scottish Input-Output tables.

For the purpose of this report, we have adapted the existing Scottish Government Input-Output table to include a new column and row for the new Scottish UOG sector. The new column and row are designed to reflect:

- The Scottish UOG sector's demand for inputs from other sectors; and
- The demand for other sectors in the Scottish economy for the outputs of the Scottish UOG sector.

To identify which industries will face demand from the UOG sector, we have assessed the expenditure breakdown of the conventional oil and gas industry in the UK (SIC 06-07) by looking at the UK Input-Output tables. Based on our analysis, we have assumed that the expenditure breakdown for the conventional oil and gas sector will be the same for the UOG sector.

Input-Output analysis is a widely used and transparent tool for assessing economic impact. However it has some limitations, which should be borne in mind in interpreting our results. Notably:

- We use the most recent Scottish Input-Output tables available published in 2012. While there will be changes to the Scottish economy since 2012, this is the most recent set of tables available.
- The numbers we present are gross impacts, they do not factor in any displaced activity in production of fossil fuels or behavioural responses caused by price differences. We do not expect significant levels of displacement given the relatively small scale of Scottish UOG development

versus the size of the overall economy. The impacts will not be felt uniformly across the sectors of Scotland's economy. Sectors which experience the biggest impact outside of the energy sector are those that produce the intermediate inputs and capital goods (and services) for the UOG sector. The size of the industry is relatively small compared to the size of the Scottish economy and most of the sectors it is drawing on, which will minimise the size of displacement effects. With the trend towards reduction in the North Sea oil and gas sector, this has the potential to release resources in the economy which will also minimise displacement and crowding out effects as well.

- The model only allows a certain level of granularity in the analysis: there is, for example, no separate treatment of UOG construction, but only a generic construction sector.

The Input-Output analysis provides a basis for our estimates of Gross Value Added, employment and tax revenues supported by a Scottish UOG industry as detailed in our three deployment scenarios. Details of key assumptions can be found in Appendix C of this Report.

By using our Input-Output table analysis, we are able to report on the aggregate impact of UOG on the Scottish economy under the different scenarios. We are then able to generate a series of multipliers to quantify the economic impacts.

The study considers the potential direct, indirect and induced impacts of the UOG sector on the Scottish economy. Based on this analysis we assess the contribution to Scottish GVA/GDP. This impact is driven by capital and operational expenditure on UOG projects. UOG spend can be attributed to specific industries by splitting the expenditure of the industry into component parts and identifying what other sectors of the economy that part of UOG expenditure will be placed with. From this, the indirect and induced effects can be calculated using the multipliers.

3.5 The impact on employment

The study considers how the UOG sector can affect employment in Scotland. The Independent Expert Scientific Panel (2014) estimated that the development of this industry could have positive impacts on employment for Scotland. The economic impacts from the potential development of the UOG sector could be dispersed across large areas of Scotland. This may include areas identified as deprived by the Scottish Index of Multiple Deprivation (2012). (See section 5.3 for more details).

A number of skills and direct roles could be required for the development of UOG. The EY study (2014) provides seven categories of direct roles and services considered critical for UOG development:

1) Drilling and completions;
2) Hydraulic fracturing;
3) Petroleum engineering, geosciences and environmental consultants;
4) Planning approval and permitting issuance, health, safety and environmental monitoring;
5) Operations management;
6) Construction; and
7) Office support.

We have estimated employment impacts by evaluating the jobs that would be needed directly by the spend in the UOG sector in Scotland, based on previous work by EY (2014) and the Institute of Directors (2013). We have also taken into consideration the indirect and induced employment effects on industries that form part of the supply chain through the Input-Output table analysis. These sectors include, but are not limited to, construction, repair and maintenance, electricity, gas, water transport, financial services, legal activities, architectural services, etc.

3.6 The impact on tax receipts across the United Kingdom

The activity of the UOG industry and its supply chain would lead to the generation of tax revenues. As part of the macroeconomic analysis we assessed the likely impact on tax revenues for the UK.

Based on total UOG expenditure (Scotland, the UK, rest of the world), we assess three sources of tax revenues from UOG development:

- Direct taxes;
  - On corporates developing UOG; and
  - On employees in the UOG and other impacted sectors income tax and NI.
- Indirect taxation (VAT) on the goods and services purchased in the supply chain to support UOG development; and
- Local government taxation through business rates.

We have assessed total tax income from across the UK. We have modelled a series of assumptions to arrive at estimates of the key taxable financial streams and the associated effective tax rates. These broad estimates serve to illustrate the potential size of the tax revenue across the UK. These receipts have not been further split between Scottish and UK governments, as currently there is no allocation of tax receipts from the sector between Scotland and the remainder of the UK. It is important to note that a bespoke set of tax arrangements for UOG in the UK has not yet been developed. We have therefore assumed that the sector would face current rate of corporation tax. Outturn tax receipts would depend on the design of the tax regime for UOG.

3.7 Links to other Scottish Government research projects

The assumptions and scenarios in this study were used in other UOG studies (workstreams) commissioned by the Scottish Government, mainly the Climate Change Impacts study and the Decommissioning, aftercare and financial liability study. Some aspects of these studies are used in this economics study.

The climate change offers insight on whether the economic scenarios exceed the GHG targets.

The climate change study refers to the scenarios for Scottish UOG provided by this economic study.

The economic study also uses data developed by the decommissioning study, in particular regulatory costs involved with changing regulation. As well as scenarios and for UOG, there are other estimates from the economic study such as decommissioning and aftercare costs that are used within the decommissioning study.

There have been regular interactions between the different workstreams to ensure analytical consistency. This included a cross-project meeting on 30th March 2016 in Edinburgh.

4

Scenarios for UOG development in Scotland

4.1 Coverage

Three sources of UOG are considered as part of this study, namely:

- Gas extracted from onshore shale sources using hydraulic fracturing;
- Associated liquids extracted from onshore shale sources using hydraulic fracturing; and
- Coal bed methane.

Based on discussions with industry, we assume that the focus for developers in Scotland would be shale gas development with liquids as an associated product, should exploration be successful. The evidence base on coal bed methane is limited, especially in the Scottish context. Resources estimates for CBM are uncertain[21] and CBM is thought to be located in the same geographical areas as shale gas and associated liquids. Based on surface access, geology, development costs and estimated well recovery rates, CBM is currently unlikely to be a major product in Scotland. As such, we have assumed that only two CBM pads would be developed.

4.2 The scenarios considered

There is considerable uncertainty regarding a wide range of factors in the Economic Impact Assessment of Scottish UOG. Following workshops with stakeholders, UKOOG provided us with some of their members' views on UOG development in Scotland. The scenarios developed for the purposes of this study are therefore based on UKOOG's submission as well as wider information gathered through literature review – this includes the IoD report on shale gas (2013) and the EY report on shale gas and its supply chain (2014). KPMG discussed the scenarios with UKOOG and took on board their comments. As a result, the scenarios reflect a range of outcomes in the development of UOG in Scotland. Three production scenarios in which exploration is successful were assessed:

- Central scenario – based on midpoint estimates of potential production;
- High scenario – in which significant development occurs in the next decade or so[22]; and
- Low scenario – in which development is initially slow and does not grow significantly, for example there is a low level of production[23].

Given the uncertainty regarding the level of shale resources in place, we also consider the costs of exploration should no development of UOG resources take place. In this alternative case, no economic benefits would arise and operators involved in exploration would incur a loss.

All of our scenarios are modelled up to 2062 to allow consideration the full lifecycle of pads through planning and licensing, exploration, development, production and decommissioning and aftercare. We have taken a long-term view in this study to evaluate the full economic lifecycle of the industry and to consider the implication of decommissioning and aftercare costs. Regarding Scottish demand for gas, we assumed that total demand[24] remains unchanged over the studied period.

Our UOG development scenarios are based on the potential pads operators could develop in the Midland Valley of Scotland. The Midland Valley is a highly populated area of Scotland, hence there are limits to the available surface that can be used for UOG resource development (see Appendix C for further details). Our scenarios are based on the potential developable area in the Midland Valley and is based on a different number of pads for each scenario. Multi-lateral wells drilled from a single 'mother bore' are increasingly used in the US but it is unclear at present whether this approach would be successful in Scotland due to complex geology and thinner shales (BGS, 2014). Industry estimates suggest that drilling 6 to 12 mother bores per pad in a smaller area or between 15 to 30 mother bores per pad in a larger area is a reasonable estimate. Industry has also suggested in Scotland it is reasonable to assume only one production or lateral well per mother bore. For ease of reading, we refer to a mother bore with one lateral well as a 'well'.

Well recovery data varies with local geology and/or well location, i.e. well recovery can be different from one shale area to another as highlighted by Ozkan & Duman (2015) in their report on the economic evaluation of Marcellus and Utica shale plays. At the lower end a well could produce less than 3 bcf over its lifetime while a high end estimate could be over 5 bcf/well over lifetime. Because of the level of uncertainty around UOG resources in Scotland and the proportion of these that could be recovered, we have been cautious in our approach to well recovery. This is reflected in our assumption that a well could produce c3.16 bcf over its lifetime.

Footnotes:

21. It is estimated that the total CBM resource in the UK is 2.9 trillion m3 (102 tcf), and that the recoverable part of the resource is unlikely to exceed 1% due to low seam permeability, low gas content and planning constraints. No separate figures are available for Scotland, but from areal estimates of resources (DECC, 2010) it is possible that Scottish resources are just 22% of those of the whole UK (Independent Expert Scientific Panel, 2014). Based on this estimate, Scottish resources are 22.44 tcf.
22. This scenario is based on a shorter planning horizon.
23. This scenario also draws on input/suggestions received from Scottish Environment LINK and Friends of the Earth Scotland. This does not imply any endorsement of the scenario by these stakeholders.
24. Total intermediate consumption.

4.3 Resource development

4.3.1 Central scenario

The Central scenario is our potential midpoint scenario regarding the development of shale gas and associated liquids in Scotland. We assume a three[25] year period for planning and licensing (2018-2021). We assume that exploration lasts two years (2022-2023) and the development of the pad infrastructure is completed within a year (2023-2024). We assume that the first flow of product is in 2024 with peak production reached in 2036. It is assumed that a pad has a 15-year lifespan, i.e. for a pad built in 2023 production ceases in 2038, and that decommissioning can take up to three years, i.e. from 2039 to 2041-2042 for a pad built in 2023.

Shale gas

This scenario is based on the development of 20 pads of 15 wells each built over 11 years starting in 2023-2024. Shale gas volumes are produced until c2048. At industry level, peak production is reached in 2036 with a total annual output of approximately 76 bcf. The cumulative production of a single pad over its lifespan is 47.3 bcf, which represents an average of 3.16 bcf per annum.

Associated liquids

Associated liquids is produced as an associated product to shale gas and it is assumed that:

- It has the same production profile as shale gas;
- 75% of 'existing' shale gas pads also produce associated liquids, i.e. 15 pads; and
- Associated liquids are produced over a period to 2046.

Industry-wide peak production is reached in 2036 with a total annual output of approximately 1.5 MMBOE. The cumulative production of a pad over its lifespan is 1.2 MMBOE, which represents an average of 0.08 MMBOE per annum over 15 years.

Coal bed methane

We assume that two CBM pads are developed over two years. Each pad has 15 wells and produce 13.1 bcf over 12 years – an average production of 1.1 bcf per annum. We assume that all CBM wells are drilled in the development phase. Production commences in 2024 and lasts until 2036. However, at current gas prices, the development of two coal bed methane pads and associated production volumes would not generate high enough revenues to justify the investment. If CBM can be economically developed it will have a positive GVA contribution to the Scottish economy as demonstrated in Section 5.

4.3.2 High scenario

The High scenario models a positive case for both shale gas and associated liquids. For a pad starting planning and licensing in 2018, we assume that this could take up to two years and is completed by 2019-2020 – this is a shorter lead time compared to our Central scenario based on shorter planning horizon. It is assumed that exploration lasts two years and the development of the pad infrastructure is completed by 2022. We assume that the first flow of products is in 2023 and that peak production is reached in 2037. It is assumed that a pad has a 15-year lifespan, i.e. for a pad built in 2022 production ceases in 2037, and that decommissioning can take up to two years, i.e. from 2038 to 2039-2040.

Shale gas

This scenario is based on the development of 31 pads of 30 wells each built over 13 years starting in 2021-2022. Shale gas volumes are produced until c2049. At industry level, peak production is reached in 2037 with a total annual output of approximately 228 bcf. The cumulative production of a pad over its lifespan is 94.7 bcf, which represents an average of 6.31 bcf per annum.

Associated liquids

The principles and assumptions used in the Central associated liquids scenario are also used in this scenario (see Central scenario for common assumptions). This scenario makes use of the shale gas High scenario, with associated liquids being an associated product flow. Out of 31 shale gas pads, 23 of them also produce associated liquids.

Peak production at industry level is reached in 2036 with a total annual output of approximately 3.8 MMBOE. The cumulative production of a pad over its lifespan is 2.4 MMBOE, which represents an average of 0.16 MMBOE per annum over 15 years.

Coal bed methane

Our assumptions for CBM are as in the Central scenario.

Footnotes: 25. Based on experience of some planning applications in the UOG sector in England.

4.3.3 Low scenario

The Low scenario models the 'slowest' and least successful route to market. For a pad starting planning and licensing in 2018, we assume that this could take up to five years and is completed by 2022-2023 – this is a longer lead time compared to the Central scenario representing the impact of public enquiries and other delays. We assume that exploration lasts three years (to 2025) and the development of the pad infrastructure is completed by 2027. Based on a drilling schedule, we assume that the first flow of product in 2028. Based on our pad building schedule, peak production is reached in 2037. It is assumed that a pad has a 15-year lifespan, i.e. for a pad built in 2028 production ceases in 2042, and that decommissioning can take up to five years, i.e. from 2043 to 2047-2048 for a pad built in 2023.

Shale gas

This scenario is based on the development of 10 pads of 10 wells built over nine years starting in 2027-2028. Shale gas volumes are produced until c2048. At industry level, peak production is reached in 2037 with a total annual output of approximately 29.5 bcf. The cumulative production of a pad over its lifespan is 31.6 bcf, which represents an average of 2.1 bcf per annum. The production profile of a pad is phased in such a way that peak production is reached twice at around 3.3 bcf.

Associated liquids

As in the previous two scenarios, the associated liquids Low scenario makes use of the shale gas Low scenario, with associated liquids being an associated product flow (see Central scenario for common assumptions). Out of 10 shale gas pads, 8 of them also produce associated liquids.

Peak production at industry level is reached in 2038 with a total annual output of approximately 0.05 MMBOE. The cumulative production of a pad over its lifespan is 0.06 MMBOE, which represents an average of 0.004 MMBOE per annum over 15 years.

Coal bed methane

Our assumptions for CBM are as in the Central scenario.

4.4 Other assumptions

4.4.1 Costs

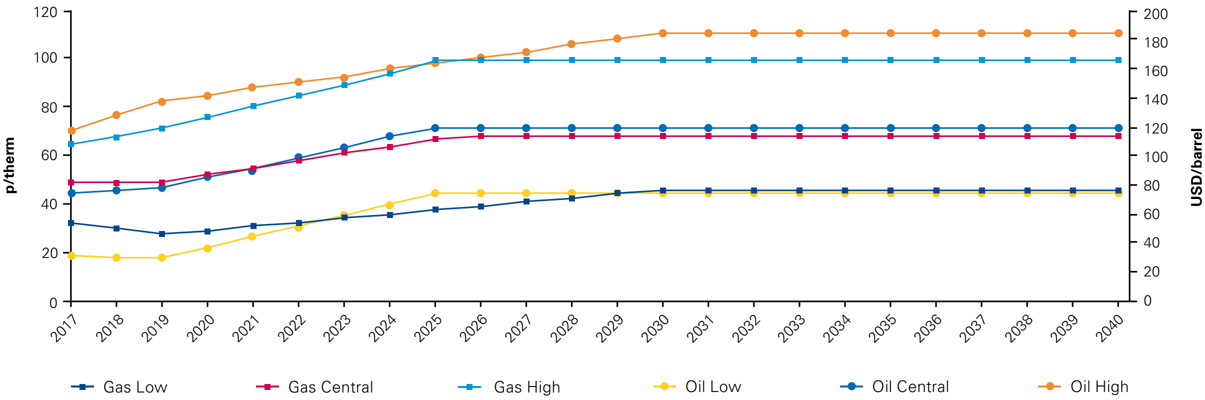
In costing our scenarios we have used publicly available data. Our assumptions are based on existing information (EY 2014, Institute of Directors 2013, Independent Expert Scientific Panel 2014) inflated and adjusted as appropriate, discussions with industry, stakeholders (see Appendix D for contribution from stakeholders) and the other workstreams. Although the data used is the latest available, it is over two years old. This increases the level of uncertainty surrounding any conclusions we are able to draw from our analysis and should be factored into the readers' own interpretation of our findings.

The study published by EY in 2014 on shale gas and its supply chain and skills requirements provides a breakdown of the estimated costs of hydraulic fracturing, drilling and completions, waste disposal and storage and transportation. These estimated costs were for a hypothetical pad of 10 vertical wells with four laterals each (total of 40 laterals). In this study, we used the estimated costs provided in the EY study and scaled them in accordance with the number of wells assumed in each scenario. We have added a number of other costs to cover expenditure on planning and licensing (this includes the costs associated with the development of a regulatory regime), exploration, pad development, decommissioning and aftercare. We have also added operating expenditure to cover the production phase of the pads. The same central cost assumptions have been used for CBM with the only difference that well fracturing costs are much lower to reflect the difference in geology and hence the difference in accessing the gas.

Shale gas and associated liquids opex are based on a fixed element (2.5% of annual cumulative capex for both shale gas, CBM and associated liquids) and a variable element (£0.25m/bcf for gas and CBM and £1.65m/MMBOE for liquids. The costs of monitoring carbon emissions are also included in the operating costs – these are estimated to be £100,000 per year per pad for the duration of the pad's lifespan based on information from the CCC. This does not include EU ETS costs.

In terms of efficiency improvements, we assume that there are economies of scale in pad construction. The Central scenario (and CBM pads) benefits from a cost reduction of 5% of capex for five pads after the first pad is built. The High scenario benefits from a cost of reduction of 7% for

Figure 4.1 DECC fossil fuel prices projections.



Source: DECC (2015)

five pads after the first pad is built. We assume a smaller cost reduction percentage in the Low scenario, i.e. only 3% for three pads after the first pad is built. These assumptions are in line with the approach used by the US Department of Energy for components of energy systems (U.S. Department of Energy, n.d.).

4.4.2 Prices

Fossil fuel prices, especially oil, are sensitive to a number of factors including supply, elasticity of demand, weather, economic cycles and geopolitical events that may cause market uncertainty. Government (formerly DECC, now BIES going forward) publishes fossil fuel price projections on an annual basis.

We have used 2015 DECC low oil and gas wholesale fossil fuel price assumptions in modeling our three scenarios. It should be noted that there is considerable uncertainty as of how fossil fuel prices may change in the future. In Section 5.8 we use DECC high and central price projections to quantify the economic impacts to the Scottish economy should fossil fuel prices increase. For the purposes of this study NGLs are assumed to be sold at a discount to the oil price, in line with historical averages.

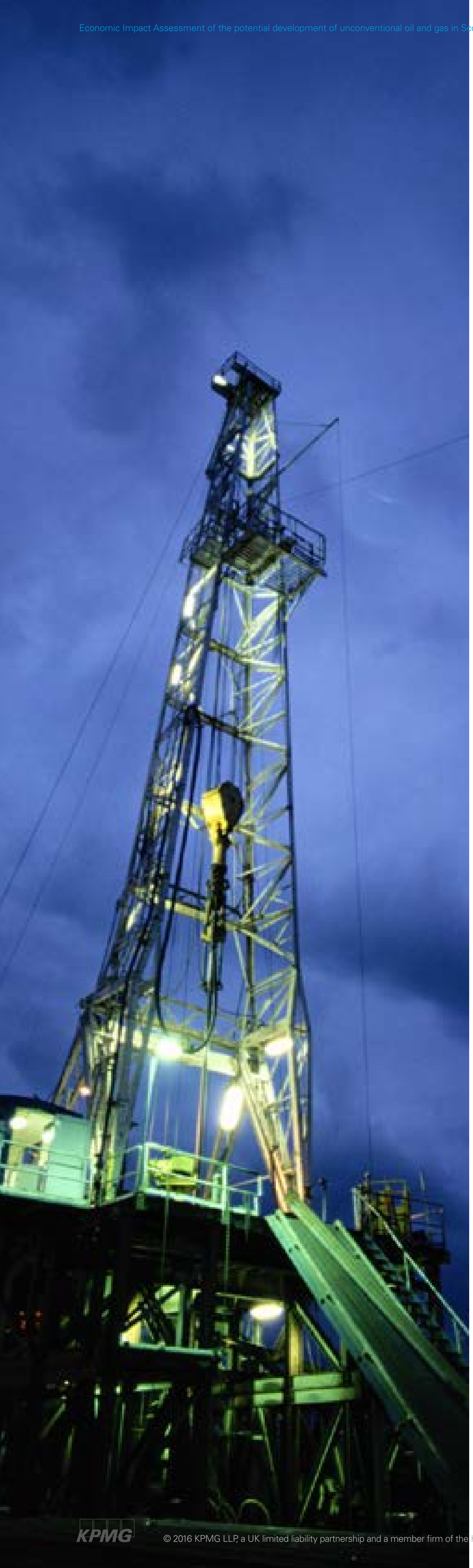
It is worth noting that given limited recoverable volumes, UK UOG outputs would only represent a fraction of the supply to the global market (House of Lords, 2014). Furthermore, the scale of development in Scotland will be much lower than that in the US and hence Scottish UOG is unlikely to have an impact on global energy prices. This implies that there may be substitution between gas sources rather than gas for other sources of energy. This is consistent with the CCC workstream in that overall usage of hydrocarbons is unchanged[26].

4.5 Comparison of scenarios

We have assumed production volumes based on a number of pads because in the Midland Valley (a relatively densely populated area of Scotland) there are limits to the available space that can be used for UOG resource development. A 'developable' area is limited by urbanisation, faulting, water bodies, designated areas, etc. which limit the number of potential pad developments. We estimate that 20 pads could be developed in the Central scenario, while 31 and 10 could be developed in the High and Low scenarios respectively. Additionally, we assume that two CBM pads are developed in each scenario.

The unit costs of production from our scenarios at c45p/therm in the Central and Low scenarios (the Central and Low scenario have similar unit costs due to different cost assumptions) and 35 p/therm in the High scenario demonstrate that in a persistently low price environment the economics of development are likely to be marginal. It should be noted that there is considerable uncertainty as of how fossil fuel prices may change in the future. Fossil fuel price fluctuations would have an impact on the economic contribution of UOG for Scotland (see Section 5.8 for more details) as well as on the operators' financial standing.

Footnotes: 26. As a result of this we have not formally considered the impacts on carbon prices.



The study published by EY in 2014 on shale gas provides a breakdown of the costs of hydraulic fracturing, drilling and completions, waste disposal and storage and transportation. These costs were for a hypothetical pad of 10 vertical wells with four laterals each (total of 40 laterals). In this study, we used the costs provided in the EY study and scaled them in accordance with the number of wells assumed in each scenario.

Table 4.1 provides a summary of the key parameters of each scenario. A detailed breakdown of costs is provided in Appendix C. The Institute of Directors (2013) study used a scenarios-based approach to demonstrate what the industry may look like in terms of production capacity and cost profiles. The study provides a breakdown of costs and production profiles for a smaller pad of 10 wells of one lateral each (10 laterals in total) and a larger pad of 10 wells of four laterals each (40 laterals in total). The authors of the study assume that for the smaller pad, expected gas production could reach 31.6 bcf over lifespan – our Low scenario assumes the same production output. Unlike this study, the study assumes that a 10 well pad costs £142 million while we estimate that this could cost £153 million (capex and opex) plus £5.5 million of decommissioning costs.

For the larger pad, the IoD study assumed that production could reach 126.2 bcf over lifespan (40 laterals), with investment of £514 million of investment. This is not directly comparable to our Central or High scenarios. In addition to the single pad cases presented in the IoD study, the authors provide an illustrative example of what widespread development could look like in the UK. This widespread development scenario assumes that shale gas production could reach commercial scale and that a hypothetical development of 100 pads of 10 wells of four laterals each (i.e. a total of 4,000 laterals) could produce between 853 bcf and 1,389 bcf per annum at peak, based on the Institute of Directors (2013) sensitivity analysis.

Other studies such as the ones by Amion Consulting on the potential economic impacts of shale gas in the Ocean Gateway (2014) and the Bowland shale (2015), used a number of assumptions from the IoD (2013) study. For example, the authors assessed that for the Ocean Gateway area, a development of 30 shale gas production sites of 10 wells of four laterals each could be envisaged. This is similar to our High scenario in terms of number of pads but more optimistic in terms of total number of wells (vertical and horizontal).

4

Scenarios for UOG development in Scotland

Table 4.1 Summary of key parameters of each scenario.

	Product		Units	Central	High	Low
What could be produced	Shale gas	Cumulative output by 2062	bcf	947	2,934	316
		Lifetime production per pad	bcf	47.3	94.7	31.6
	Associated liquids	Cumulative output by 2062	MMBOE	17.8	49.7	0.5
		Lifetime production per pad	MMBOE	1.2	2.4	0.1
	CBM	Cumulative output by 2062	bcf	26.3	26.3	26.3
		Lifetime production per pad	bcf	13.1	13.1	13.1
How much would be produced (development approach)	Shale gas	Number of pads	No.	20	31	10
		Wells per pad	No.	15	30	10
		Production life of a well	Years	15	15	15
	Associated liquids	Number of shale gas pads also producing associated liquids	No.	15	23	8
		Wells per pad	No.	15	30	10
		Production life of a well	Years	15	15	15
	CBM	Number of pads	No.	2	2	2
		Wells per pad	No.	15	15	15
		Production life of a well	Years	12	12	12
How much would it cost	Shale gas and associated liquids	Capex[27]	£bn	3.0	7.2	1.0
		Opex	£bn	1.3	3.2	0.4
		Decommissioning	£bn	0.1	0.4	0.1
		Expenditure within Scotland	£bn	2.2	6.5	0.5
	CBM	Capex[28]	£bn	0.3	0.3	0.3
		Opex	£bn	0.1	0.1	0.1
		Decommissioning	£bn	~0.0	~0.0	~0.0
		Expenditure within Scotland	£bn	0.2	0.2	0.2
Community benefits payments and taxation	Shale gas and associated liquids and CBM	Community benefit payments	% of revenue	4%	4%	4%
		Taxation assumptions	Direct taxes: corporate tax payable on taxable company profits. Income tax and National Insurance contributions on salaries.			
			Indirect VAT assumed recoverable on purchases with supply chain but levied on wholesale product sales. Local government: business rates charged on a per pad basis.			
Estimated FTE employment per pad	Shale gas and associated liquids	Number of FTE jobs[29]	FTE	80	90	55
	CBM	Number of FTE jobs[30]	FTE	-	-	-
Estimated timing		Planning and licensing	years	3	2	5
		Exploration	years	2	2	3
		Development	years	1	1	2
		Production	years	15	15	15
		Decommissioning	years	3	2	5
		Aftercare	years	20	20	20

Footnotes:
27. Including the impact of cost reduction through learning.
28. Including the impact of cost reduction through learning.
29. Including capex, opex and decommissioning jobs.
30. Our analysis demonstrates that in the current context (current price of gas, cost of development, estimated well recovery rates, etc.) the development of CBM may not be economic and may therefore not materialise. As such, we have not included FTE jobs for CBM. For a summary of the analysis on CBM, please see Section 5 (Table 5.1).

Figure 4.2 shows the overall pad development profile in terms of the number of pads starting production in each year.

Total annual gas consumption in Scotland (2014) is estimated at 164 bcf/year (94 bcf/year for domestic sector and 70 bcf/year for non-domestic[31]) (The Scottish Government, 2015). As a point of comparison, a total production of 947 bcf of gas in our Central scenario represents about 5.5 years of Scottish consumption. In our High scenario (2,934 bcf) this represents about 18 years of Scottish consumption.

Figure 4.2 Pad development profiles by scenario.

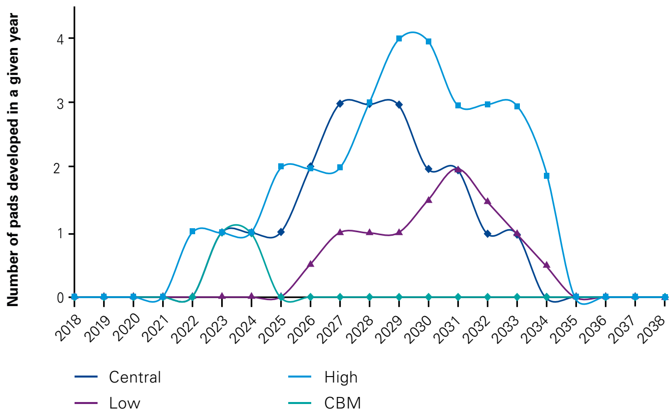


Figure 4.3 Shale gas total annual output.

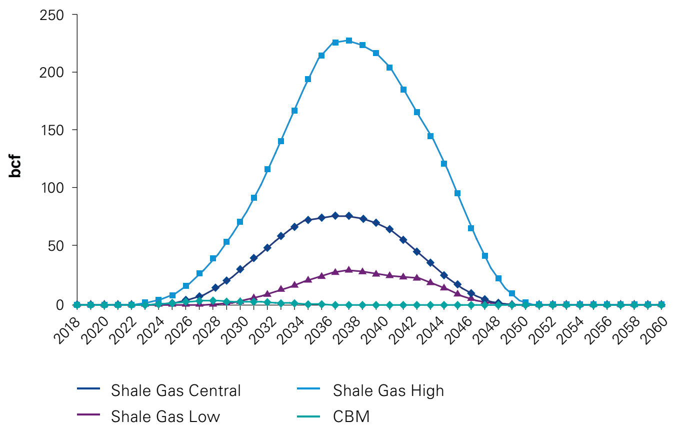


Figure 4.4 Shale gas total cumulative output.

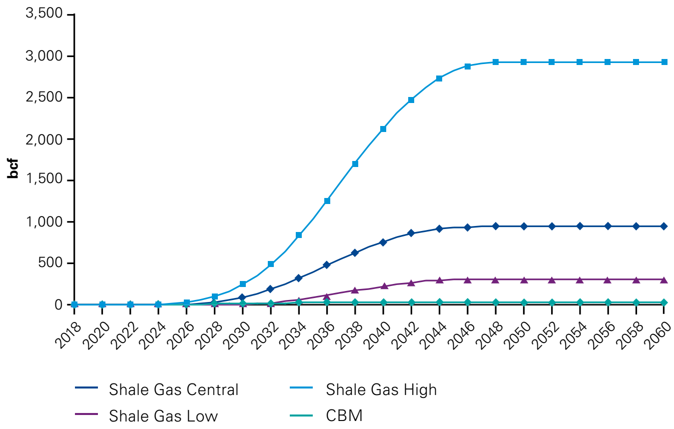


Figure 4.5 Associated liquids total annual output.

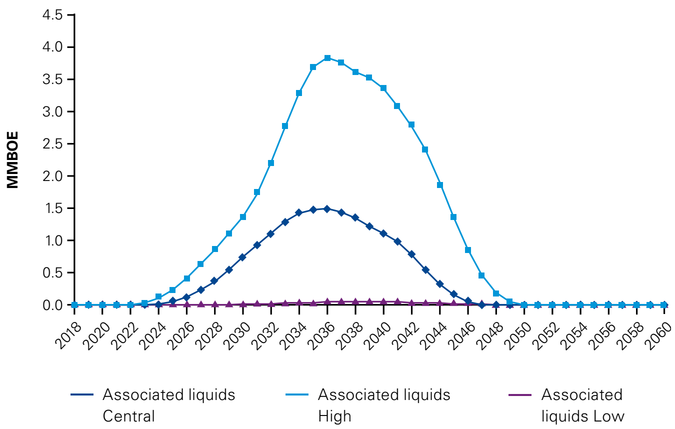
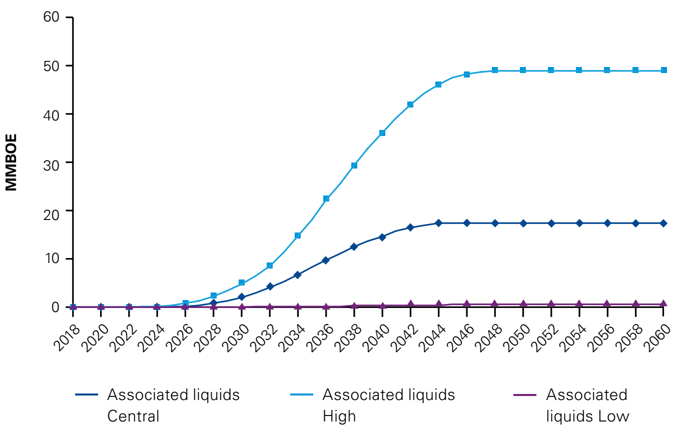


Figure 4.6 Associated liquids total cumulative output.



Footnotes: 31. Converted from GWh to bcf.

5

Measuring the economic contribution of UOG to Scotland

5.1 Summary of key findings

In this section, we summarise our key findings regarding the economic impact of each of the scenarios we considered.

Table 5.1 presents a summary of economic impacts from UOG development in Scotland. Key metrics are described below:

1) **Total spend:** Represents the industry's total spend for the extraction of shale gas, associated liquids and CBM. Total spend includes the monies invested in Scotland, the UK and the rest of the world.

2) **Spend in Scotland:** Represents the UOG industry spend in Scotland (only) for the extraction of shale gas, associated liquids and CBM. It is the monies invested by the UOG sector in other Scottish businesses/sectors – i.e. the direct spend in Scotland by the UOG sector. Assumptions on localisation are set out in Appendix C.3.3.

3) **GVA/GDP contribution:** Represents the Gross Value Added of the spend in Scotland. CBM is presented for illustrative purposes only.

4) **Employment:** The total number of jobs at peak, i.e. peak year employment.

5) **Total tax receipts:** Represents the total at UK level, including both from devolved Scottish Government taxes (e.g. income tax partially and rates) and UK income tax, NI and corporate tax from direct (corporation and labour taxes) and indirect (VAT) taxation as well as rates. Total tax receipts are derived from Total spend. CBM is presented for illustrative purposes only.

5.2 Contribution to GVA/GDP

To arrive at our estimates of GVA we passed the assumptions on capex, opex, gas and oil prices and output for the three production scenarios (discussed in earlier sections) through our Input-Output model. The results of our analysis are shown in Table 5.2. The total GVA (cumulative to 2062) comes to £1.1 billion in our Central scenario[32], with £0.1 billion in GVA generated directly added to £1.0 billion in indirect and induced effects (including CBM). As outlined in Section 3.4, the numbers we present are gross impacts and do not take into account of any price effect.

The economic benefits shown in Table 5.1 should be considered in the context of the alternative case in which exploration for UOG in Scotland takes place but resources are not economically viable for development. In this case,

Table 5.1 Summary of economic impacts from UOG development in Scotland[33].

Cumulative £ billion to 2062		Central	High	Low
1) Total spend (£bn)	Shale gas and associated liquids	4.4	10.8	1.5
	CBM	0.4	0.4	0.4
	Total	**4.8**	**11.1**	**1.9**
2) Spend in Scotland (£bn)	Shale gas and associated liquids	2.2	6.5	0.5
	CBM	0.2	0.2	0.2
	Total	**2.4**	**6.6**	**0.7**
3) GVA/GDP contribution (£bn)	Shale gas and associated liquids	1.2	4.6	0.1
	CBM	-0.1	-0.1	-0.1
	Total	**1.1**	**4.5**	**~0.0**
4) Peak year employment	Shale gas and associated liquids	1,400	3,100	470
	CBM	-	-	-
5) Total tax receipts UK (£bn)	Shale gas and associated liquids	1.4	3.8	0.5
	CBM	0.1	0.1	0.1
	Total	**1.5**	**4.0**	**0.6**

Footnotes:
32. Cumulative over the period 2018-2062.
33. This table includes the benefits/ disbenefits of CBM. Totals do not add up due to rounding.

Table 5.2 Estimated direct, indirect and induced GVA for Scotland from UOG development[34].

Cumulative £ million to 2062		Central	High	Low
Total direct GVA	Shale gas and associated liquids	473	2,515	36
	CBM	-334	-334	-334
	Sub-total	**139**	**2,181**	**-298**
Total indirect GVA	Shale gas and associated liquids	658	1,804	92
	CBM	183	183	183
	Sub-total	**841**	**1,987**	**275**
Total induced GVA	Shale gas and associated liquids	90	234	15
	CBM	24	24	24
	Sub-total	**114**	**258**	**39**
Total impacts		**1,095**	**4,427**	**17**

expenditure on exploration would take place (our cost estimate for exploration activity in the Central scenario is £240m) but no actual development would take place.

It can be noted that the estimated GVA impacts for CBM are negative. This is a result of revenues from sales of methane produced at anticipated market prices being less than the costs of extraction. The development of CBM would be unlikely in an environment where the costs of extraction exceed revenues. The negative economic contribution for CBM in Tables 5.1 and 5.2 are presented for illustrative purposes only.

5.3 Contribution to employment

The UOG industry would require workers in construction of pads, the manufacture of equipment, including rigs, etc., and in operations and maintenance. Estimates of the number of jobs based on UOG spend in Scotland required to design, build, maintain and decommission shale gas/oil pads vary widely, as discussed below.

Peak year employment is the metric used to quantify the number of additional jobs that could be created by the UOG sector. Peak employment is dependent on the number of pads being developed and is also affected by the pad development profiles whereby more jobs are needed when a greater number of pads are built at

Table 5.3 Peak year employment comparisons.

Peak year employment (FTE)		Central	High	Low	Ocean Gateway	Bowland shale area (with hub)	Bowland shale area (without hub)
Direct employment	Shale gas and associated liquids	930	1,280	430	1,482	5,463	2,179
	CBM	-	-	-	NA	NA	NA
Indirect employment	Shale gas and associated liquids	410	1,700	20	1,792	4,683	2,383
	CBM	-	-	-	NA	NA	NA
Induced employment	Shale gas and associated liquids	60	120	20	230	3,002	769
	CBM	-	-	-	NA	NA	NA
Total peak employment		**1,400**	**3,100**	**470**	**3,504**	**13,148**	**5,333**

Source: Ocean Gateway (2014) and Bowland shale (2015), Amion Consulting.

Footnotes: 34. Totals do not add up due to rounding.

the same time. This study assumes that a maximum of three pads would be built in any given year in the Central scenario (4 in the High and 2 in the Low). We assume that once a pad is built, a given worker would then work on the next pad being built; this results in one single job being maintained over a longer time rather than the creation of additional jobs for every pad built. Table 5.3 summarises the results of our analysis of the number of jobs that could arise from UOG development in Scotland while these jobs are created in Scotland, skills limitations may mean they are filled internationally.

The results in Table 5.3 need to be interpreted with caution. Our estimate of jobs differs from the ones presented in the IoD (2013) and EY (2014) studies as our analysis is based on different production development profiles which are specific to Scotland only. The EY (2014) study and the Institute of Directors (2013) study suggest that jobs created in the UK by unconventional gas could be 64,500 (EY) or 74,000 (IoD) at peak and that spend could be up to £33 billion in supply chain activities from 2016 to 2032. We understand that the approach used to calculate peak employment in the EY (2014) and IoD (2013) studies is different to our economic multipliers methodology.

Comparing our peak employment to studies that have looked at a regional development assists the reader in putting our numbers in context. A report by Amion Consulting (2014) on the UK Ocean Gateway area[35] estimates that 3,504 jobs could be associated with the Ocean Gateway development. This is based on estimated cumulative spend to 2035 of £9.8bn[36]. Another study looking at the potential development of a supply hub for the Bowland shale (Amion Consulting, 2015) estimates that for a total of 100 pads (of 10 vertical wells and 40 laterals[37]) peak employment could reach 5,333 jobs if a supply hub is not developed. Alternatively, if a supply hub is developed in the Bowland area to support the development of Bowland shale, the authors estimate that employment could peak at 13,148 jobs. The Deloitte (n.d.) study on the Bowland Basin Shale gas development in the north of England provides estimates that between 6,900 and 23,600 jobs could materialise based on estimates from developed US shale gas fields. It is worth noting that more recent jobs estimates (2015) for the Bowland shale indicate much lower employment impacts than previous estimates (2013, 2014). Direct and indirect jobs will fall under a number of different categories at shown in the Table 5.4 below.

Table 5.4 Employment categories and job type.

Employment categories	Job type
1) Planning and licensing	– Environmental and regulatory approval – Surface leasing and permits – Site excavation, preparation – Drilling – Evaluation
2) Exploration	– Geophysical and geochemical surveys
3) Pad development	– Designing well pad requirements – Installing infrastructure
4) Drilling and completion	– Mobilising drill rig requirements – Cementing casing into bore – Sourcing and receiving drilling mud additives – Drilling and installing production casing
5) Fracturing	– Sourcing and receiving fracturing fluids – Pumping fracturing fluids – Treating/transport waste and waste water – Testing for recovery potential
6) Production	– Confirming well viability – Installing surface facilities – Installing pipe infrastructure
7) Decommissioning and aftercare	– Preparing site for decommissioning – Decommissioning and aftercare

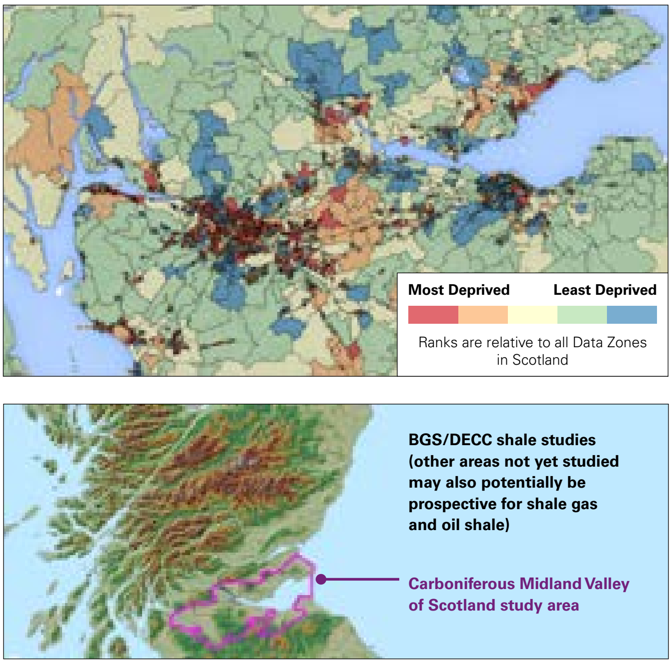
As noted in Section 3.5, we have also taken into consideration the indirect and induced employment effects on industries that form part of the supply chain through the Input-Output table analysis. These sectors include, but are not limited to, repair and maintenance, electricity, gas, water transport, financial services, legal activities, architectural services, etc.

Scotland is host to a large petrochemical sector with 150 manufacturing companies involved in the manufacture of chemical and chemical products as well as refined petroleum products (Fame Databased). The sector currently employs over 3,500 workers (Fame Databased, SIC codes 1920 and 20). Section 5.6 explains how the development of UOG could provide additional employment opportunities in the petrochemical sector and its supply chain and potentially help to provide increased competitiveness to existing industries.

Also noted in section 3.5, economic impacts from the potential development of the UOG sector could be dispersed across large areas of Scotland and it is not clear exactly where these jobs would be created. As

Footnotes:
35. The Ocean Gateway area covers Liverpool, Manchester, Cheshire and Warrington.
36. The Ocean Gateway study assumes that 30 sites of 10 vertical wells with 4 horizontal laterals each (40 laterals per production site). This equals to a total of 300 vertical wells and 1,200 laterals
37. Total of 1,000 vertical wells and 4,000 laterals.

Figure 5.1 SIMD zones in the Midland Valley of Scotland.



Source: UK Data Explorer (2012) & British Geological Survey (2014)

shown in Figure 5.1, we note that a large concentration of areas classed as deprived are located in the Midland Valley of Scotland[38]. The development of the UOG sector in the Midland Valley could offer some new employment opportunities as UOG development takes place.

5.4 Contribution to tax/government revenues across the United Kingdom

The activity of the UOG industry and its supply chain has the potential to lead to the generation of tax revenues. In 2013 the UK Government announced a package of measures designed to support the development of shale gas, including streamlining the permit process, new planning guidance in England and Wales and working with operators to seek community benefits payments (HM Treasury, 2013). Subsequent to the 2013 Budget, the Government announced that the full business rates income in England and Wales would be retained locally. The development of tax regimes for UOG is still in early stages and as result of this early stage of development we have made no explicit assumptions regarding the inclusion of specific onshore oil sector tax costs or benefits, our assessment is based on the typical company taxation regime in the UK.

The government held a consultation throughout 2013 but since then very little has been pushed forward with regard to a new tax regime.

As part of the macroeconomic analysis, we assessed the likely impact on tax revenues. This relates to the direct extraction costs and sale of gas/oil as well as the indirect and induced effects from the supply chain[39]. We assess four sources of tax revenues for the UK government from Scottish UOG development:

- Direct taxes on corporates developing UOG;
- Direct taxation on employees in the UOG and other impacted sectors;
- Indirect taxation (VAT) on the goods and services purchased in the supply chain to support UOG development; and
- Local government taxation receipts.

As shown in Table 5.5 we have estimated total tax over the period to 2062 to amount to up to £1,400 million in the Central scenario. These broad estimates serve to illustrate the potential size of the tax revenue across the UK. These receipts have not been further split between Scottish and UK governments, as currently there is no allocation of tax receipts from the sector between Scotland and the remainder of the UK.

Table 5.5 Tax receipts from UOG across the United Kingdom to 2062.

(£ million)		Central	High	Low
Direct tax	Corporation tax	110	860	25
	Labour (Income/NI) tax	250	610	90
Indirect tax (VAT)		890	2,140	310
Rates		150	240	75
Total		**1,400**	**3,850**	**500**

Footnotes:

38. Seven domains are used to measure the multiple aspects of deprivation. This includes employment, income, health, education, skills and training, geographic access to services, crime and housing (ONS & The Scottish Government, 2012). We note that potential employment opportunities from the UOG sector in deprived areas may arise from indirect and induced jobs through the supply chain instead of direct highly skilled (specialists) jobs.
39. Tax receipts are calculated on total spend (including Scotland, the UK and the rest of the world).

Jobs supported by the industry would also lead to reductions in benefit payments, where workers would otherwise be unemployed. This would also add to the exchequer, although these benefits are not counted here. Tax rates are kept constant over time in our analysis.

The Deloitte study (n.d) on the Bowland Basin Shale gas development in the north of England provides estimates of possible tax revenue generation of up to £580 million per annum by 2020. The study points to considerable uncertainty in terms of fiscal impact estimates given the absence of any large scale extraction facility in the UK.

5.5 Contribution to communities

As part of the 2013 package of measures designed to support the development of shale gas, the Government sought to work with operators to seek (at least) a £100,000 community donation per exploratory well and a community revenue stream of (no less than) 1% of revenues during production (HM Treasury, 2013). This forms part of UKOOG's Community Energy Charter and a number of other UK studies on UOG have used this to calculate community benefits payments.

We note that a licence holder announced in 2014 that it would be giving 6% of the shale gas and liquid revenues to homeowners, landowners and communities close to its wells[40]. In our study we have assumed a contribution of 4% of revenues to local communities, which is an approximate midpoint between the Community Energy Charter and the licence holder's position (Community Energy Charter fact sheet, n.d.). Tables 5.6 and 5.7 show the likely contribution to communities from UOG development.

In August 2016 HMT launched a consultation on the Shale Wealth Fund. The purpose of this consultation is for Government to seek views on the delivery method and priorities of the Shale Wealth Fund with a particular focus on five key issues:

- What the government's priorities should be for the Shale Wealth Fund;
- The allocation of funding from the Shale Wealth Fund to different stakeholder groups;
- The extent to which the industry community benefits scheme and the Shale Wealth Fund should be aligned;
- The potential delivery models for the Shale Wealth Fund – to ensure that households and communities benefit; and
- To decide how funds are spent, and how any process should be administered.

This consultation should provide further clarity on how communities could benefit from the exploitation of shale resources in their local communities.

5.6 Contribution to feedstock for other industries

Development of UOG could also generate some spillover effects for large scale industry. UOG could be a source of

Table 5.6 Total cumulative benefit payment under 4% Community benefits payments.

		Central	High	Low
Shale gas	£m	187	578	63
Associated liquids	£m	30	85	1
Total	**£m**	**217**	**663**	**64**

Table 5.7 depicts what community benefits payments may be if operators give 6% of total revenues to local communities

Table 5.7 Total cumulative benefit payment under 6% Community benefits payments (sensitivity).

		Central	High	Low
Shale gas	£m	280	867	94
Associated liquids	£m	45	127	1
Total	**£m**	**325**	**994**	**95**

Footnotes: 40. http://www.ineos.com/news/ineos-group/ineos-plans-25-billion-shale-gas-giveaway/

feedstock to existing manufacturing companies. An increase in the amount of domestically produced liquids/oil and gas through the development of UOG could allow companies to substitute imported energy sources for domestic ones.

One of the main uses of UK oil and related products (NGLs) is for feedstock in other manufacturing industries. Currently around 30% of Britain's oil consumption is used as petrochemical feedstock in UK based manufacturing plants (UK Oil & Gas, 2016). These are companies that use NGLs such as ethane, propane, butane and pentane in the manufacture and production of everyday consumer goods such as plastics, rubber, fertilisers and certain types of fuel. The Scottish chemicals manufacturing sector generates approximately £9.3 billion revenue in Scotland (UK Trade & Investment, 2009) and basic chemicals account for about 40% of the industry's gross value added (Chemical Sciences Scotland, 2010).

In the UK and Scotland there is an established industry for petrochemicals. In Scotland itself there are 150 manufacturing companies involved in the manufacture of chemical and chemical products as well as refined petroleum products. (Fame Database).

Most of these companies are large and well established organisations. These include the likes of INEOS which operate Scotland's largest petrochemical refinery in Grangemouth. The 10 million tonnes of chemical products produced annually at Grangemouth are used as building blocks for a range of everyday consumer goods such as emulsion paint, car fuel tanks, plastic used for plastic bottles, wrappers, food film, carpets, cabling, water pipes, camping gas and many more (Chemical Industries Association, 2012). Increasingly in the UK, sites are beginning to operate in a similar way to Grangemouth whereby the refineries (which use crude oil/NGLs to produce the feedstock) are closely integrated with adjacent petrochemical plants (UKPIA, n.d.). However Grangemouth has been unable to operate at full capacity due to lack of feedstock, and have advocated the use of shale gas as a feedstock announcing they will be using US shale gas ethane to run the plant at full rate (INEOS, 2016).

There is also a large ethylene plant in Fife which was the first plant specifically designed to use NGLs from the North Sea as feedstock. This has an annual capacity of 83,000 tonnes of ethylene and around 50% of this is distributed via the UK ethylene pipeline network (Chemical Industries Association, 2012).

The development of UOG could provide a positive effect on the petrochemical industry in Scotland. One of the key drivers for the petrochemical sector is the increasing demand for refined and petrochemical products and the new discoveries of types of oil and gas such as UOG (BIS, 2012). In both the UK and Scotland imports of petrochemical products exceed exports hence there is an opportunity for import substitution if the UOG sector were to develop to domestically provide feedstock to existing manufacturing plants (Chemical Industries Association, 2012). Current manufacturing companies, for example a number of petrochemical companies, could see a positive impact on their supply chain if UOG is developed – this could be translated into lower costs as they would avoid the costs of importing/transporting their primary input. UKOOG suggest that UK-wide the impact of shale gas development could safeguard up to 100,000 jobs in petrochemicals alone (UKOOG, n.d.)[41] of which a sizeable proportion is located in Scotland.

In the US, the development of shale gas has led to significant investment in the downstream activities of the chemical industry of over USD 100 billion linked to UOG development and has also resulted in US feedstock products now nearly half the price that of the European identical products (Independent Expert Scientific Panel, 2014).

5.7 Development of the supply chain

Should the UOG industry in Scotland develop, there may be a larger product market for potential suppliers and opportunities for investing in research and development, skills and training.

5.7.1 Developing the supply chain

The prospect of being closer to that market may attract downstream elements of the UOG supply chain and, potentially, research and development activity. Scotland is one of the leading economies in Europe in the conventional oil and gas sector and so should the UOG supply chain develop to a size comparable to the conventional oil and gas sector, the country may be well placed to compete within Europe for elements of the UOG industry once its domestic industry has reached a critical size. However, there may be a limited window of opportunity for attracting such activity as other 'centres of excellence' may have started to develop elsewhere. For example, there is an appetite for creating a shale gas supply hub for the Bowland Shale, as emphasised in a recent report by Amion Consulting (April 2015). Once a

Footnotes: 41. This study does not quantify the number of direct, indirect or induced jobs related to the petrochemical sector.

supply hub/chain is established in other parts of the UK or other European countries it will be more difficult to compete and develop a similar hub in Scotland.

A critical success factor for sustainability is a robust and competitive supply chain strategy. Establishing a supply chain for a group of companies wishing to market their specialisms would be crucial. Critical to the success of the supply chain is the participation of strategic supply chain partners (first tier suppliers) who need to be willing to develop long-term relationships. Research suggests that a limited number of first tier suppliers might be a manageable objective at the outset and could be expanded in subsequent years (Constructing Excellence, 2004). For example, there is a need for critical partners capable of reliably supplying products and services at competitive prices. There are already a number of existing suppliers in Scotland that offer products and services for the conventional oil and gas sector. By leveraging their expertise, there could be a significant opportunity to expand product and service offering to supply the UOG sector. This could also attract other specialist suppliers that may be willing to invest in Scotland in response to this window of opportunity. The supply chain opportunity lies in potential new markets such as the manufacturing of high tonnage drill rigs and suppliers to supply existing materials, equipment and services which currently do not exist in the UK. The authors of 'Getting ready for shale gas' (EY, 2014) suggest there is potential for a new £1.6 billion rig manufacturing industry. They further state that there is the potential for £17 billion worth of specialised equipment and skills for manufacturing. Using existing suppliers and logistics channels could contribute to faster supply chain development. For example, there is already an existing logistics chain for the conventional oil and gas sector in Scotland and this could be used for the UOG sector as well. This demonstrates that there are a number of possible synergies that could be captured by developing a supply chain hub in Scotland. Additionally, Scotland already has the critical infrastructure and pipe network in place, and as such the country is well positioned to cope with the potential UOG demand. As more opportunities arise there may be potential for developing new businesses – in water, rail, road, etc. – to service the industry as well.

5.7.2 Contribution to skills, training and research and development

Training and development would be key to bring the Scottish supply chain up to speed with the potential development pathways modelled in our scenarios. Investment in education, especially in the areas of geology, chemicals process and engineering would be required.

'Getting ready for shale gas' (EY, 2014) highlights the fact that the UK does not currently have a developed supply chain and that there is currently a shortage of domestic skills in this industry. Critical roles for the shale sector include petroleum engineers, geoscientists, drillers, hydraulic fracturing personnel, planners and health, safety and environmental experts. Those are skills where the UK does not have extensive onshore expertise. There will also be a need for both specialists and general skills at different levels, therefore the development of UOG provides an opportunity to upskill the existing Scottish talent pool, especially in the context of developing an UOG centre of excellence in Scotland. Many of these critical jobs for UOG development command up to six times the national average salary providing further benefits to the economy.

However, with no substantial development of UOG yet, Scotland may find it difficult to attract overseas experts. Similarly upskilling the current workforce may take a significant amount of time. The EY (2014) study recommends the UK starts to plan for this as early as possible, for example to build modular conversion courses specific to shale and offer international secondment opportunities to accelerate skills transfer. Research councils and universities[42] may also want to support skills development, research and innovation in technologies

The promotion of access to employment opportunities could also play a major role in upskilling the existing talent pool as well as attracting specialists. There may be a role for public sector organisations or economic development agencies such as Scottish Enterprise and Skills Development Scotland and local authorities in promoting employment and training opportunities.

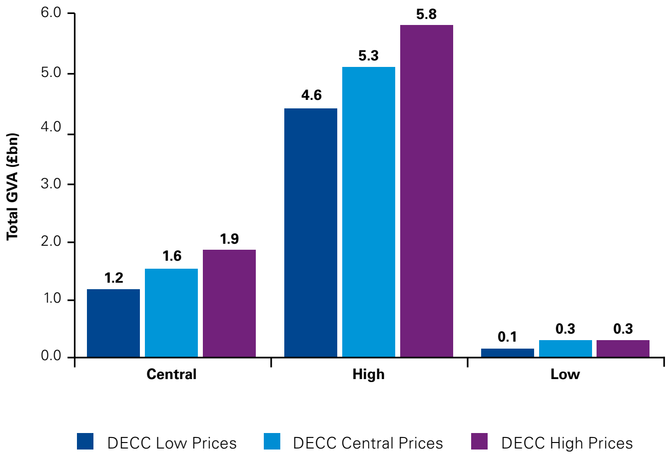
5.8 Sensitivities

Figure 5.2 shows the difference in total direct, indirect and induced GVA under alternative DECC fossil fuel price projections. One can note that GVA varies considerably under different price assumptions. It is worth noting that 2015 DECC fossil fuel price scenarios are higher than current broker/analyst estimates.

There are also greater tax revenues in a higher price environment. This is because operators would be in

Footnotes:
42. For example, the creation of an independent research consortium on hydraulic fracturing, known as ReFINE. The consortium is led jointly by Durham University and Newcastle University, with support from academics across Europe and North America. https://www.dur.ac.uk/dei/resources/briefings/refine/

Figure 5.2 Sensitivity analysis on economic impact: Total GVA under DECC fossil fuel price projections



a position to generate higher profits sooner and thus contribute to corporation tax.

5. 9 Carbon mitigation costs

When we take into consideration the additional expenditure costs of mitigating carbon emissions, the additional economic benefits to the Scottish economy are negligible in terms of GVA. Spend associated with emission technologies is very small in proportion to overall costs. Yet, there would be some capex and opex related jobs for the installation and operation of carbon emission equipment. Our analysis suggests that carbon mitigation measures would generate c100 jobs in the Central scenario, 160 in the High scenario and c40 jobs in the Low scenario.

Table 5.8 presents the results of our analysis.

5.10 Other considerations

This study has evaluated the economic impacts of UOG in terms of its contribution to GVA, employment, tax/ government revenues, community benefits payments, feedstock for other industries, supply chain and skills, training and development. In this section we provide commentary analysis on other economic and environmental/societal impacts UOG may have on the Scottish economy. This includes considerations such as house price trends, roads, water and health. As these considerations are harder to quantify, we have considered these qualitatively as they are important in relation to the development of UOG.

5.10.1 Other economic considerations

Housing prices

Living in satisfactory housing conditions is one of the most important aspects of people's lives. Housing costs take up a large share of the household budget and represent the largest single expenditure for many individuals and families (OECD: Better Life Index, n.d.). Changes in house prices can have considerable effects on the rest of the economy. For example, a change in house prices affects the value of household wealth.

The evidence around the effect on housing prices in relation to the potential development of UOG is mixed. For example, there is a concern that it could lead to a significant reduction in housing prices for the surrounding areas due to reluctance of residents to be within close proximity to a perceived noise and air pollution. In the areas close to the Cuadrilla site in the UK, UK mortgage and estate agent industry blogs have reported a drop in house prices (Independent Expert Scientific Panel, 2014) (Property and Land Information, 2012). Similarly perceived effects have also been seen in Canada (Barth, 2013) and other parts of the US (Munasib & Rickman, 2014). One study by the US National Bureau of Economic Development has found that those living within two miles

Table 5.8 Estimated cumulative economic impact to 2062 including carbon mitigation costs

Estimated cumulative economic impact to 2062	Excluding carbon mitigation costs			Including carbon mitigation costs		
	Central	High	Low	Central	High	Low
Total spend (£bn)	4.4	10.8	1.5	4.4	10.8	1.5
Spend in Scotland (£bn)	2.2	6.5	0.5	2.2	6.5	0.5
Total additional economic impact of UOG spend in Scotland (£bn)	1.2	4.6	0.1	1.2	4.6	0.1
Additional jobs created (at peak employment year)	1,400	3,100	470	1,500	3,260	510

of a shale gas field in the US could see house prices fall due to perceived groundwater risk (Muehlenbachs, Spiller, & Timmins, 2012). In their submission on Economic Impact and Scenario development, Scottish Environment LINK noted that "a Defra report and an investigation by journalists at the Ferret, have suggested that fracking could have an adverse impact on house prices, estimating house prices may be affected by up to 10%" (Department for Environment, Food and Rural Affairs, 2015).

In contrast, other studies suggest that, at least temporarily, there is a positive effect on housing prices in areas near UOG production sites. The construction peak of a large mining project requires a large workforce and this is likely to increase the demand for accommodation in local areas. Areas surrounding CBM sites in Queensland saw house prices rise versus the Queensland median (Australian Government, 2015). This is similar in some areas in the US where Colorado saw significant increases in housing prices in surrounding areas (Independent Expert Scientific Panel, 2014) (Witter, et al., 2008).

Without further UK specific evidence, it may be too early to conclude what the effect on house prices could be.

Roads

The potential impacts of UOG on roads were raised in our consultation with key stakeholders. This issue is discussed in the research project on understanding and mitigating community level impacts on transport commissioned by the Scottish Government.

Regulatory costs

Both the Broad Alliance and Scottish Environment LINK expressed their views regarding the costs of UOG regulation and that this should not be borne by the public. Similarly, COSLA noted that "costs in relation to proposed or actual UOG activity should not be borne by planning authorities, or have to be extracted from difficult to source operators to fund restoration/aftercare". We acknowledge the importance of taking into account the costs of developing and applying a regulatory and enforcement regime for UOG, including the costs of ongoing monitoring. This topic is covered in the site restoration and aftercare study. In developing our scenarios, we have included a number of additional costs to reflect those related to the development and enforcement of a regulatory regime. The same cautious approach was used in developing our cost base for decommissioning and aftercare costs.

5.10.2 Other environmental/societal considerations

The Independent Expert Scientific Panel report concluded that "many of these social (and environmental) impacts can be mitigated if they are carefully considered at the planning and application stage. Added to which, there are already considerable legislative safeguards to ensure such impacts are not realised" (Independent Expert Scientific Panel, 2014).

Water use, water contamination, wastewater disposal and impacts on biodiversity

UOG activities could have an impact on water, for example there is a possible risk of water contamination through any escape of 'flowback fluids' into the ground that contain chemical additives associated with hydraulic fracturing. In their submission to KPMG on Economic Impact, the Broad Alliance noted that the National Farmers Union journal, Farmers Weekly, reports concerns regarding UOG development on possible damage to properties, contamination of groundwater and the potential for damage to land, crops and livestock (Farmers Weekly, 2016).

In addition, Scottish Environment LINK expressed their concern regarding the quantities of water needed to fracture a well and the disposal of the flowback fluids given the current limited number of waste facilities able to treat waste fluid of this sort.

A report by the Environment Agency (EA) suggests there is low risk of groundwater contamination at the exploratory stage (Environment Agency, 2013) but does not comment on the longer term risks during the production phase. The EA's views on groundwater contamination at the exploratory stage is consistent with what has been observed in Queensland, Australia, where water contamination risks have been managed and hence no sub-surface equipment leaks have been reported (Australian Government, 2015).

The UOG sector is sometimes associated with possible impacts on biodiversity. Biodiversity is the variety of plant and animal life in a particular habitat which is considered to be important and desirable.

Possible methane leaks associated with UOG exploration/operations are also a concern given that methane is a greenhouse gas and may impact biodiversity. Scottish Environment LINK expressed their concern regarding groundwater contamination from well leakage and migration of contaminants from fractured shale/coal seams, as well as accidental surface spillages of waste fluids and the related impacts on biodiversity. Yet, it is worth noting that estimates from the National Assembly for Wales (2015) suggest the risk of pollution by possible fugitive emissions at the exploratory stage are low. We do acknowledge Scottish Environment LINK's view in that despite a low risk of pollution, the potential for long-term impacts and costs associated with any potential incident could be important. A recent publication by Dalzell (2016) suggests that the cost to mitigate these methane leaks may exceed the lifetime revenues generated by the well which produced them. The author also stipulates that the UK has a poor record of ensuring adequate decommissioning and restoration bonds which may lead to further public funding being required (Dalzell, 2016). Further analysis of this issue and potential regulatory approaches/ mitigations are considered in the Climate change impacts and Decommissioning site restoration and aftercare research projects.

Air quality, air emissions and climate change

The concern around air quality and air emissions relates to both CO_2 and methane which are produced as part of the UOG production process. The National Assembly of Wales alluded to the idea that UOG could reduce the UK's carbon emissions as it is considered by some to be a low carbon fossil fuel (National Assembly for Wales, 2015). Emissions from electricity generated from shale gas are estimated at around 2% to 10% lower than electricity generated from conventional pipeline gas located outside of Europe (AEA, 2012), LNG imports also result in higher emissions as a result of carbon emissions from transportation vessels.

Climate change is an aspect considered in the CCC research project. Costs associated with monitoring carbon emissions have been included in all of our scenarios. We have also considered the costs of mitigating emissions in Sections 5.9 and C.7. The CCC has performed some analysis on the UOG scenarios developed in the study in the context of national carbon budgets.

Agriculture

The impact on agriculture comes from the reduction of available agriculture land and potential contamination as it is used for oil and gas extraction. Dalzell (2016) highlights the fact that "[a] rapid boom may lead to rapid industrialisation and subsequent collapse of a rural community leading to a loss of identity as what may have, in one example, previously identified as a 'fishing village' becomes a derelict industrial estate". Input from Nourish Scotland (through Scottish Environment LINK) suggests there could be a reputational impact on farmers and producers, retail and catering in case of actual contamination and the perceived risk of contamination, looking both at internal consumption and exports.

Agricultural producers are also concerned about the possible risks related to UOG development, specifically both groundwater and soil contamination. Some commentators assert that both crops and animal stock could be poisoned by possible adverse chemical spills from UOG activities into the soil and water (Drouin, 2014) (Wilson, 2014).

The role of renewables

Both Scottish Environment LINK and the Broad Alliance expressed their concern regarding the impact of the UOG sector on energy produced by renewable sources. Scottish Environment LINK drew our attention to a report by the International Energy Agency (IEA) which state the following: "An abundance of natural gas might diminish the resolve of governments to support low and zero-carbon sources of energy: lower gas prices (and therefore lower electricity prices) can postpone the moment at which renewable sources of energy become competitive without subsidies and, all else being equal, therefore make renewables more costly in terms of the required levels of support" (International Energy Agency, 2012). The IEA goes on to add that "[…] an expansion of gas in the global energy mix can also facilitate greater use of renewable energy, if policies are in place to support its deployment, given that gas-fired power generation can provide effective back-up to variable output from certain renewable sources. Moreover, lower electricity prices can encourage customer acceptance of a higher component of electricity from renewable sources. Ultimately, the way that renewables retain their appeal, in a gas-abundant world, will depend on the resolve of governments" (International Energy Agency, 2012).

Our analysis demonstrates that the industry would not be large enough to have an impact on international gas prices. As such, it is not directly obvious that the potential development of UOG would suppress investment in renewables.

Visual amenity

Scottish Environment LINK and the Broad Alliance expressed their concern regarding landscape impacts and visual amenity. Scottish Environment LINK noted that DECC's Strategic Environmental Impact Assessment for the 14th onshore oil and gas licencing round plans highlighted that "there is potential for a significant negative effect on landscape associated with onshore oil and gas activities. This principally reflects the potential landscape and visual impact of construction activities and associated machinery such as drilling rigs" (DECC, 2013). Scottish Environment LINK added that networks of access roads, pipelines, gas and water treatment facilities, vents and flares can also have an impact on visual amenity[43].

Yet, the Independent Scientific Expert (2014) study asserts that "the use of drilling rigs where multiple pads are developed in a given area is considered to have a moderate risk of significant visual effects especially in residential areas". This is due to the size of parts of the drilling rigs which can be up to 30 meters in height. Once production is complete, the drill hole is capped with an extraction point and protective cage which is approximately 3 meters high suggesting the permanent visual impact is much less after hydraulic fracturing completion (Independent Expert Scientific Panel, 2014).

There have also been cases where impact on visual amenity is limited. The often-cited example of Wytch farm in Dorset, UK, is one of the largest onshore oilfields in Western Europe. The oilfield is within an area of outstanding natural beauty and local residents claim "most people don't even notice it's there" (Gray, 2013). The National Assembly for Wales highlighted in their research paper on UOG the fact that hydraulic fracturing and drilling can take place beneath areas of natural beauty providing the well site is located outside the boundaries (National Assembly for Wales, 2015).

Health related costs

The impact on public health is also referenced in relation to UOG development. There are various associations of UOG to public health risks such as hazards to workers on site, hazards associated with the impacts on infrastructure and also possible risks from atmosphere. Some evidence suggests that chemicals used in hydraulic fracturing could have adverse health impacts (Independent Expert Scientific Panel, 2014). However, for the majority, any undesirable impacts would only occur from exposure to very high concentrations of the substance which is something that could be controlled and hence the risk could be limited/mitigated with robust regulation (Independent Expert Scientific Panel, 2014). The impacts on health are covered in a separate research project (Public Health Impact Assessment) being undertaken on behalf of the Scottish Government.

The House of Lords analysis concludes that for the UK "potential risks to public health from exposure to the emissions associated with shale gas extraction are low if the operations are properly run and regulated" (House of Lords, 2014). This is similar to the conclusions made in a CBM report commissioned by the Australian Government, i.e. there are very few studies that demonstrate a correlation between CBM activities and adverse health outcomes, much less a causal relationship (Australian Government, 2015).

Footnotes: 43. It is worth noting that some of these aspects can be mitigated by delivering water via pipe instead of tankers and by transporting gas away by pipeline without flaring for example.

Appendix A

Bibliography

AEA. (2012, July). Climate impact of potential shale gas production in the EU: Final report.
Retrieved from http://ec.europa.eu/clima/policies/eccp/docs/120815_final_report_en.pdf

Amion Consulting. (2014, June). Potential Economic Impacts of Shale Gas in the Ocean Gateway.
Retrieved from http://www.igasplc.com/media/10851/ocean-gateway-shale-gas-impact-study.pdf

Amion Consulting. (2015, April). Shale Gas - Creating a Supply Hib for the Bowland Shale.
Retrieved from http://www.peelgasandoil.co.uk/media/Peel_Gas_and_Oil_Ltd_-_Shale_Gas_-_Creating_a_supply_hub_for_the_Bowland_Shale_FINAL_100415.pdf

Australian Government. (2015). Review of the socioeconomic impacts of coal seam gas in Queensland.
Retrieved from http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/coal-seam-gas/Socioeconomic-impacts-of-coal-seam-gas-in-Queensland.pdf

Barth, J. M. (2013). The economic impact of shale gas development on state and local economies: benefits, costs and uncertainties.
Retrieved from http://www.cbu.ca/wp-content/uploads/2015/10/l0t8274802306125.pdf

BIS. (2012, August 8). Oil, gas, refining and petrochemicals: international trade regulations.
Retrieved from Gov.uk: https://www.gov.uk/guidance/oil-gas-refining-and-petrochemicals

Bloomberg. (2016, June 2). Is It Really Summer? U.K. Natural Gas Trades Like It's Winter.
Retrieved from http://www.bloomberg.com/news/articles/2016-06-02/is-it-really-summer-u-k-natural-gas-trades-like-it-s-winter

Bounds, A., & Stacey, K. (2016, May 16). North Yorkshire approves UK's first fracking tests in 5 years.
Retrieved from Financial Times: http://www.ft.com/cms/s/0/d40af152-2110-11e6-9d4d-c11776a5124d.html#axzz4Az3Vi7ZC

British Geological Survey. (2014). The Carboniferous shales of the Midland Valley of Scotland: geology.
Retrieved from DECC: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360471/BGS_DECC_MVS_2014_MAIN_REPORT.pdf

BVG Associates. (2015, November 17). The UK content of operating offshore wind farms.
Retrieved from Renewable UK: http://www.renewableuk.com/news/279486/The-UK-Content-of-Operating-Offshore-Wind-Farms.htm

Chemical Industries Association. (2012, May). Advantage Scotland.
Retrieved from http://www.cia.org.uk/Portals/0/scotland%20brochure%20final.pdf

Constructing Excellence. (2004, March 19). Supply Chain Management.
Retrieved from http://constructingexcellence.org.uk/wp-content/uploads/2015/03/supplychain.pdf

Dalzell, D. C. (2016, April). The Economics of Shale Gas Extraction.
Retrieved from Common Weal Policy: http://allofusfirst.org/tasks/render/file/?fileID=B60C60DC-9E11-9DF7-448E84BA4CC8E6D4

Davies Boren, Z. (2015, August 20). Super low gas price spells trouble for fracking in the UK.
Retrieved from Energy Desk: http://energydesk.greenpeace.org/2015/08/20/super-low-gas-price-spells-trouble-for-fracking-in-the-uk/

DECC. (2013). DECC Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing Environmental Report.
Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/273997/DECC_SEA_Environmental_Report .pdf

DECC. (2013). The unconventional hydrocarbon resources of Britain's onshore basins - coalbed methane.
Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/367286/Promote_UK_CBM_2012.pdf

DECC. (2015, November). Amber Rudd's speech on a new direction for UK energy policy.
Retrieved from DECC: https://www.gov.uk/government/speeches/amber-rudds-speech-on-a-new-direction-for-uk-energy-policy

DECC. (2015, November). Fossil Fuel Price Assumptions.
Retrieved from DECC: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477958/2015_DECC_fossil_fuel_price_assumptions.pdf

DECC. (2015). Updated energy and emissions projections: 2015.
Retrieved from Annex J: total electricity generation by source: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2015

DECC. (2016, April 4). Oil and gas: field data.
Retrieved from https://www.gov.uk/guidance/oil-and-gas-uk-field-data

Deloitte. (n.d.). Potential Bowland Basin shale gas development: Economic and fiscal impacts.
Retrieved from http://www2.deloitte.com/content/dam/Deloitte/uk/Documents/energy-resources/potential-bowland-basin-shale-gas-development.pdf

Department for Business Innovation and Skills. (2015, March). The size and performance of the UK low carbon economy.

Department for Environment, Food and Rural Affairs. (2015, July 1). Draft Shale Gas Rural Economy Impacts paper.
Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440791/draft-shale-gas-rural-economy-impact-report.pdf

D'Hernoncourt, J., Cordier, M., & Hadley, D. (2011, January). Input-Output Multipliers Specification Sheet and Supporting Material.
Retrieved from SPICOSA: http://www.coastal-saf.eu/output-step/pdf/Specification%20sheet%20I_O_final.pdf

Drouin, R. (2014, August 3). Fracking the Farm: Scientists worry about chemical exposure to livestock and agriculture.
Retrieved from http://www.truth-out.org/news/item/25216-fracking-the-farm-scientists-worry-about-chemical-exposure-to-livestock-and-agriculture

Appendix A

Bibliography

Environment Agency. (2013). An Environmental Risk Assessment for shale gas exploratory operations in England.

EY. (2014, April). Getting ready for shale gas: Supply chain and skills requirements and opportunities.
Retrieved from http://www.ey.com/Publication/vwLUAssets/Getting_ready_for_UK_shale_gas/%24FILE/EY-Getting-ready-for-UK-shale-gas-April-2014.pdf

FAME database. (n.d.).

Farmers Weekly. (2016, June 2). Insurance unlikely to cover fracking damage, farmers warned.
Retrieved from http://www.fwi.co.uk/business/insurance-unlikely-to-cover-fracking-damage-farmers-warned.htm

Gray, L. (2013, August 10). The town where a form of 'fracking' is already happening.
Retrieved from The Telegraph: http://www.telegraph.co.uk/news/earth/earthnews/10233955/The-town-where-a-form-of-fracking-is-already-happening.html

Hefley, W. E., & Seydor, S. M. (2011, August). The Economic Impact of the Value Chain of a Marcellus Shale Well.
Retrieved from University of Pittsburgh. PittBusiness: http://www.business.pitt.edu/faculty/papers/PittMarcellusShaleEconomics2011.pdf

HM Government. (2012, December). The Nuclear Supply Chain Action Plan.
Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65658/7176-nuclear-supply-chain-action-plan.pdf

HM Treasury. (2013, December 10). Harnessing the potential of the UK's natural resources: a fiscal regime for shale gas.
Retrieved from https://www.gov.uk/government/consultations/harnessing-the-potential-of-the-uks-natural-resources-a-fiscal-regime-for-shale-gas/harnessing-the-potential-of-the-uks-natural-resources-a-fiscal-regime-for-shale-gas

Independent Expert Scientific Panel. (2014, July). Report on Unconventional Oil and Gas.
Retrieved from http://www.gov.scot/Resource/0045/00456579.pdf

INEOS. (2014, October 13). NEOS acquire majority interest in Shale Gas licence (PEDL pedl 162) in Scotland from Reach Coal Seam Gas Limited.
Retrieved from INEOS: http://www.ineos.com/news/ineos-group/ineos-acquire-majority-interest-in-pedl-162

INEOS. (2014, September 28). INEOS plans £2.5 billion shale gas giveaway.
Retrieved from http://www.ineos.com/news/ineos-group/ineos-plans-25-billion-shale-gas-giveaway/

INEOS. (2015). Grangemouth.
Retrieved from http://www.ineos.com/sites/grangemouth/

INEOS. (2016, March 29). The Grangemouth shale gas revolution moves closer to reality.
Retrieved from INEOS: ttp://www.ineos.com/sites/grangemouth/news/the-grangemouth-shale-gas-revolution-moves-closer-to-reality

Institute of Directors. (2013). Getting shale gas working.
Retrieved from http://www.igasplc.com/media/3067/iod-getting-shale-gas-working-main-report.pdf

International Energy Agency. (2012, November 12). Golden Rules for a Golden Age of Gas.
Retrieved from World Energy Outlook: Special Report on Unconventional Gas: http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf

International Energy Agency. (2015). Key World Energy Statistics.
Retrieved from http://www.iea.org/publications/freepublications/publication/KeyWorld_Statistics_2015.pdf

Muehlenbachs, L., Spiller, E., & Timmins, C. (2012, September). Shale gas development and property values: differences across drinking water sources.
Retrieved from http://www.nber.org/papers/w18390

Munasib, A., & Rickman, D. S. (2014, July 27). Regional economic impacts of the shale gas and tight oil boom: A synthetic control analysis.

National Assembly for Wales. (2015, March). Unconventional Gas: shale gas and coal-bed methane.

National Statistics. (2016, February 10). Quarterly National Accounts Scotland: Quarter 3 2015.
Retrieved from Scottish Government: http://www.gov.scot/Resource/0049/00493867.pd

OECD: Better Life Index. (n.d.). Housing.
Retrieved from http://www.oecdbetterlifeindex.org/topics/housing/

Office for National Statistics. (2015). Summary of labour market statistics: A01.
Retrieved from http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/summaryoflabourmarketstatistics

Oil and Gas UK. (2015). Economic Report.
Retrieved from http://oilandgasuk.co.uk/wp-content/uploads/2015/09/Oil-Gas-UK-Economic-Report-2015-low-res.pdf

Oil and Gas UK. (n.d.). Glossary.
Retrieved from http://oilandgasuk.co.uk/glossary.cfm

ONS & The Scottish Government. (2012, December 18). Scottish Index of Multiple Deprivation 2012.
Retrieved from http://22fa0f74501b902c9f11-8b3fbddfa1e1fab453a8e75cb14f3396.r26.cf3.rackcdn.com/simd_448749_v7_20121217.pdf

Oxford Economics. (n.d.). Economic Impact Analysis.
Retrieved from https://www.oxfordeconomics.com/economic-impact/economic-impact-analysis

Poyry. (2013, November). Macroeconomic effects of European shale gas production.
Retrieved from http://www.poyry.co.uk/sites/poyry.co.uk/files/public_report_ogp__v5_0.pdf

Appendix A
Bibliography

Property and Land Information. (2012, June 25). Fracking Effects House Prices.
Retrieved from Property and Land Information: http://www.paliltd.com/blog/fracking-effects-house-prices

Resources for the Future. (2013, May). US Shale Gas Development - What led to the boom?
Retrieved from http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-IB-13-04.pdf

Reuters. (2016, February 24). U.S. exports first shale gas as LNG tanker sails from Sabine Pass terminal.
Retrieved from http://www.reuters.com/article/us-shale-export-idUSKCN0VY08B

Scottish Enterprise. (2008, November 1). Additionality & Economic Impact Assessment Guidance Note.
Retrieved from https://www.scottish-enterprise.com/~/media/se/resources/documents/abc/additionality-and-economic-impact-assessment-guidance.pdf

Scottish Government. (2015, June). Oil and Gas Analytical Bulletin.
Retrieved from http://www.gov.scot/Resource/0048/00480348.pdf

Scottish Government. (2016, March). Government expenditure and revenue Scotland 2014-2015.
Retrieved from http://www.gov.scot/Resource/0049/00495386.pdf

Scottish Government. (n.d.). Business and Regulatory Impact Assessment.
Retrieved from http://www.gov.scot/Topics/Business-Industry/support/better-regulation/guidance/Guidance

Shale Gas Europe. (n.d.). Shale Gas Explained.
Retrieved from http://shalegas-europe.eu/shale-gas-explained/shale-gas-and-europe/france/

Task Force. (2015). Task Force on Shale Gas: Economic Impacts.
Retrieved from https://www.taskforceonshalegas.uk/reports

The Ferret. (2015, December 8). Fracking could cut house prices 10%, say experts.
Retrieved from https://theferret.scot/fracking-property-prices-scotland/

The Scottish Government. (2015). Energy in Scotland 2015.
Retrieved from http://www.gov.scot/Resource/0046/00469235.pdf

U.S. Department of Energy. (n.d.). National Energy Technology Laboratory.
Retrieved from http://www.netl.doe.gov/

U.S. Energy Information Administration. (2012, April 20). Today in Energy.
Retrieved from What are natural gas liquids and how are they used?: http://www.eia.gov/todayinenergy/detail.cfm?id=5930

U.S. Energy Information Administration. (2015, April 28). Projections show U.S. becoming a net exporter of natural gas.
Retrieved from Today in Energy: http://www.eia.gov/todayinenergy/detail.cfm?id=20992

U.S. Energy Information Administration. (2015, September 24). World Shale Resource Assessments Analysis & Projections.
Retrieved from https://www.eia.gov/analysis/studies/worldshalegas/

UK Data Explorer. (2012). Scottish Index of Multiple Deprivation 2012.
Retrieved from http://ukdataexplorer.com/simd/

UK Oil & Gas. (2016, May 19). Kimmeridge Oil Britannia.
Retrieved from UKOG energy for Britain: http://www.ukogplc.com/ul/UKOG%20Kimmeridge%20Oil%20Shale%20World%2019%20May%202016.pdf

UK Trade & Investment. (2009, January). Chemicals - the UK advantage.
Retrieved from Adding value for global investors and industry: http://www.cia.org.uk/Portals/0/downloads_pdf_1_Chemicals-Brochure-FINAL-JAN-09.pdf

UKOOG. (n.d.). Drilling and the Hydraulic Fracturing Process.
Retrieved from http://www.ukoog.org.uk/onshore-extraction/drilling-process

UKOOG. (n.d.). Economic Benefits.
Retrieved from http://www.ukoog.org.uk/economy/benefits

UKpia. (n.d.). Petrochemicals.
Retrieved from http://www.ukpia.com/industry_information/marketing/petrochemicals.aspx

White, E., Fell, M., & Smith, L. (2016, January 15). Briefing paper: Shale gas and fracking.
Retrieved from House of Commons Library: http://www.parliament.uk/briefing-papers/sn06073.pdf

Wilson, A. (2014). The real cost of Fracking: How America's shale gas boom is threatening our families pets and food.
Retrieved from https://www.researchgate.net/profile/Allison_Wilson2/publication/280239017_The_Real_Cost_of_Fracking_How_Americas_Shale_Gas_Boom_Is_Threatening_Our_Families_Pets_and_Food_Reviewed_by_Allison_Wilson_

Witter, R., Stinson, K., Sackett, H., Putter, S., Kinney, G., Teitelbaum, D., & Newman, L. (2008, September 15). Potential Exposure-Related Human Health Effects of Oil and Gas Development.
Retrieved from https://www.nrdc.org/sites/default/files/hea_08091702a.pdf

Appendix B

Survey of relevant research

B.1 Context

Our views regarding potential development scenarios for UOG in Scotland and the approach to assessing the economic impact of the industry have been informed by a review of work that has been undertaken to assess the impact of UOG both in the UK and internationally. This appendix summarises some of the key papers we have assessed.

The research we reviewed covered a range of areas, with particular focus on:

- The UOG sector in Scotland, the UK and internationally;
- Economic impact assessment techniques from academic and government sources; and
- Methodologies employed in other Economic Impact Assessments for the UOG sector.

This enabled us to understand the various methodologies used in other UOG economic impacts studies and assess their strengths and limitations. The review also allowed us to identify factors that have been included or excluded in these studies in the past.

B.2 Reviews of UOG in Scotland, the UK and internationally

Given that the UOG sector in Scotland is in its infancy, there is a limited number of publically available data and studies on the subject.

The latest position of UOG in Scotland is the 'Report on Unconventional Oil and Gas' by the Independent Expert Scientific Panel (2014) on behalf of the Scottish Government. This study assesses the scientific evidence relating to UOG (including shale gas, associated liquids and CBM) and includes summaries of the geological and seismic evidence. The study also considers at length the regulatory requirements for the development of the UOG sector in Scotland. The authors conclude that there could be potential for positive economic impacts in terms of jobs created, taxes paid and gross value added from developing the UOG sector in Scotland. The authors stipulate that the industry could be developed at a reasonable scale, based on UK scenarios from reports by the (Institute of Directors (2013) and EY (2014) which suggest jobs created in the UK by unconventional gas could be between 64,500 and 74,000 at peak and spend could be up to £33 billion in supply chain activities between 2016 to 2032. The report also identified that any community impacts such as concerns around water contamination, public health, seismicity, climate impacts and wider social impacts could be mitigated as long as they are carefully considered and communities are consulted as early as possible.

There is a wider range of reports on the UOG sector for the UK. One of the key reports "Getting Shale Gas Working' (Institute of Directors, 2013)" also outlines the benefits of developing shale gas in terms of exports, taxes, job creation and environmental benefits. The authors used a scenarios-based approach to demonstrate what the industry may look like in terms of production capacity and cost profiles. The report provides a breakdown of costs and production profiles for a smaller pad of 10 wells with one lateral each (10 laterals in total) and a larger pad of 10 wells with four laterals each (40 laterals in total). The authors assume that for the smaller pad, expected gas production could reach 31.6 bcf over lifespan, with required investment of £142 million (per pad) and that each single pad could create up to 406 jobs at peak (total of direct, indirect and induced). For the larger pad, the authors assumed that production could reach 126.2 bcf over lifespan, with investment of £514 million of investment and 1,104 jobs created at peak (total of direct, indirect and induced). In addition to the single pads cases presented in the study, the authors provide an illustrative example of what widespread development could look like in the UK. This widespread development scenario assumes that shale gas production could reach commercial scale and that a hypothetical development of 100 pads of 10 wells of four laterals each (i.e. a total of 4,000 laterals) could produce between 853 bcf and 1,389 bcf per annum at peak. Under this scenario combined capex and opex would peak at £3.7 billion and jobs would peak at 74,000 in total (direct, indirect and induced). This UK-wide study did not provide a breakdown of the benefits by region/country.

'Getting ready for shale gas' (EY, 2014) analyses the cost profiles and supply chain impacts associated with development of shale gas in the UK. The authors highlight the fact that the UK does not currently have a developed supply chain and that there is currently a shortage of domestic skills in this industry. The authors suggest there is potential for a new £1.6 billion rig manufacturing industry and a new market for existing UK businesses. Compared to the Institute of Directors (2013) study, the EY report estimates that the shale gas industry could

 KPMG

provide for 64,500 jobs. Both reports agree on the fact that the industry would provide an opportunity for skills development within the UK.

Similarly, Amion Consulting produced reports on the UK Ocean Gateway potential (2014) and the Bowland Shale (2015). It considers the six main stages of activity involved in shale gas extraction, which are in line with those identified by EY (EY, 2014). The authors based the cost profiles on sites of 10 vertical wells of four laterals each and then use economic multipliers to calculate the economic impacts. Finally, the UK Ocean Gateway study estimates cumulative spend to 2035 of £9.8 billion and potential number of jobs in the UK at over 3,504 associated with Ocean Gateway. The 2015 report estimates cumulative spend to 2048 of £30.6 billion and potential number of jobs in the UK at over 5,300 without a supply hub and 13,100 with a supply hub.

In line with the reports mentioned above, the Task Force (2015) published a report on the economic impact of shale gas and concluded that the UOG sector could create thousands of jobs for the country. The Deloitte (n.d.) study on the Bowland Basin Shale gas development in the north of England provides estimates of possible tax revenue generation of up to £580 million per annum by 2020 as well as the number of jobs the industry could support. They estimate that between 6,900 and 23,600 jobs could materialise based on estimates from developed US shale gas fields.

Of reports on the UOG sector internationally, Hefley and Seydor (2011) give an overview of the costs associated with building a Marcellus shale well. They estimate direct costs of nearly USD 8 million per well. The authors conclude that although the costs are significant, the development will deliver considerable economic benefits to the region through supply chain development, particularly where companies can outsource. The study highlights the opportunity to enter a new market for small business owners. The report also highlights further studies that have projected up to 110,000 jobs in Pennsylvania (Hefley & Seydor, 2011).

A study conducted by the Australian Government analyses the costs and benefits of coal bed methane in Queensland (Australian Government, 2015). The authors identify and assess the 'socioeconomic' impacts and so consider community costs and benefits as well, such as physical and mental health impacts, environmental and physical impacts and demographic and social change. The conclusions drawn are that the economic impacts of CBM development are net positive; for example, during the peak construction period for CBM in Queensland unemployment fell in the Surat Basin by 2.8% and in the Bowen Basin by 2.1% (although this cannot all be attributed to the CBM sector only). Another example is that there was an increase in the number of high income residents in CBM regions with direct value added to Gross State Product (GSP) in 2013-2014 of AUD 13.3 billion (USD 10.18 billion; GBP 7.15 billion). However, it was found that the community impacts were more variable with positives and negatives mostly due to how the impacts are distributed. The report also highlights that evidence so far suggests there has only been negligible impacts on water and air quality.

B.3 What is typically considered in an 'economic impact assessment'?

Typically an economic impact assessment measures three main impacts: 1) Direct impacts to GDP, employment, wages etc. 2) Indirect impacts and 3) Induced impacts (Oxford Economics, n.d.). Direct impacts are those that are directly associated with the developing industry, for example an increase in capital expenditure may cause a rise in GDP. Indirect and induced impacts are deduced from economic multipliers which are generated by bodies such as Office for National Statistics (ONS) in the UK using Input-Output tables. Input Output tables are a tool used to identify the amount of spend occurring in an economy between different industries. From this it is possible to identify how a change in one industry can impact others.

B.4 Topics considered in other economic impact assessments for UOG

UK-based Economic Impact Assessments on UOG consider the following range of impacts:

- The costs of production, although studies differ on which components to include. Both EY (2014) and Institute of Directors (2013) do not explicitly appear to include costs associated with planning and licensing and exploration;
- The effect on GDP/GVA and expenditure;
- The effect on employment and wages;

Appendix B

Survey of relevant research

- The development of further skills and infrastructure – for example the EY (2014) report 'Getting ready for shale gas' did an extensive review on the matter; and
- Tax revenues and allocation of community benefits payments to local communities.

A study by Poyry (2013) on the macroeconomic effects of European shale gas production also includes the effects of UOG development on gas and energy markets, including impact on prices and fuel imports. Further impacts are also considered in a report on UK shale by Amion Consulting (2014) where the authors consider impacts on business competitiveness and the related costs of seismic testing.

From the studies reviewed for the purpose of this Report, the UOG-related economic impact assessments do not tend to include evaluations or quantifications of the potential environmental impacts of UOG development. Some socioeconomic studies that have tried to do this for example a report entitled 'Review of the socioeconomic impacts of coal seam gas in Queensland' suggested that community impacts may have a greater influence on welfare in the long run than more traditional economic impacts such as employment and GDP (Australian Government, 2015). However, even within these studies there are some limitations to quantifying these impacts, and socioeconomic impacts therefore tend to be handled in a qualitative manner.

Appendix C

Assumptions underlying the scenarios

C.1 Resources

C.1.1 Products considered

Three sources of unconventional of oil and gas are considered as part of this study namely:

- Gas extracted from onshore sources using hydraulic fracturing;
- Associated liquids extracted from onshore sources using similar recovery techniques; and
- Coal bed methane.

The evidence base suggests that the focus for developers is shale gas development with associated liquids as a secondary priority. That is the reason why we have modelled shale gas and liquids together as liquids is a premium to gas.

The evidence base on coal bed methane is limited, especially in the Scottish context. Resource estimates for CBM are approximate[44] and thought to be located in the same geographical areas as shale gas/oil and liquids. Based on surface access, geology, development costs and estimated well recovery rates, CBM is currently unlikely to be a major product in Scotland. As such, we have assumed that only two CBM pads would be developed.

C.1.2 Location of resources and use of land

We have only considered resources in the Midland Valley for development as part of this study. The Midland Valley region appears to have the concentration of resources to support an integrated supply chain. We recognise that there are resources available in other parts of Scotland however many are comparatively small and may not individually be cost competitive to develop. A developable area is limited by urbanisation, faulting, water bodies, designated areas, etc. Exploration and production would therefore be limited to accessible areas within the basin as shown in Table C.1.

Production volumes scenarios are derived from the ability to develop pads within the Midland Valley. We also cross-reference the potential outputs of the pads against available resources. UKOOG and their members thought this approach was reasonable.

C.1.3 Resource availability

Assessments of resource availability are derived from BGS (2014) as shown in the Table C.2 below.

We have assumed production volumes based on the number of pads because in the Midland Valley (a highly populated area of Scotland) there are limits to the available space that can be used for UOG resource development. A 'developable' area is limited by urbanisation, faulting, water bodies, designated areas, etc. which limits the number of potential pad developments. We estimate that 20 pads could be developed in the Central scenario, while 31 and 10 could be developed in the High and Low scenarios respectively.

Table C.1 Potential developable area in the Midland Valley.

Developable area	Central	High	Low
Share of basin	Large part of the basin	Large part of the basin	Core of the basin
km^2	~ 160 km^2	~ 160 km^2	~ 42 km^2

Table C.2 Potential total in-place shale oil, shale gas and coal bed methane in the Midland Valley in Scotland.

Scenario	Central	High	Low
Shale gas (tcf)	80.3	134.6	49.4
Shale oil (billion bbl)	6.0	11.2	3.2
Coal bed methane (tcf)	22.4	NA	NA

Source: British Geological Survey (2014) & Independent Expert Scientific Panel (2014).

Footnotes:

44. It is estimated that the total CBM resource in the UK is 2.9 trillion m3 (102 tcf), and that the recoverable part of the resource is unlikely to exceed 1% due to low seam permeability, low gas content and planning constraints. No separate figure is available for Scotland, but from areal estimates of resources (DECC, 2010) it is possible that Scottish resources are just 22% of those of the whole UK (Independent Expert Scientific Panel, 2014). Based on this estimate, Scottish resources are 22.44 tcf.

C.2 Development and production

The table below provides a summary of assumptions on the development and production of UOG across our scenarios.

Table C.3 Summary of the assumptions across our scenarios.

Scenario		**Central**	**High**	**Low**
Resources				
Shale gas	tcf	80.3	134.6	49.4
Associated liquids	MMBOE	6,000	11,200	3,200
CBM	tcf	22.4	22.4	22.4
Development				
Number of shale gas pads	No.	20	31	10
Of which also producing associated liquids		15	23	8
Wells per shale pad		15	30	10
Number of CBM pads		2	2	2
Wells per CBM pad		15	15	15
Production				
Expected output per pad				
Shale gas	bcf	47.3	94.7	31.6
Associated liquids	MMBOE	1.2	2.4	0.1
CBM	bcf	13.1	13.1	13.1
Percentage of shale gas pads also producing associated liquids	%	75%	75%	75%
Production life of a shale gas well	years	15	15	15
Production life of a CBM well	years	12	12	12
Start of first production	year	2024	2023	2028
End of production	year	2048	2049	2049

C.3 Cost profiles

C.3.1 Capital costs

The study published by EY in 2014 on shale gas and its supply chain and skills requirements provides a breakdown of the costs of hydraulic fracturing, drilling and completions, waste disposal and storage and transportation. These costs were for a hypothetical pad of 10 vertical wells with four laterals each (total of 40 laterals). In this study, we used the costs provided in the EY study and scaled them in accordance with the number of wells assumed in each scenario.

Furthermore, we added a number of other costs to cover expenditure on planning and licensing, exploration, pad development, decommissioning and aftercare costs. We also added operating expenditure to cover the production phase of the pads. These additional cost categories do not seem to form part of other publicly available studies.

Appendix C
Assumptions underlying the scenarios

Table C.4 below provides a breakdown of costs for all scenarios. It is worth noting that the costs are allocated to shale gas and associated liquids respectively based on an energy equivalent basis ratio[45].

The volumes of associated liquids produced in the low scenario are so low that associated costs are negligible.

Figure C.1 overleaf depicts total annual costs for shale gas and associated liquids on a per pad basis.

Table C.4 Cost breakdown for a given pad in each scenario (totals may not add up due to rounding)

Costs £m	Central		High		Low	
	Shale gas and associated liquids	CBM	Shale gas and associated liquids	CBM	Shale gas and associated liquids	CBM
1. Planning and licensing	1.2	1.2	2.5	1.2	0.8	1.2
2. Exploration	11.3	11.3	10.0	11.3	6.7	11.3
3. Development costs	40.0	40.0	40.0	40.0	20.0	40.0
4. Main capex						
Drilling and Completion						
Steel casing	8.6	8.6	17.3	8.6	5.8	8.6
Rig hire	8.1	8.1	16.3	8.1	5.4	8.1
Ancillary equipment and service	4.5	4.5	8.9	4.5	3.0	4.5
Cementing services	3.1	3.1	6.2	3.1	2.1	3.1
Directional drilling service	2.8	2.8	5.6	2.8	1.9	2.8
Drilling fluids and fluids engineering	2.1	2.1	4.3	2.1	1.4	2.1
Drill rig fuel	1.7	1.7	3.5	1.7	1.2	1.7
Hydraulic fracturing						
Equipment	64	32.0	128.0	32.0	42.7	32.0
Propants	7.6	5.1	15.2	5.1	5.1	5.1
Other	2.8	2.8	5.6	2.8	1.9	2.8
Mobilisation/demobilisation	1.7	1.7	3.4	1.7	1.1	1.7
Miscellaneous	0.8	0.8	1.7	0.8	0.6	0.8
Waste disposal						
Wastewater management	5.4	5.4	10.9	5.4	3.6	5.4
Drilling waste management	5.0	5.0	9.9	5.0	3.3	5.0
Storage and transportation						
Waste transportation	2.8	2.8	5.6	2.8	1.9	2.8
Water storage and transportation	2.0	2.0	3.9	2.0	1.3	2.0
Sub-total (main capex)	**123**	**89**	**246**	**89**	**82**	**89**
Total Capex (items 1, 2, 3 & 4)	**176**	**141**	**299**	**141**	**110**	**141**
Decommissioning	7.7	7.7	17.5	7.7	5.1	7.7
Aftercare	0.8	0.9	0.8	0.9	0.8	0.9

Footnotes: 45. We used the following formula: Total oil energy equivalent/Total oil energy equivalent + Total gas energy equivalent).

Appendix C
Assumptions underlying the scenarios

C.3.2 Fixed and variable operating costs

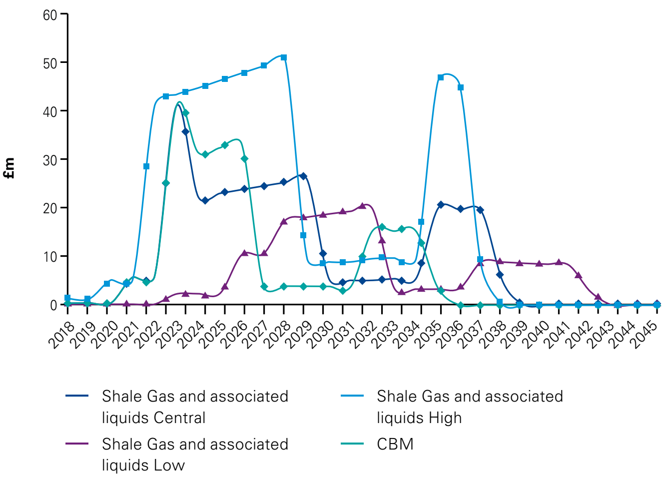
The opex is based on a fixed and a variable element. The costs associated with the monitoring of carbon emissions are also included in the operating costs - these are estimated to be £100,000[46] per year per pad for the duration of the pad's lifespan. We assume that the variable element is linked to production while the fixed element is linked to capex. A breakdown of the variable operating cost is provided below:

Table C.5 Variable operating costs

Variable opex	All scenarios
Shale gas and CBM	£0.25m/bcf
Associated liquids	£1.65m/MMBOE

The fixed operating cost is 2.5% of annual cumulative capex for shale gas, CBM and associated liquids.

Figure C.1 Shale gas and associated liquids cost profiles (per pad)



C.3.3 Localisation

Key to assessing the economic impact of UOG development is the amount spent within the Scottish economy, i.e. localisation. Our assumption is that in the Central scenario (and CBM) 50% of spend is within the Scottish economy, i.e. £2.2 billion. For the High scenario, we would expect 60% of UOG spend to remain in Scotland, i.e. £6.5 billion and for the Low scenario, we would expect 30%, i.e. £0.5 million.

These assumptions are broadly in line with localisation figures used in other sectors, namely the offshore wind and nuclear industries (BVG Associates, 2015) and (HM Government, 2012).

A North American market exists for construction, labour and procurement of equipment of shale gas and associated liquids. The extent to which the Scottish UOG sector will need to import materials and expertise will depend on how quickly the domestic supply chain can develop to meet the industry's needs and the amount of localisation that is expected to occur in Scotland. Should Scotland become a centre of excellence in shale, it could become self-reliant in expertise which could also provide some potential export opportunities in Europe and elsewhere.

Table C.6 Localisation assumptions

Scenario	Central	High	Low	CBM
Percentage of cost in Scotland	50%	60%	30%	50%

C.3.4 Efficiency

We assume that the UOG supply chain would develop as more pads are developed. We also assume there is an element of 'learning by doing' whereby it becomes cheaper to drill subsequent wells.

In terms of efficiency improvements, we assume that there are economies of scale in pad construction. The Central scenario (and CBM pads) benefits from a cost reduction of 5% of capex for five pads after the first pad is built. The High scenario benefits from a cost of reduction of 7% for five pads after the first pad is built. We assume a smaller cost reduction percentage in the Low scenario, i.e. only 3% for three pads after the first pad is built. These assumptions are in line with the approach used by the US Department of Energy for components of energy systems (U.S. Department of Energy, n.d.) A generating technology's learning rate is a weighted average of the learning rates of its component parts. We have not assumed any learning rate for opex.

Footnotes: 46. Representing the costs of staff performing monitoring.

C.3.5 Community benefits

In the Central, High and Low scenarios, we assume that 4% of total revenues are given to local communities. Table C.8 provides a summary of community benefits payments across our scenarios (including if CBM were to be developed).

C.4 Decommissioning and aftercare

As described in Figure C.10 on the previous page, we assume that the decommissioning and aftercare costs are 25% of drilling and completions costs. This assumption is broadly in line with the IoD study (2013) and industry estimates.

We assume that aftercare costs are £40,000 per year per pad which represent a very small percentage of total drilling completion. See Table C.11 on the previous page.

C.5 Pricing

We have used DECC's latest oil and gas wholesale fossil fuel price assumptions. Given current market prices, our scenarios are based on DECC's low projection scenarios (DECC, 2015).

In our model, we assume that the volumes produced in Scotland are unlikely to result in movement in international prices. This implies that there is substitution between

Table C.7 Efficiency improvement assumptions

Scenario	Central	High	Low	CBM
Efficiency improvement assumptions	5%	7%	3%	5%

Table C.8 Total cumulative benefit payment under 4% Community benefits payments[47]

		Central	High	Low
Shale gas and associated liquids	£m	217	663	64
CBM	£m	5	5	5
Total	**£m**	**222**	**668**	**69**

Table C.9 depicts what community benefits payments may be if operators give 6% of total revenues to local communities.

Table C.9 Total cumulative benefit payment under 6% Community benefits payments[48]

		Central	High	Low
Shale gas and associated liquids	£m	325	994	95
CBM	£m	7	7	7
Total	**£m**	**332**	**1,001**	**102**

Table C.10 Summary of decommissioning and aftercare assumptions scenario

Scenarios		Central	High	Low
Decommissioning cost as a % of drilling and completion	%	24.85%	24.93%	24.68%
Aftercare cost per site per year (shale gas only) as a % of drilling and completion	%	0.15%	0.07%	0.32%
Number of years to spread over decommissioning		3	2	5
Number of years to spread over aftercare		20	20	20

Footnotes:
47. Totals do not add up due to rounding.
48. Totals do not add up due to rounding.

gas sources rather than gas for other sources. This is consistent with the CCC workstream in that overall usage of hydrocarbons is unchanged.

See Section 4.4.2 for more details.

C.6 Financial assumptions

Table C.11 below provides a summary of our financial assumptions across all three production scenarios.

Table C.11 Summary of financial assumptions across all scenarios

Scenario	Units	
Depreciation	years	30
Salvage value for depreciation	£m	0
Corporate tax rate	%	20%
Payroll costs as a percentage of Opex	%	22%
Commercial interest rate	%	5%
WACC	%	10%

C.7 Carbon mitigation costs

The Climate change impact study has identified that a number of carbon mitigation technologies would be required in the Central, High and Low scenarios to ensure Scottish emissions targets are not exceeded. The carbon mitigation measures included in the CCC's 'Minimum Necessary Regulation' case are presented in Table C.12.

Table C.12 Carbon mitigation costs by scenario.

Carbon mitigation technologies	Estimated cost of mitigation	Unit	Type of cost	Central	High	Low	Notes
Leak Detection and Repair (LDAR)	£20,300	/pad/year	Opex	£304,500	£304,500	£304,500	£20,300/pad/year for 15 years
Reduced emissions completions (REC) (per use, equipment can be used numerous times)	£12,500	/well	Development costs	£187,500	£375,000	£125,000	£12,500/well x number of wells
Liquids Unloading plunger lift (assumes operates for the final 10 years) Capex	£22,900	/well	Development costs	£343,500	£687,000	£229,000	£22,900/well x number of wells
Liquids Unloading plunger lift (assumes operates for the final 10 years) Opex	£1,000	/well	Opex	£150,000	£300,000	£100,000	1,000/well x number of wells for 10 years
Dry Seal Compressor	£416,000	/compressor	Development costs	£416,000	£416,000	£416,000	1 compressor/pad
Low-flow pneumatic devices	2,480	/device	Development costs	£4,960	£9,930	£2,480	Central: 2 devices/ pad High: 4 devices/pad Low: 1 device/pad
Vapour recovery units (VRU)	£49,800	/pad	Development costs	£49,800	£49,800	£49,800	1 VRU/pad
Total (£m) per pad				**1.5**	**2.1**	**1.2**	
Grand total (£m) for the scenario (all pads)				**29.2**	**66.5**	**12.3**	

Source: Supporting Annex to CCC (2016) Scottish Unconventional Oil and Gas – Compatibility with Scottish Greenhouse Gas emissions targets

For more information on the techniques and technologies which can be employed to mitigate carbon emissions, please refer to the Supporting Annex to CCC (2016) Scottish Unconventional Oil and Gas – Compatibility with Scottish Greenhouse Gas emissions targets.

Appendix D

Contribution from stakeholders

D.1 Workshop with stakeholders on 21 and 22 March 2016

D.1.1 Scottish Environment LINK and Friends of the Earth Scotland

Welcome and introductions

Team introductions and brief description by KPMG of the objectives of the meeting and the work being conducted, and purdah limitations.

Scottish Environment LINK provided a brief overview of their functions. They informed KPMG, AECOM and BGS that there are numerous subgroups within Scottish Environment LINK and that some of these subgroups may want to input into the process. Responses would therefore be collated and returned to KPMG.

Objectives of the research projects

An overview of the scope of the research project was provided. KPMG, AECOM and BGS highlighted that the purpose of the study is to increase the evidence base for the Scottish Government on UOG and no formal recommendations will be provided to the Government.

KPMG, BGS and AECOM provided an overview of the six work streams and the public health study that is being produced.

One key point Scottish Environment LINK highlighted was the lack of overall environmental study which would combine all five work streams. They also stated that the five work streams should highlight any gaps in evidence or data.

Economic Impacts Study

KPMG gave an overview of the scope of work and proposed approach for the Economic Impact Assessment study. This also included a discussion of the aspects to be covered in the Economic Impact Assessment and the use of the Scottish Input-Output table to generate the multipliers for the UOG sector.

There was a discussion with the group on the breadth of the project. KPMG informed Scottish Environment LINK that it is not included in the scope to use shadow pricing for externalities or environmental impacts but that wider impacts would be considered despite not being able to formally quantify these impacts within the model.

KPMG described the use of a scenarios based approach, looking at potential development of the industry, costs associated with this and supply chain impact on the Scottish economy. Scottish Environment LINK also highlighted the need for a scenario whereby developers initiate drilling but then do not complete any extraction.

In the detailed Economic session, Scottish Environment LINK raised some further points to be considered by KPMG in the Economic Impact Assessment:

- Whether the development of the industry would affect international gas prices and whether this would have a net greenhouse emissions effect.
- Energy price changes and what effect this may have on the industry and associated supply chain.
- The transitional nature of the industry and how to consider this within a model.
- Further costs of development including heritage costs, environmental costs, public enquiry costs, permitting costs, effects on house prices and costs that may not be incurred by the developer.

KPMG requested further information from Scottish Environment LINK around costs of unconventional oil and gas to understand fully the externalities that could be incurred and what could be a suitable way to approach these.

Following the stakeholder workshop, KPMG received written input from Scottish Environment LINK and Nourish Scotland.

D.1.2 UKOOG

Welcome and introductions

Team introductions and brief description by KPMG of objectives of the meeting, including data requests and purdah limitations.

Objectives of the research projects

An overview of the scope of the research project was provided. KPMG, AECOM and BGS highlighted that the purpose of the study is to increase the evidence base for the Scottish Government on UOG and no formal recommendations will be provided to the Government. KPMG, BGS and AECOM provided an overview of the five work streams and the further public health study that is being produced.

Appendix D

Contribution from stakeholders

UKOOG stated they would like the opportunity to discuss options and mitigations before they are included in the final report, however it was noted that stakeholder time has to remain equal among the different stakeholder groups.

The regulatory structure for decommissioning is set at a UK level and UKOOG represents the whole of the UK, hence they would like to know any further developments in options and mitigations which could have a direct impact on England, Scotland and Wales.

Economic Impacts Study

KPMG gave an overview of the scope of work and proposed approach to complete this, including discussion of Economic Impact Assessment and Input-Output modelling. KPMG informed UKOOG that as part of this Economic Impact Assessment, environmental impacts are only considered in terms of cost drivers rather than creating any shadow pricing for externalities. KPMG described the use of a scenarios based approach, looking at potential development of the industry, costs associated with this and supply chain impact on the Scottish economy.

KPMG requested any further industry data from UKOOG that could assist in refining scenarios and completing assumptions.

Key discussion topics were:

- The difficulty in splitting the impacts between Scotland and the UK in terms of skills, jobs etc. This is because the industry is framed in a UK wide context. It was also discussed that demand would leak into the international market.
- The difficulty in determining where the supply chain may reside. It could be that the supply chain will go to the initial production areas which currently look like it will be England. In this case, the longer Scotland takes to develop the industry, the more Scotland will miss the benefits from the supply side. It could be that English companies operate in Scotland in which case some of the benefit would still remain with England.
- Technology development: More activity would lead to more R&D in the industry, which is then exportable. This learning then could give rise to lower costs. Better technology has also resulted in higher production per site in some cases in the US. KPMG informed UKOOG that they would use I-O tables to reflect the relevant sectors that benefit from the increased R&D.
- KPMG mentioned that the project considers recoverable resources in the Midland Valley. There was discussion on what impact this assumption would have. The consensus was that it was only worthwhile looking at this area, as it does not appear to be economical or even feasible to develop smaller and remote areas.
- KPMG highlighted that a key assumption is that there are not enough resources in Scotland to affect European/GB prices. The consensus was that this was a sensible assumption given EU market dynamics.
- KPMG provided an overview of their initial thinking around cost and production profiles. UKOOG expressed their view on this and informed KPMG that the methodology used in the IoD/EY study may not be directly applicable to the Scottish context. The consensus was that it would be very difficult to create a new cost base but KPMG could take the existing cost base from the EY or IoD studies and make adjustments based on recent economic changes. UKOOG suggested comparing the unit cost (p/therm) with the conventional oil and gas sector in the North Sea.
- KPMG modelling assumptions: UKOOG suggested that the model could be a bottom up analysis rather than top down. UKOOG informed KPMG that the UKOOG members would have an internal discussion before sharing with KPMG industry data and estimates. Other assumptions such as the production time frames that should be used and the use of multilateral wells were discussed. UKOOG informed KPMG that they would provide further insight on well productivity and how it can be applied to the Scottish context.
- UKOOG informed the group that there has been recent investment in centres and universities for industry-specific courses to acquire the skills required to ramp-up the national supply chain. UKOOG assume that the skillsets produced from this would stay in Scotland and the rest of the UK.

D.1.3 COSLA

Welcome and introductions

Team introductions and brief description by KPMG of objectives of the meeting, including data requests and purdah limitations.

Appendix D
Contribution from stakeholders

COSLA provided a brief overview of their functions. COSLA informed the group that a summary of the stakeholder session would be fed back to the local authorities and responses would be collated and returned to KPMG.

COSLA clarified that they do not take a particular political view regarding the potential development of unconventional oil and gas – currently they have a neutral opinion towards hydraulic fracturing.

Objectives of the research projects

An overview of the scope of the research project was provided. KPMG, AECOM and BGS highlighted that the studies will not make any formal recommendations to Government. The group informed COSLA that there might be a formal consultation process by the Scottish Government after the completion of the five research studies and interested stakeholders might wish to engage with this more formally.

COSLA were keen to understand who else had contributed at this stage. The group provided a description of the stakeholders that had been engaged at the request of the Scottish Government.

Economic Impacts study

KPMG provided an overview of the scope of work and proposed approach to complete this, including a discussion of the Economic Impact Assessment and Input-Output modelling.

KPMG informed COSLA that as part of this Economic Impact Assessment, environmental impacts would only be considered in terms of cost drivers rather than creating any shadow pricing for externalities. KPMG are to use a scenarios based approach, looking at potential development of the industry, costs associated with this and supply chain impact on the Scottish economy.

KPMG requested further information on policy monitoring and associated costs and they are keen to understand how/if these could be inputs into the model.

KPMG described their key assumptions including the fact that the study would focus on the potential development of shale gas, associated liquids and coal bed methane in the Midland Valley.

COSLA enquired whether the study would account for impacts on local enterprises rather than multi-nationals.

KPMG responded that this would not be analysed explicitly within the study as the model developed for this study would be an aggregate for sector-by-sector analysis. It was highlighted that traditionally most oil and gas companies sub-contract their work, some of which will be likely to go to SMEs.

KPMG and COSLA also discussed the degree to which it can be assured that the impacts will be within Scotland. This would imply that the gas produced in Scotland would be consumed domestically.

COSLA made the following points:

- Whether there would be an appropriate local supply chain. KPMG responded that currently there is an offshore industry in Aberdeen where some resources and skills could potentially be transferred onshore.
- Whether there is the appropriate expertise in Scotland. Investment in local skills is occurring in Scotland but there is also quite a lot of recent investment in England. These factors will be considered in the written report but not formally quantified.
- Whether to consider regeneration effects for deprived areas.
- Whether to consider procurement: for example the extent to which the government can mandate suppliers to pay the living wage. This could factor into a cost base.
- New regulations regarding landowner tax for derelict land which could be positive for the industry.

Following the stakeholder workshop, KPMG received written input from COSLA.

D.1.4 Broad Alliance

The Broad Alliance was not able to participate in a stakeholder workshop. Instead, they provided written input for KPMG to consider. A summary of this is provided below.

In their written submission to KPMG, Broad Alliance raised their concern regarding the potential use of a Cost Benefit Analysis (CBA) as a tool for quantifying economic impacts (please note however, this Report is not based on Cost Benefit Analysis by Economic Impact Assessment). Broad Alliance argued for a different approach to assessing the economic impacts of UOG, for example the Scottish Government's National Performance Framework (NPF) or Oxfam's Humankind Index.

Broad Alliance highlighted that the shale gas industry in the US is an example of a boom and bust case. In their opinion, the overall impact of the shale industry in the US has resulted in:

- Greater economic instability;
- Devastation for communities (environmental destruction and industrialisation of rural area); and
- Devastation for families who have staked their future, including borrowing and mortgages, on this industry and now face unemployment.

Based on US experience, Broad Alliance concluded that the extraction of UOG would negatively affect Scottish communities and industries. Regarding employment, Broad Alliance stated that there would be some scope for job creation during the production phase in communities surrounding the wells. However the spend in the local economy and with supply companies would be temporary and minimal.

Broad Alliance highlighted their concern regarding the level of indebtedness of UOG players in the UK. It emphasised the need for examination and assessment of the economic standing of the key players.

Broad Alliance also provided some commentary on the costs associated with regulation and decommissioning, the potential negative impacts on house prices and other businesses, the health-related issues that may arise from UOG exploitation along with the associated costs for the NHS and the negative impacts the UOG industry could have on renewables, including emissions resulting from the development on UOG in Scotland.

kpmg.com/uk

ISBN: 978-1-78652-396-9