

Kimmeridge Limestone Oil

The UK opportunity

April 2016





Introduction

EY was commissioned by UK Oil & Gas Investments PLC (UKOG) to conduct an economic impact assessment of the potential benefits of investing in, and extracting Kimmeridge Limestone Oil in the Weald Basin in the South East of England.

This report focuses on the potential economic impact of both the investment, and the extraction, of oil in terms of the impact on economic output and tax receipts, and the impact on employment and the supply chain. The impacts are assessed on a local scale (the South East of England, excluding London), and at a national scale.

Kimmeridge Limestone Oil is typically found within a reservoir rock with naturally occurring fractures. Kimmeridge Limestone Oil likely requires “stimulation”¹ to flow to the surface at commercial rates. The primary stimulation method for wells in limestone rock formations is acidizing. This method of stimulation is distinct from massive hydraulic fracturing, known as “fracking”, which is a technique used in the extraction of gas and oil from ‘shale’ rock formations by injecting large volumes of water at high pressure.

The natural fractures in the two main Kimmeridge limestone reservoirs mean that no massive fracking is required. UK regulations also prevent fracking at depths below ground of less than 1,000m. The Kimmeridge limestone reservoir is present at or less than this burial depth over the majority of the Weald basin. The two Kimmeridge limestones recently flow tested at the Horse Hill-1 oil discovery were at 900m and 840m below ground level.

Nutech has estimated that there are 124 billion barrels of oil in place in three Jurassic shales and interbedded limestones in the Weald Basin, of which 19.5 billion barrels of oil in place² (16%) are in the two main Kimmeridge limestones.

The report concludes that the development of Kimmeridge Limestone Oil in the Weald Basin, assuming it can be extracted from a development site at the volumes projected by UKOG, has the potential to generate significant economic value to the UK economy, partially off-set the decline in oil production from UK fields, support employment, and generate significant tax benefits to the exchequer. These benefits will be maximised via the development of a UK-based supply chain, and through a series of targeted policies and initiatives to appropriately mitigate potential barriers to development.

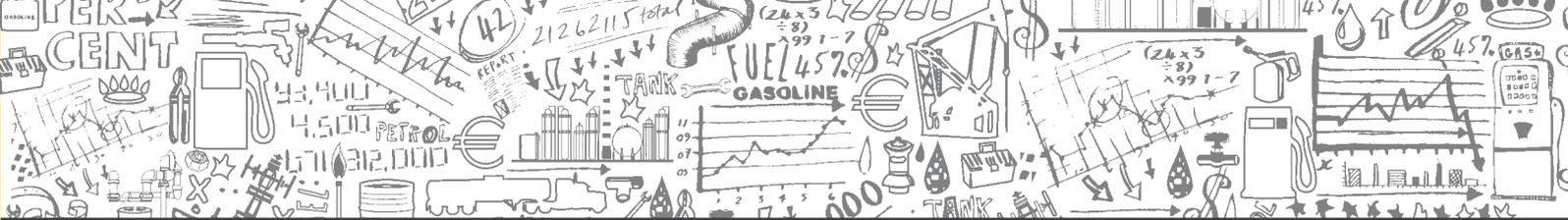
Since this report was commissioned, extended flow testing of the Kimmeridge limestones in the Horse Hill-1 discovery well has been completed. The Upper and Lower Kimmeridge limestones flowed naturally (without pumping) at a combined stable dry oil rate of 1,365 barrels per day, in a near-vertical well. The production profiles used in this report assumed an initial oil flow rate of only 400 barrels per day, assuming a pumped horizontal well. As such, the initial flow rates and resulting economic impacts in this report should be considered as conservative.

The report is structured as follows:

- ▶ A summary of the impact of the development of unconventional oil in North America, and the Kimmeridge Limestone Oil opportunity in the UK;
- ▶ A discussion of some of the key areas of expenditure required for a supply chain for the development and operation of Kimmeridge Limestone Oil in a UK context;
- ▶ A description of UKOG’s production scenarios which underlie the economic impact assessment;
- ▶ Presentation of the estimate of the potential economic contribution of future development of oil from the Kimmeridge limestones in the Weald Basin; and
- ▶ A discussion of how to maximise the benefits from the development of an onshore Kimmeridge Limestone Oil industry in the UK.

¹ Activities undertaken to increase the productivity of a well

² Oil in place volumes are not recoverable resources, contingent or prospective resources, or reserves and should not be interpreted as potential producible hydrocarbons prior to any successful flow tests and the assessment of an estimated recovery factor



Market context

Unconventional oil changed the energy landscape in the US

Exploration and full-scale development of unconventional oil in the US has transformed the energy and economic landscape in recent years, through reducing its dependence on imported energy and providing a competitive advantage to energy-intensive industries³. Between 2009 and 2014 US imports of crude oil fell by 18.5% according to the US's Energy Information Administration⁴. The USA was the world's largest oil producer in 2014⁵.

Kimmeridge Limestone Oil could represent a security of energy supply opportunity for the UK

Historically the UK has been a net exporter of crude oil (primarily extracted from the fields in the North Sea), but since 2005 imports have exceeded exports⁶, with import dependency forecast to rise in future as set out in **Table 1** below.

Table 1: UK oil production and demand, historic data and projections⁷

	UK oil production (million tonnes of oil equivalent)	UK oil demand (million tonnes of oil equivalent)	Import dependency (%) ⁸
2000	138	89	-55%
2010	69	81	15%
2020	34	70	52%
2030	20	69	71%

Conceptual studies and oil in place estimates previously conducted suggest a significant opportunity for the UK to secure a proportion of its energy from the Weald Basin.



Photographs courtesy of CNN/Turner Broadcasting

³ US Chamber of Commerce Foundation, <https://www.uschamberfoundation.org/energy-catalyst-reindustrialize-america>

⁴ US Energy Information Administration, https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbb_l_a.htm

⁵ US Energy Information Administration, <https://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1>

⁶ DECC, <https://www.gov.uk/government/statistical-data-sets/crude-oil-and-petroleum-production-imports-and-exports-1890-to-2011>

⁷ DECC (2015), UKCS Oil & Gas Production Projections https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/482767/OGA_production_projections_-_November_2015.pdf

⁸ Negative percentages denote net exports



A supply chain for Kimmeridge limestones

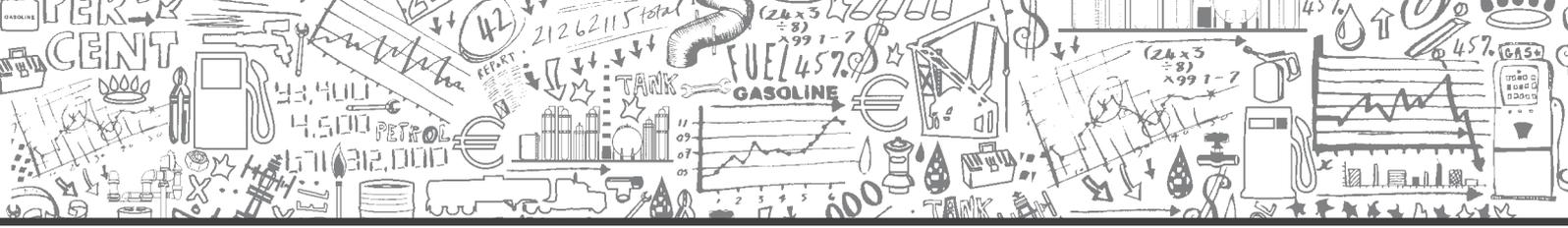
A key challenge to enabling the large scale and cost-effective extraction of oil from Kimmeridge limestones is the ability to develop a fully functioning, flexible and responsive supply chain. This provides an opportunity for local and national suppliers to develop new and expanded capabilities to deliver manufactured goods and services to Kimmeridge Limestone Oil field operators.

Figure 1 below sets out the core activities that will take place in the development of Kimmeridge limestones, with the yellow sections highlighting activities within scope of this report.

Figure 1: Kimmeridge limestones core value chain lifecycle⁹



⁹ Upstream refers to the exploration and production of oil; midstream describes the processing, storing and transportation of oil; and downstream includes oil refineries, petrochemical plants, petroleum products distributors, and petrol stations



Down stream

le &
nsport

6. Process
& Refine

7. Store &
Distribute

7. Market
& Sell

9. Decommission

Key areas of expenditure in the Kimmeridge limestones supply chain would include:

- ▶ **Capital facilities and equipment** - developing a Kimmeridge limestones pad will require considerable capital investment with drilling and well stimulation equipment to enable extraction. Local regulations and standards indicate that overseas equipment would be costly to import and reconfigure to the correct standard;
- ▶ **Drilling and completions** - horizontal drilling, which is essential to maximise reservoir recovery, is a high-skilled capability and typically provided by teams which have considerable previous experience in the technique;
- ▶ **Materials** - the drilling and stimulation elements of oil production can be input intensive, with significant volumes of water, muds, cement and acid stimulants required during the initial phases of the lifecycle. Given the commoditised nature of the required materials and low value-add nature of the supporting industries, these are likely to be supported through existing local suppliers with expanded capacity or imported where existing large scale partnerships already exist;
- ▶ **Logistics** - the midstream phase of Kimmeridge limestones production is likely to be conducted through the use of existing road infrastructure; the viability of developing pipeline infrastructure is likely to be limited given the potential costs of obtaining pipeline rights of way from landowners. In addition, logistics related to waste management and water treatment invariably favours a local supply chain given its nature and stringent regulatory requirements for processing; and
- ▶ **Other services** - there are wider technical and non-technical requirements underpinning the development of Kimmeridge limestones including Health, Safety, Security and the Environment (HSSE), environmental engineering, and geo-seismic evaluations. The North Sea is an established centre of excellence in specific technical areas.

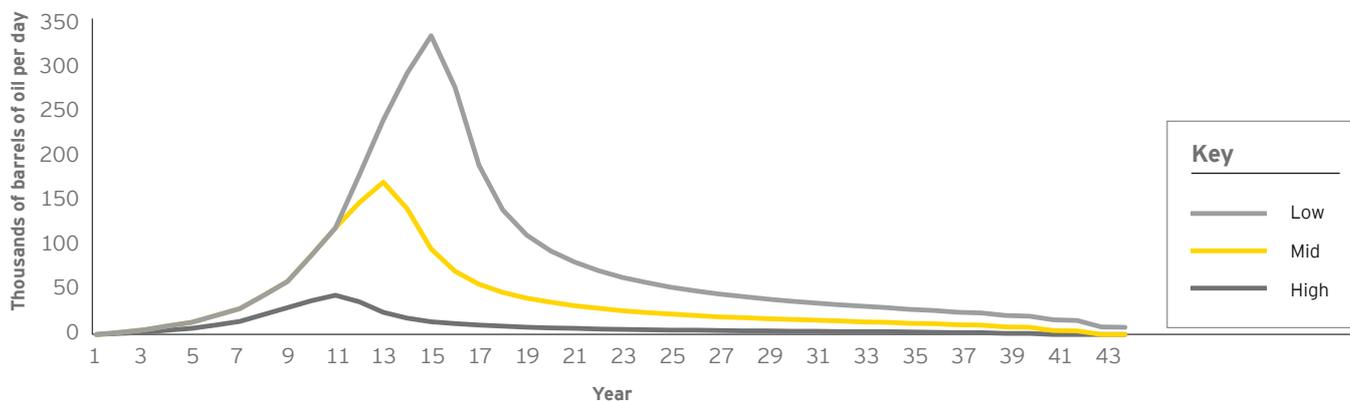


Production scenarios

The assessment was based on a range of scenarios for the deployment of wells and resulting production of oil, developed by UKOG prior to the extended flow test on Horse Hill-1¹⁰. Each of these scenarios have been combined with oil price projections from the Department of Energy and Climate Change's (DECC)¹¹ and cost estimates from UKOG to calculate the potential economic impact of the development of Kimmeridge Limestone Oil in the Weald Basin.

The production scenarios are presented in **Figure 2** below.

Figure 2: Kimmeridge limestones production scenarios



The “Low” scenario represents limited investment in, and extraction of, oil from the Kimmeridge limestones, whereas the “High” can be interpreted as the development of oil from the Kimmeridge limestones throughout the entire Weald Basin.

Total production from the scenarios of the lifetime of the fields is estimated at 140 million barrels in the Low scenario, rising to 560 million barrels in the “Mid” scenario, and 1,125 million barrels in the High scenario. Peak oil production in the Mid scenario is around 170,000 barrels per day¹², and in the High scenario over 330,000 barrels per day¹³, representing approximately 14% and 27% of 2014 UK daily oil demand respectively.

It should be noted that results of recent extended flow testing of Kimmeridge Limestone Oil were far above expectations. As such, the production scenarios in this report are conservative.

In the UK, the largest product refined from oil is petroleum, followed by diesel; every barrel of oil produces approximately 47 litres of petrol¹⁴. In 2014, road transport¹⁵ used 16.7 billion litres of petrol¹⁶. **Table 2** presents the proportion of 2014 petrol demand from road transport that could be met by the average production over a year for the Low, Mid, and High scenarios.

Table 2: Proportion of 2014 road transport petrol demand met by the Low, Mid and High Scenario

Scenario	Average production of oil (thousand barrels per day)	Estimated volume of petrol produced per year (millions of litres)	As a proportion of 2014 road transport petrol demand
Low Case	10	171	1%
Mid Case	38	651	4%
High Case	72	1,242	7%

¹⁰ The Horse Hill-1 discovery well is located within onshore exploration Licence PEDL137, on the northern side of the Weald Basin. The exploration drilling phase of the Horse Hill-1 well was originally completed at the end of 2014. Further flow tests were conducted in February and March 2016

¹¹ Fossil fuel price projections: 2015. <https://www.gov.uk/government/publications/fossil-fuel-price-projections-2015>

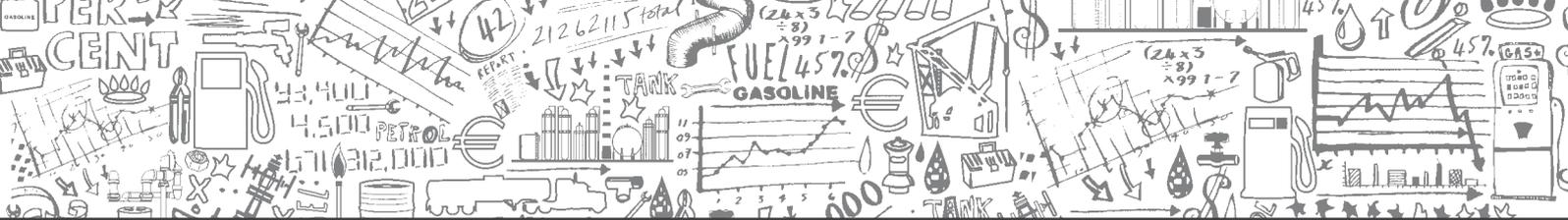
¹² Over the estimated 41 years of production under the Mid Scenario, the peak is projected to occur in year 12

¹³ Over the estimated 43 years of production under the Mid Scenario, the peak is projected to occur in year 14

¹⁴ In 2014, nearly 16 million tonnes of petrol was produced in UK refineries from approximately 60 million tonnes of oil DECC (2015), Digest of United Kingdom Energy Statistics 2015 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/450302/DUKES_2015.pdf

¹⁵ Includes cars, taxis, light vans, motorcycles and mopeds

¹⁶ Equivalent of 12.3 million tonnes DfT, Petroleum consumption by transport mode and fuel type <https://www.gov.uk/government/statistical-data-sets/env01-fuel-consumption>



Economic Impact

Unconventional oil changed the energy landscape in the US

The contribution of the future development of Kimmeridge limestones in the Weald Basin can be split into three impacts: direct, indirect and induced. These impacts can be summarised as follows:

- ▶ A **direct impact** arising from the initial increase in economic activity;
- ▶ An **indirect impact** arising from the additional demand of goods and services along the industry's supply chain; and
- ▶ An **induced impact** arising as an effect of individuals spending a share of the additional income, generated through the provision of labour, on the consumption of goods and services.

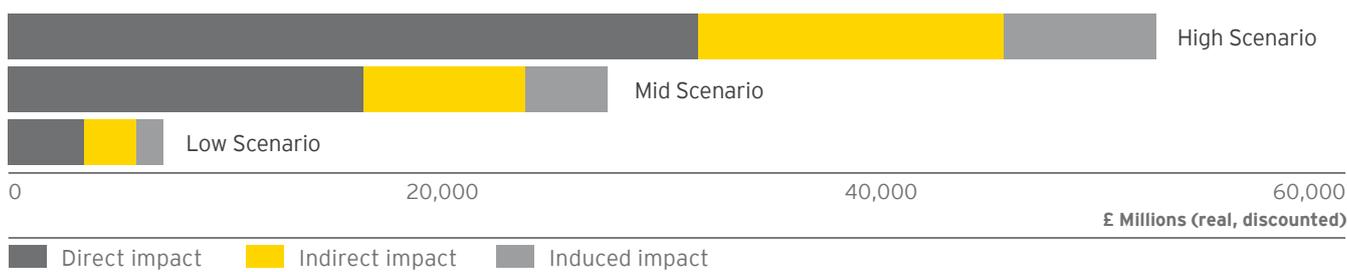
Total Gross Value Added (GVA)¹⁷ impact estimated to be between **£7.1 billion** and **£52.6 billion**

In summary, development of oil from the Kimmeridge limestones is estimated to result in:

- ▶ £7.1 billion of National GVA in the Low scenario, of which £3.5 billion would be a direct impact, and £3.6 billion would come from indirect and induced activity;
- ▶ £27.4 billion contributed to National GVA in the Mid scenario, of which £16.3 billion would be a direct impact, and £11.1 billion would come from indirect and induced activity; and
- ▶ An estimated contribution to National GVA of £52.6 billion in the High scenario. This can be split between the direct impact (£31.7 billion), and the indirect and induced impact (£20.9 billion).

The results are presented visually in **Figure 3** below:

Figure 3: Total lifetime GVA of the development of oil from the Kimmeridge limestones



The direct impact is a result of operational activities involved in the extraction of oil, and hence is primarily driven by company earnings. Employee income only accounts for a very small proportion of the direct impact. The indirect impact captures the associated spending on the UK supply chain, not only related to operational activities, but also related to spending on the construction and drilling of the wells. The modelling assumes that the supply chain for the industry will be largely situated in the UK reflecting the nature of activities and existing UK capabilities in the offshore industry.

¹⁷ Gross Value Added (GVA) is the contribution of each individual producer, industry or sector to the economy. The GVA of an economy is its GDP (Gross Domestic Product) adjusted for taxes and subsidies

Impact on GVA in the South East of England

The impact on regional GVA is estimated by considering what activities are based in the South East of England. Any activities that take place in the Weald Basin, i.e., operational activities, take place in the South East by definition. As the direct impact on national GVA results from the operational activities, the direct impact on GVA in the South East of England is estimated to be £3.5 billion to £31.7 billion, the same as the direct impact on national GVA.

The regional indirect and induced impacts are materially smaller than their national counterparts because of the assumed location of the supply chain and jobs, and in turn spending of income. These have been estimated at £536 million in total under the low scenario, increasing to £2.5 billion in the High scenario. This analysis has been based on a view of the local supply chain's current capability; it is assumed that as the Kimmeridge limestones are developed, the local supply chain would grow to support activities, increasing the regional indirect and induced impacts on GVA.

Community Benefits

In addition to the GVA impact, it is expected that development of oil from the Kimmeridge limestones will lead to additional community benefits; UK Onshore Oil and Gas (UKOOG) members have all signed up to a community benefits scheme¹⁸. Assuming a similar arrangement¹⁹ as set out by UKOOG, the total estimated Community Benefit ranges from £77m under the Low scenario, to £291m under the Mid scenario, and up to £557m under the High scenario, for the period of construction and operation.

¹⁸ <http://www.ukoog.org.uk/community/benefits>

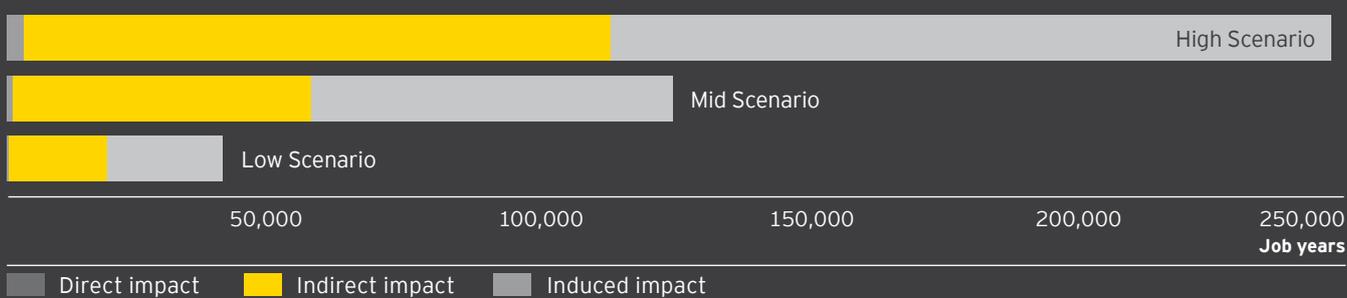
¹⁹ Community Benefits for the development of Kimmeridge Limestone Oil have been calculated as assuming the following parameters: 1% of revenues per year for the lifetime of the development, £100,000 per pad, and £20,000 per well



Total impact on UK jobs is dominated by the indirect and induced impacts

The total impact on UK jobs, estimated to be between 994 and 5,607 jobs on average per year over the lifetime of the development, is dominated by the indirect and induced impacts, as operational activities (which drive the direct impact on jobs) are not labour intensive, and there is significant dependency on the supply chain. Jobs involved in construction and drilling of wells are captured in the analysis via the indirect impact throughout the supply chain, as they are assumed to be filled by contractors. The results of our analysis are summarised in **Figure 4** below:

Figure 4: Total job years related to the development of oil from the Kimmeridge limestones



Impact on jobs in the South East of England

Any activities that take place in the Weald Basin take place in the South East of England by definition. Accordingly, the direct impact on jobs in the South East of England is assumed to be the same as it is nationally (the direct impact only captures jobs related to operational activities).

The indirect and induced impact on jobs in the South East of England is estimated to be lower than nationally due to the assumed location of the supply chain and jobs, and in turn spending of income, as was the case for GVA.

Under the Low Scenario, the total impact on employment in the South East of England is estimated to be an average of 314 jobs per year, with this rising to 794 under the Mid Scenario, and 1,519 under the High Scenario.



Photograph courtesy of Bloomberg Business

Photograph courtesy of Bloomberg Business

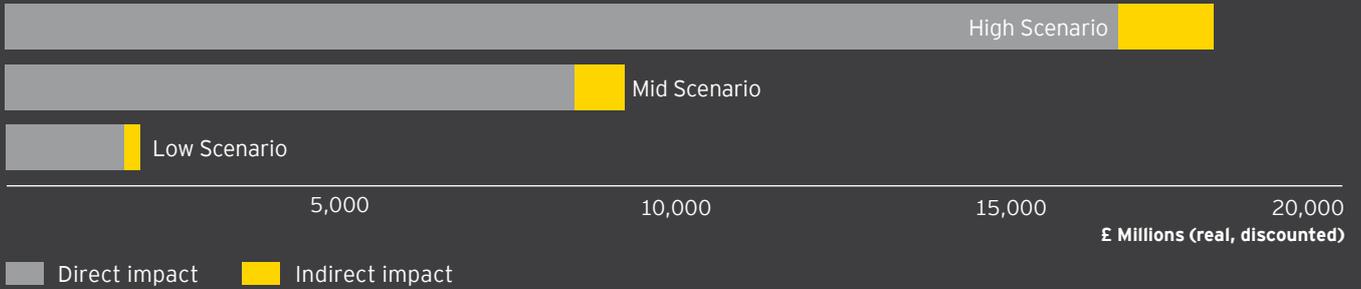


Lifetime tax revenues are dominated by the direct impact

Lifetime tax revenues from the development of Kimmeridge Limestone Oil are estimated to be between £2.1 billion in the Low scenario and £18.1 billion in the High scenario and are dominated by the direct impact, driven by the level of earnings and the tax regime for oil companies.

The analysis on the impact on tax revenue included Ring Fenced Corporation Tax of 30%, a Supplementary Tax of 20%, investment allowances, and the Ring Fenced Expenditure Supplement, in addition to Business Rates set at 2% of gross revenues for the purposes of the analysis. Income tax payments, and employee and employers' National Insurance contributions have been included.

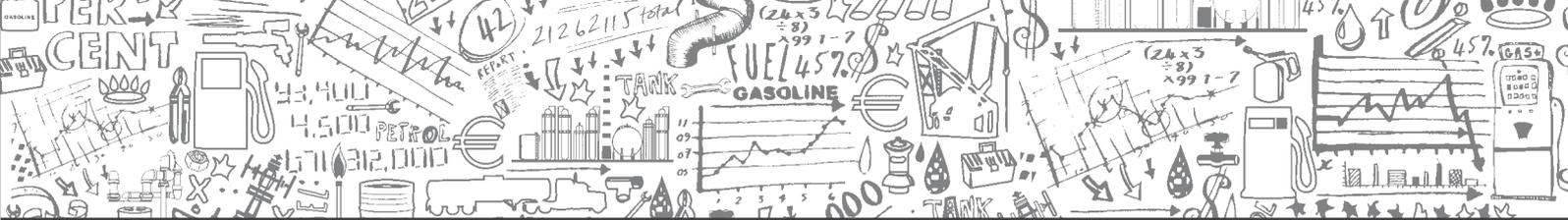
Figure 5: Total lifetime tax revenue related to the development of oil from the Kimmeridge limestones



Business Rates

In October 2015, the Chancellor of the Exchequer announced that, by the end of the current Parliament, local government will be able to retain 100% of local taxes, including revenue from Business Rates. Business Rates are typically reviewed every five years, creating uncertainty over the rate which would be applied to any future development of Kimmeridge limestones. For the purposes of this analysis, it has been assumed that Business Rates will be 2% of gross revenue. Payment of Business Rates has therefore been estimated to be between £140m and £1,035m across the scenarios.





Maximising the total benefit from Kimmeridge limestones

In order to maximise the total benefit of the development of oil from the Kimmeridge limestones, there are a number of areas that need to be addressed, a selection of which are set out below:

- ▶ **Skills** - for the successful development of an onshore Kimmeridge Limestone Oil industry, the industry needs to be able to employ individuals with the required skills. Skills are a key driver of productivity and source of competitive advantage; it is important that any shortages are addressed so as not to impede the development of an onshore Kimmeridge Limestone Oil industry in the UK;
- ▶ **Regulation** - the development of an onshore Kimmeridge Limestone Oil industry will require efficient regulation, and back-to-back drilling of production wells. The current regulatory environment is complex, with four different key regulators involved in the regulation of the onshore oil industry. A streamlined and co-ordinated regulatory process would aid the development of an onshore oil industry in the UK;
- ▶ **Public opposition** - for any new development of Kimmeridge Limestone Oil, companies will need to develop an effective relationship with local residents to explain the exact nature of the development, i.e., the difference between Kimmeridge Limestone Oil and shale oil, and highlight the potential benefits to the area, as well as taking steps to mitigate any negative impacts of the development such as chosen truck routes to and from the wells; and
- ▶ **Economic environment** - the oil price has fallen by over 60% since summer 2014, driven by a global expansion of supply and slower global demand growth, in the context of a slowdown in emerging markets, and in particular, China. This has implications for the economic viability of new oil developments.

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