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The Research Team

Onshore hydrocarbon exploration on the Island of Ireland

NIAR 147-12

The following paper draws together and updates previous research into hydrocarbon exploration and hydraulic fracturing on the Island of Ireland.

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Key Points

Four licences have been granted for hydrocarbon exploration in Northern Ireland. All four licensees are at the early stage of exploration. Only one, Tamboran, has explicitly stated the hydraulic fracturing is an option.

In the Republic of Ireland three licence options have been granted. These allow exploratory work to be carried out.

Ministers in both jurisdictions have made assurances that any activity beyond exploratory work, including deep drilling and hydraulic fracturing, will require all necessary permissions and environmental assurances.

Tamboran has estimated (based on their initial work) approximately 62 billion cubic metres of shale gas within its licence area. They argue that this will provide 600 direct jobs, 2,400 indirect jobs and £6.9bn in tax revenues. No independent confirmation of these estimates could be found.

The level of emissions associated with shale gas is contested. The International Energy Agency suggests that estimates *that 'shale gas produced to proper standards of environmental has slightly higher 'well-to-burner' emissions than conventional gas'.* The first peer review assessment of emissions by Cornell University found that *'over 20 years, shale gas emits up to twice as much CO_2 for each unit of energy it contains'.* Further study and data collection is required on this issue.

The environmental impacts of hydraulic fracture are contested. On the issue of water pollution, the House of Commons Select Committee found that the process of hydraulic fracturing does not itself cause pollution, rather it is the integrity of the well that is the issues.

The US Environmental Protection Agency has found that in one specific case, Pavillion, Wyoming, chemical associated with hydraulic fracturing had found the way into the groundwater.

A number of studies will be released over the coming months and years that will help bring further clarity to the debate.

In March 2012 the Environmental Protection Agency in the Republic of Ireland will release preliminary findings on the environmental impact of hydraulic fracturing.

The US Environmental Protection Agency will release preliminary findings of its investigation on hydraulic fracturing and drinking water by the end of 2012, with final result expected in 2014.

Executive Summary

Background

The granting of onshore hydrocarbon exploration licences in Northern Ireland and of option licences in the Republic of Ireland is due to the implementation of EU *Directive 94/22/EC of the European Parliament and of the Council on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons*.

Northern Ireland Licences

To date four companies have been granted licences to *'search and bore for and get petroleum'* in Northern Ireland.

- Infrastrata plc. and eCORP Oil & Gas UK Ltd – Lough Neagh Basin (Central Lane) (note: eCORP has withdrawn);
- Tamboran Resources Pty Limited – Lough Allen Basin (North);
- Rathlin Energy Limited – Rathlin Basin.; and
- P.R. Singleton Ltd. – Rathlin Island.

Each licence is for five years, with drill or drop decisions to be made in the third year (in most cases). All licences require that well drilling beyond shallow exploration (including for the purposes of hydraulic fracturing) is subject to securing necessary permissions and an environmental impact assessment (planning permission and landowner permission, etc.).

All licence holders are in the early stages of exploration.

Of the four licences, only Tamboran's refers to the process of hydraulic fracturing. The company is also the only one that has explicitly stated that hydraulic fracturing is a method under consideration. Infrastrata have explicitly stated that their exploration will be for conventional hydrocarbons only.

Republic of Ireland Licences

In the Republic of Ireland three companies have been granted licence options:

- Tamboran Resources PTY Ltd over 986 sq km in the Northwest Carboniferous Basin;
- Lough Allen Natural Gas Company Ltd over 467 sq km in the Northwest Carboniferous Basin; and
- Enegi Oil Plc over 495 sq km in the Clare Basin.

These licence options do allow for initial exploration including drilling to a depth of 200m (650ft) and for technical studies to indicate whether the resources are commercially viable. If successful the companies will have a first option on an exploration licence.

The Minister for Communications, Energy and Natural Resources has stated that any work beyond this, including hydraulic fracturing, will be subject to permissions and an environmental impact assessment.

The Environmental Protection Agency in the Republic of Ireland is conducting a study into environmental impact of hydraulic fracturing. The results of the desk top study will be published in March 2012.

General environmental risks of hydrocarbon exploration

There are a number of potential environmental risks that could arise from hydrocarbon exploration in general. These include:

- Noise pollution;
- Air pollution;
- Landscape impacts; and
- Traffic and road damage.

Unconventional gas

The US National Petroleum Council defines unconventional gas as:

> *…natural gas that cannot be produced at economic flow rates nor in economic volumes of natural gas unless the well is stimulated by a large hydraulic fracture treatment, a horizontal wellbore, or by using multilateral wellbores or some other technique to expose more of the reservoir to the wellbore.*

There are a number of types of unconventional gas, including shale gas, which is the focus of this paper focuses upon.

Shale gas potential resource

The US Department of Energy estimate that at 2007 production rates of 19.6 trillion cubic feet (approximately 546 billion cubic metres) the current recoverable resources will provide enough gas to supply the country's gas needs for 90 years. Other estimates extend this to 116 years.

UK estimates point to 150 billion cubic metres of potential reserves, although the gas content of these reserves is not known.

On the Island of Ireland, Tamboran estimate that there is approximately 62 billion cubic metres of shale gas within its licence area (potentially providing 50 years of gas at current consumption rates).

Shale gas potential benefits

For Northern Ireland shale potentially offers an indigenous source of natural gas, this is significant for a region dependent on importing to meet its gas needs.

In a more general sense, unconventional gas, in displacing coal or oil in energy markets, may reduce overall greenhouse gas emissions. Although there are concerns regarding the emissions of shale gas compared to conventional natural gas.

The only estimate of the economic benefits of shale gas in Northern Ireland has been put forward by Tamboran. Central to these are 600 direct jobs, 2,400 indirect jobs and £6.9bn in tax revenues (note: such revenue will go to the Treasury).

Shale gas emissions

Natural gas has fewer emission per unit of energy than other fossil fuels – 0.19 kilograms of CO_2 per kilowatt hour of energy used (CO_2/kWh), compared to 0.25CO_2/kWh from oil, 0.34CO_2/kWh from solid fuel and 0.54CO_2/kWh from electricity.

The International Energy Agency estimates *that 'shale gas produced to proper standards of environmental has slightly higher 'well-to-burner' emissions than conventional gas'.*

The first peer reviewed assessment of shale gas emission, produced by Cornell University, found that:

> *…over 20 years, shale gas emits up to twice as much CO_2 for each unit of energy it contains. Even when allowing for greater efficiency of gas-fired power stations, electricity from shale as still releases as much as forty per cent more CO_2 equivalent than coal. This finding has been debated however.*

The emission levels of shale gas are likely to become better understood as more data is recorded and more studies are carried out.

Hydraulic fracturing

Hydraulic fracturing, or fracking, is a process by which fissures or fractures are created in rocks to allow access to shale gas.

The environmental impact of hydraulic fracturing is contested.

Of particular concern is the potential for water pollution.

The House of Commons Select Committee on Energy and Climate Change, referring to the above, concluded that:

> *…hydraulic fracturing itself does not pose a direct risk to water aquifers, provided that the well-casing is intact before this commences. Rather, any risks that do arise are related to the integrity of the well, and are no different to issues encountered when exploring for hydrocarbons in conventional geological formations. We recommend that the Health and Safety Executive test the integrity of wells before allowing the licensing of drilling activity.*

In December 2011, the US Environmental Protection Agency released a draft report on its investigation of groundwater pollution from hydraulic fracturing in Pavillion, Wyoming. They concluded that:

> *…inorganic and organic constituents associated with hydraulic fracturing have contaminated ground water at and below the depth used for domestic water supply.*

The Agency will release preliminary results of a broader study of the impact of hydraulic fracturing on water supplies at the end of 2012, with final results expect in 2014.

A second area of concern, following the events in Blackpool in 2011, is the potential for seismic activity. On this, the Minister for Enterprise, Trade and Investment has stated:

> *Measurements made on thousands of hydraulic fracture treatments have shown that these may trigger minor earthquakes, usually with a magnitude less than 0 on the Richter scale, which cause no damage at the ground surface. The two seismic events recorded near Blackpool (magnitude 2.3 and 1.5) are attributed to injected fluids penetrating and causing minor slip on a fault zone. Whilst the Blackpool seismicity is linked to unusual site-specific geological conditions, the specialists' report makes a number of recommendations for the evaluation and mitigation of seismic hazard. My Department will discuss these with DECC* [Department of Energy and Climate Change] *before making any decisions on seismic monitoring and mitigation protocols for Northern Ireland.*

Contents

1 Main Heading

The following paper draws together and updates previous research into hydrocarbon exploration and hydraulic fracturing on the Island of Ireland. Particular attention is paid to:

- The licences granted in both jurisdictions;
- The potential of and emissions of shale gas; and,
- The process of hydraulic fracturing and its potential impacts.

No consensus has been reached on the impact of hydraulic fractured and shale gas. A number of key reports are expected in the coming months and years. The intention is to update and amend this paper as further information becomes available.

2 Background

The granting of onshore hydrocarbon exploration licences in Northern Ireland and of option licences in the Republic of Ireland has been in response to *Directive 94/22/EC of the European Parliament and of the Council on the conditions for granting and using authorisations for the prospection, exploration and production of hydrocarbons*.

The directive was designed with *'a view to reinforcing the integration of the internal supply market, encouraging greater competition within it and improving the security of supply'* and required Member States to establish common rules which *'establish non-discriminatory access to the activities of prospection, exploration and production of hydrocarbons'.*[i]

Hydrocarbons are chemical compounds composed of hydrogen and carbon. They are the principle components of petroleum and natural gas.[ii] The exploration licences granted in Northern Ireland have been, for the most part, granted to companies investigating the potential for sourcing natural gas in their licence areas (Rathlin Energy Limited are also exploring the potential oil resource in the Rathlin Basin). In the Republic of Ireland, two of the three licence options have been awarded to companies investigating the potential for natural gas. One has been awarded to a company investigating the oil potential of the Clare Basin.

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3 Licence areas

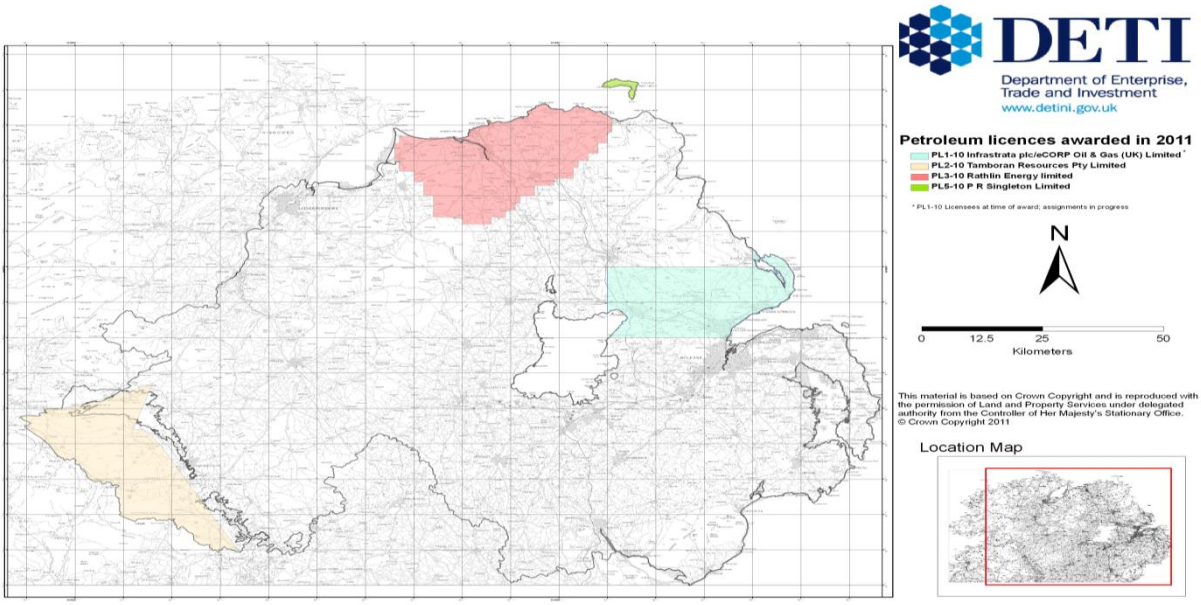
3.1 Northern Ireland

To date, four licences have been granted to companies allowing them to *'search and bore for and get petroleum'* in Northern Ireland. The companies and the areas covered are as follows:

- Infrastrata plc and eCORP Oil & Gas UK Ltd – Lough Neagh Basin (Central Lane);
- Tamboran Resources Pty Limited – Lough Allen Basin (North);
- Rathlin Energy Limited – Rathlin Basin.; and
- P.R. Singleton Ltd. – Rathlin Island.

Figure 1, provides an illustration of the areas covered by the four licences.

Figure 1: Petroleum Licences in Northern Ireland June 2011



Details of the companies awarded the licences are as follows:

- **Infrastrata PLC and eCORP Oil & Gas UK Ltd**: Although the licence is in the name of Infrastra PLC and eCORP Oil & Gas UK Ltd, eCORP is no longer a stakeholder in the Central Larne-Lough Neagh Basin licence.[iii] Infrastrata PLC began trading on the 17 January 2008, having demerged from Egdon Resources plc. It is a gas storage and petroleum exploration company with interests in Dorset, England and Antrim, Northern Ireland.[iv]
- **Tamboran Resources Pty Limited**: Tamboran are an Australian based shale gas exploration company. The company have currently secured two exploration permits, the permit to explore in the Lough Allen Basin, Co Fermanagh and a second in Australia's Northern Territory. The company have also a licensing option in the

Republic of Ireland. A further seven exploration permits are pending six of which are in Australia's Northern Territory, with the remaining permit application for Botswana (through Meerkat Energy Botswana Ltd).[v]

- **Rathlin Energy UK Limited**: Rathlin Energy UK Ltd is a wholly owned subsidiary of Canadian company Connaught Oil and Gas Ltd. The principle business of Rathlin Energy UK Ltd is the exploration and development of oil and gas in the Great Britain and Northern Ireland.[vi] In addition to the Rathlin Basin licence awarded by DETI, the company in East Yorkshire.[vii]
- **P.R. Singleton Ltd**: P.R. Singleton is a UK subsidiary of Dublin based company Providence Resources. The company's UK interests are in Rathlin Island and the offshore Rathlin Basin. The company plans to *'re-evaluate available subsurface data in order to assess whether further exploratory drilling in the area is warranted.*

Each of the licences is for an initial five years. Each licence differs as to what the holders may do. However, for the most part, activities in the first three years are limited to study activities. Tamboran's licence allows them to *'drill shallow core boreholes'* in the first three years. Rathlin Energy Ltd's licence enables them to drill a well to a minimum of 2,700 metres in depth (subject to permissions) in year three.[viii]

The licences of Infrastrata PLC/eCORP, Tamboran and P.R. Singleton require the companies to make a *'drill or drop decision'* in year three – i.e. to decide whether to drill a well or abandon the project based on the first three years of study. Rathlin Energy Ltd's licence does not include this clause.

All licences require that well drilling is subject to securing necessary permissions (planning permission and landowner permission). Licensees are subject to controls of other statutory bodies, including: Health and Safety Executive Northern Ireland, the Planning Service, the Northern Ireland Environment Agency, the Road Service, Local Councils.

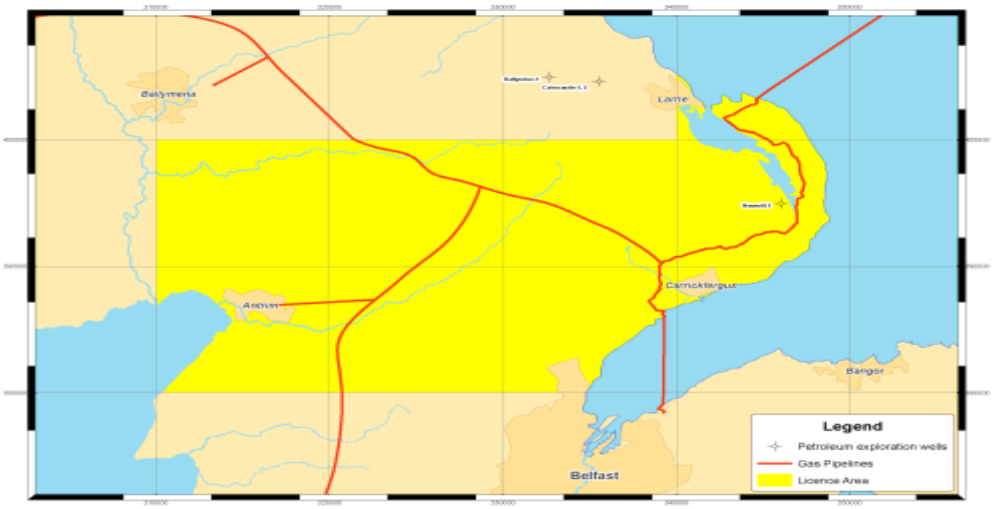
Of the four licences, only one, Tamboran's, specifies that the licence holder proposes to use hydraulic fracturing.[ix] As is the case with other drilling activities, carrying out the process of hydraulic fracturing will require the securing of necessary permissions. On this, the Minister for Enterprise, Trade and Investment has stated:

> *In order to undertake hydraulic fracturing a company would need to hold, or to be working under contract to a company that holds, a petroleum licence. The petroleum licensee must obtain approval from DETI to carry out their drilling operations, which would be dependent on the company obtaining all other permissions needed, including those from Planning Service, NIEA and HSENI. When submitting a drilling application the petroleum licensee must also nominate an Operator, to be approved by DETI, who should have the qualifications and experience appropriate to the proposed operations, as should any contractors or sub-contractors employed by the licensee.*[x]

To date the companies have carried out the following activities in their respective Northern Ireland licence areas:

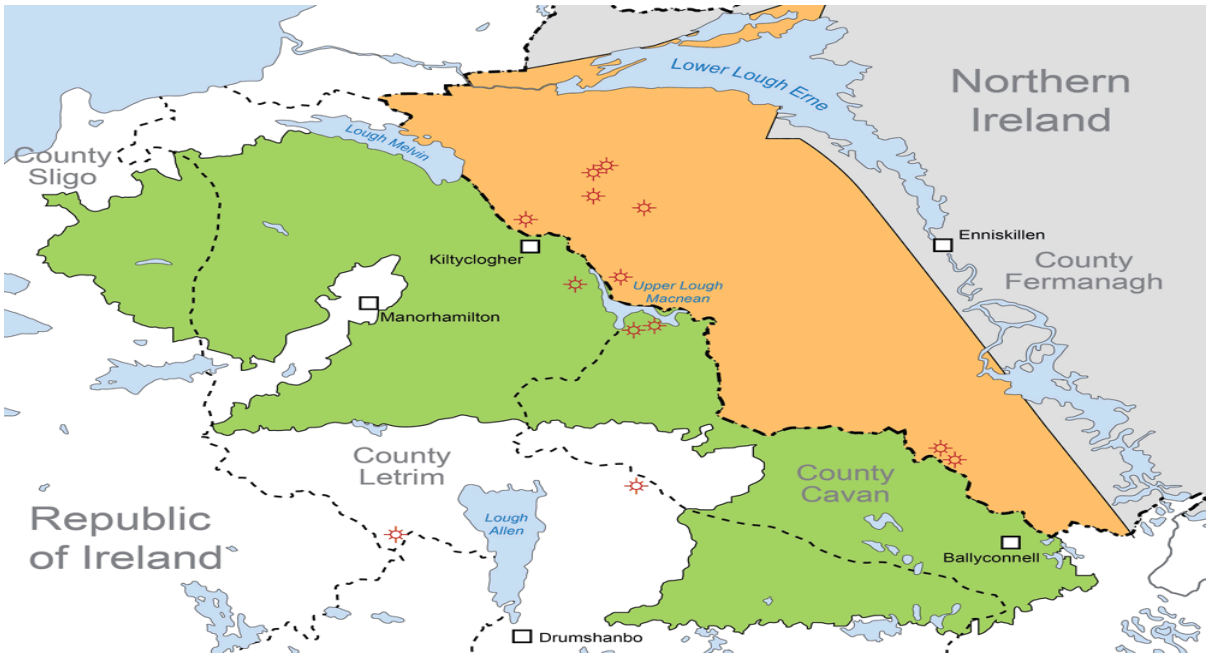
- **Infrastrata PLC and eCORP Oil & Gas UK Ltd**: a seismic programme was carried out during 2011 across an area traversing, Antrim, Newtownabbey Carrickfergus, Larne and Ballymena. The company is now reviewing the data, the result of which will dictate future plans. However, the company state that *'carboniferous oil and gas source rocks have been identified in wells drilled on the margins of the basin for coal exploration'*.[xi] Infrastrata's stress that their petroleum exploration is conventional, i.e. it is not unconventional shale gas and should therefore not involve fracking.[xii] Figure 2 provides a more detailed map of the area covered by the Infrastrata and eCORP licence.

Figure 2: Infrastrata PLC and eCORP Oil and Fas UK Ltd Licence Area



- **Tamboran Resources Pty Limited**: Tamboran note that they are at a *'very early stage'* but expect to drill shallow holes of 100m to 200m in depth and one larger borehole of 1,200m in depth over the next six months for analysis purposes. On 1 February 2012 announcing that it had completed the *'first part of its analysis to determine the feasibility of shale gas exploration in Northern Ireland'* and that it planned to publish the full analysis by the end of this year.[xiii] Figure three provides a more detailed map of the Tamboran licence area (note: this covers Northern Ireland and Republic of Ireland).[xiv] Tamboran have not ruled out the use of fracking in stating it would be *'impractical'* to do so.[xv]

Figure 3: Tamboran Resources Pty Ltd[xvi]

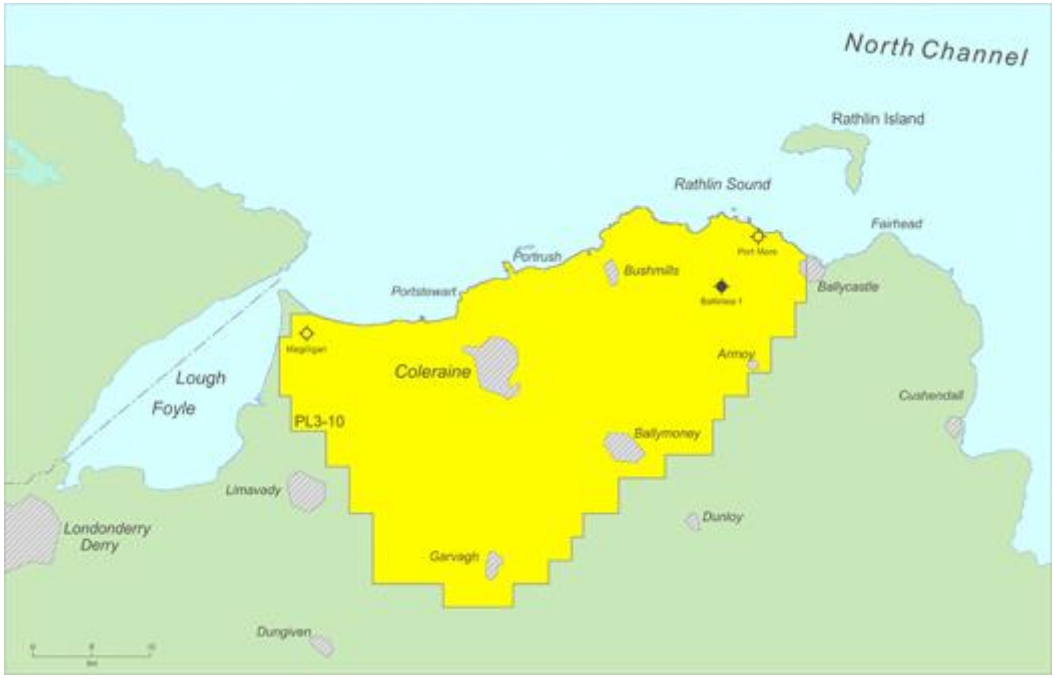


- **Rathlin Energy UK Limited**: the company has been exploring the geology of the area for over a decade. In 2008, they drilled an oil exploration well at Ballinlea, discovering oil. In February 2012, the company began a gravity survey of its licence area. This will be followed by seismic surveys which will also take place during 2012. The purpose of these surveys is assessing the area's deep geology. Based on the results of this survey, the company intends to drill a deep exploratory well to confirm the whether levels of oil and gas in the area are commercially viable.[xvii] Rathlin Energy UK Limited's publicly available information on the exploration of the Rathlin Basin does not indicate that they intend to use hydraulic fracture in the area.[xviii] They have also stated that they are *'not proposing to hydraulically fracture'* wells at their Yorkshire site.[xix] Rathlin Energy UK Limited's parent company Connaught Oil and Gas' mission statement, however, reads:

  > *Our mission is to maximize value creation for our shareholders through the identification, capture and development of* ***a portfolio of conventional and unconventional exploration*** *projects.*[xx] *(Emphasis added)*

  Figure 4 provides a more detailed overview of the Rathlin Energy UK Limited licence area.

Figure 4: Rathlin Energy UK Limited Licence Area[xxi]



- **P.R. Singleton Ltd**: P.R. Singleton's (or Providence) work programme consists largely of desk study which will enable the company to determine the hydrocarbon potential of the area. The companies licence area is 15m^2 in total, essentially the area of Rathlin Island. The information published on the firm's (Providence rather than P.R. Singleton) website makes no reference to the use of hydraulic fracturing.[xxii] Providence also states that their activities across the Island of Ireland will *'comprise a mixture of appraisal/development drilling on proven discoveries as well as exploration drilling.*[xxiii]

3.2 The Republic of Ireland

Three firms have been granted licencing options for areas in the Republic of Ireland. These are:

- Tamboran Resources PTY Ltd over 986 sq km in the Northwest Carboniferous Basin;
- Lough Allen Natural Gas Company Ltd over 467 sq km in the Northwest Carboniferous Basin; and
- Enegi Oil Plc over 495 sq km in the Clare Basin.

A licencing option is defined as follows:

> *This is a non-exclusive licence giving the holder the first right, exercisable at any time during the period of the Option, to an Exploration Licence over all or part of the area covered by the Option.*

These licence options do allow for initial exploration including drilling to a depth of 200m (650ft) and for technical studies to indicate whether the resources commercially viable. If successful the companies will have a first option on an exploration licence.[xxiv]

Commenting on the licences during February 2012, the Minister of State at the Department of Communications, Energy and Natural Resources stated:

> *Exploration drilling, including drilling that involves hydraulic fracking is not permitted under these licensing options.*
>
> *Before the companies concerned could apply for an exploration licence and proceed to an exploration drilling phase, they must first complete the licensing option work programme agreed with my Department. These work programmes are primarily based on desktop studies of existing data and should be completed by February 2013. When they have completed their work programmes each company will then have to decide if it wishes to move to the next stage and apply for an exploration licence.*
>
> *Any application for an exploration licence that proposed using hydraulic fracturing would be subject to an Environmental Impact Assessment (EIA). That assessment would include a Public Consultation Phase, of four weeks or more, which would be advertised on my Department's website and in the local press. This would provide an opportunity for the public to input into the decision making process. My Department would also seek and be guided by the expert advice of other relevant statutory authorities such as the Environmental Protection Agency (EPA), the National Parks and Wildlife Service (NPWS) and the Local Authorities. The outcome of the EIA would help determine whether or not an Exploration Licence would be granted.*[xxv]

The Republic of Ireland's Environmental Protection Agency commissioned the University of Aberdeen to carry out a study into hydraulic fracturing. The desktop, which will be complete in March 2012, will examine:

- The potential environmental impacts of fracking, in particular, and shale gas extraction in general
- The potential for methane and chemical migration into groundwater as a result of fracking
- The role of local geology in successful fracking and shale gas extraction
- The regulatory approaches taken in other countries where the fracking technique has been used
- Best Environmental Practice for shale gas exploration and extraction using the fracking technique
- Fracking without the use of chemicals and the reality of such a proposal.[xxvi]

A more comprehensive study will be produced later in 2012.

4 Environmental risks of hydrocarbon exploration in general

There are issues which are readily identifiable as potential sources of pollution and associated with standard oil or gas exploration.

4.1 Noise Pollution

Table 1 provides a summary of the activities associated with well pads prior to production. Individually and collectively this will produce noise for between 500-1500 days as indicated although it would be expected that continuous drilling of wells 24hrs per day for up to 18months would be significant for a single pad. If pads are allocated at 1.25-3.5pads/km^2 then this will create greater noise pollution for a locality.[xxvii]

4.2 Air Pollution

Air emissions occur during exploration and production activities including NOx, volatile organic compounds, particulate matter, SO_2 and methane.[xxviii] However, the Environment Agency told the House of Commons Energy and Climate Change Committee[xxix] that it was:

> *…not expecting big air quality implications […] the Government have oversight of the implementation of the Air Quality Directive […] the Environment Agency has to have regard to the National Air Quality strategy". The Environment Agency "would prefer that if methane is being discharged that it was flared, because obviously that converts it to carbon dioxide, which is a much less potent greenhouse gas […] but we would respect the Health and Safety Executive's judgment about what is safe.*

4.3 Landscape Impacts

Impact on the landscape is inevitable with any drilling operation. Again table 1 highlights the mechanical processes involved in a site prior to production and the associated requirements e.g. storage sites, chemical tanks, drilling equipment, trucks etc. The visual, and associated, impacts will depend on the number of well pads located in an area i.e. it may be difficult to take steps to alleviate the visual impact if there are multiple well pads.

4.4 Traffic and Road Damage

Increased traffic particularly truck visits to and from the site could be significant and will depend on the number of well pads. Coupled with this increase in heavy traffic is the potential for road damage.

5 Unconventional gas

The US National Petroleum Council defines unconventional gas as:

> *…natural gas that cannot be produced at economic flow rates nor in economic volumes of natural gas unless the well is stimulated by a large hydraulic fracture treatment, a horizontal wellbore, or by using multilateral wellbores or some other technique to expose more of the reservoir to the wellbore.*[xxx]

There are a number of types of unconventional gas:

- Deep natural gas;
- Tight natural gas;
- Shale gas;
- Coalbed Methane;
- Geopressurized Zones; and
- Methane Hydrates.[xxxi]

For the purposes of this paper, the following section will focus on shale gas as it this, and its extraction, that has caused considerable debate in Northern Ireland and beyond. Shale gas is:

> *…natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas.*[xxxii]

5.1 Shale gas potential resources

Shale gas has, over the last decade, become accessible due to advances in technology (most notably hydraulic fracturing) which have led to it becoming a more economically viable resource.[xxxiii]

Shale gas has already had significant impact on the gas industry in the USA. In a 2009 report*, Modern Shale Gas Development in the United States: A Primer,* prepared for the US Department of Energy Office of Fossil Energy and National Energy Technology Laboratory by the Groundwater Protection and ALL Consulting, noted that:

> *At the U.S. production rates for 2007, about 19.3 tcf* [trillion cubic feet[xxxiv]]*, the current recoverable resource estimate provides enough natural gas to supply the U.S. for the next 90 years. Separate estimates of the shale gas resource extend this supply to 116 years.*[xxxv]

The report adds:

> *Shale gas resource estimates are likely to change as new information, additional experience, and advances in technology become available.*[xxxvi]

Concluding:

> *Considering natural gas's clean-burning nature, the nation's domestic natural gas resources, and the presence of supporting infrastructure, the development of domestic shale gas reserves will be an important component of the U.S.'s energy portfolio for many years. Recent successes in a variety of geologic basins have created the opportunity for shale gas to be a strategic part of the nation's energy and economic growth.*[xxxvii]

With regard to UK resources, in 2010 the British Geological Survey (BGS) estimated that the UK shale gas reserve to be approximately 150 billion cubic metres of potential shale reserves, with significant potential reserves northern England, including the Widmerpool Gulf near Nottingham and a large area centred on the Elswick Gasfield, near Blackpool. The BGS estimate carries a number of caveats, notably that the gas content of the shale deposits is unknown and that the environmental concerns may hamper development.

In Northern Ireland, the only company that has expressly stated an intention to exploit shale gas is Tamboran. Based on its first phase studies the company estimates potential for ultimate production of up to 2.2 trillion cubic feet (tcf) (approximately 62 billion cubic metres) of shale gas (this equates to 50 years of the current daily consumption of gas in Northern Ireland).[xxxviii] Tamboran's publicity does not make it clear if this figure refers to shale deposits in Northern Ireland alone, or with in its two licence areas.

5.2 Potential benefits

The potential benefits of onshore unconventional/shale gas (and conventional in the case of Northern Ireland) exploration on the island of Ireland may be significant, but are difficult to quantify. The reason being, the companies exploring the potential of hydrocarbons on the island are at the very earlier stages of investigation.

From a Northern Ireland perspective, security of supply is a major driver. As a region Northern Ireland does not hold any indigenous marketable gas supplies and is, as a result, reliant on imports, a significant discovery of unconventional gas would address this over-reliance.[xxxix]

In a more general sense, unconventional gas, in displacing coal or oil in energy markets, may reduce overall greenhouse gas emissions. Although there are concerns regarding the emissions of shale gas compared to conventional natural gas (see below) and with shale displacing renewable development. On this latter point, the Department of Energy and Climate Change state:

> *There is also concern that increasing gas-based electricity generation, fuelled by abundant unconventional gas, would discourage investment in*

> *low-carbon technologies, making them less financially viable both in the UK and around the world.*[xl]

With respect to other factors, Tamboran Pty Ltd put forward the following arguments in favour of developing shale gas in Northern Ireland in a recent press release:

- Full natural gas security of supply in Northern Ireland for at least 20 years and a substantial reduction in imports for over 30 years leading to removal of Northern Ireland's 100% dependency on imported gas;
- Excess gas supply at peak production, enabling Northern Ireland to become a significant net exporter of natural gas;
- The creation of 600 direct jobs and an estimated 2,400 indirect jobs in County Fermanagh;
- Tax revenues of up to £6.9 billion (including royalties, corporation tax, Vat, employment taxes and exploration tax); and
- A community investment fund directed entirely within County Fermanagh, estimated to lead to additional local benefits in excess of £2 million per year once the project reaches expected commerciality in 2015.[xli]

It should be noted that Tamboran's have issued a similar press release for the Republic of Ireland. That release (available here) includes the same estimate of shale gas resource and job creation, suggesting that both the resource and benefits are likely to be on an All-island basis.[xlii]

5.3 Shale gas emissions

Natural gas produces fewer carbon dioxide emissions than other combustion fuels. Department of Energy and Climate Change data estimates that in 2008 gas CO_2 emissions in the UK were approximately 0.19 kilograms of CO_2 per kilowatt hour of energy used (CO_2/kWh), compared to 0.25CO_2/kWh from oil, 0.34CO_2/kWh from solid fuel and 0.54CO_2/kWh from electricity.

Shale gas, however, is considered to compare less favourably to other fuels:

Commenting on shale gas in its report *Are we entering a golden age of gas?*[xliii] (June 2011), the International Energy Agency (IEA) state:

> *Based on available data, we estimate that shale gas produced to proper standards of environmental has slightly higher 'well-to-burner' emissions than conventional gas, with combustion of gas being the dominant source of emissions. Best practice in production, effectively monitored and regulated, can mitigate other potential environmental risks such as excessive water use, contamination and disposal.*[xliv]

Speaking at the launch of the report, IEA executive director, Nobuo Tanaka stated:

> *While natural gas is the cleanest fossil fuel, it is still a fossil fuel. Its increased use could muscle out low-carbon fuels such as renewables and nuclear, particularly in the wake of Fukushima. An expansion of gas use alone is no panacea for climate change.*[xlv]

Recent research carried out by Cornell University has examined greenhouse gas emissions produced from shale gas. Two aspects of their work are significant here. Firstly, comparison of methane emissions from conventional wells against fractured wells found that emissions from the latter were 30% higher.

Secondly, they compared the greenhouse gas footprint of shale to other fuels finding that (note: results quoted from New Scientist report on the research):

> *…over 20 years, shale gas emits up to twice as much CO_2 for each unit of energy it contains. Even when allowing for greater efficiency of gas-fired power stations, electricity from shale as still releases as much as forty per cent more CO_2 equivalent than coal.*[xlvi]

The Cornell paper is not without its critics – the quality of data, the timescales used and the potency of methane gas have all been questioned, although the these have been defended by the authors (for example, they recognises that emissions data is limited but state they are the best available) (a fuller response to these criticism in New Scientist 25 February 2012, p50). It is key, however, that the Cornell paper is the first peer reviewed paper on methane emissions from shale. The true emissions impact of shale gas remains disputed.

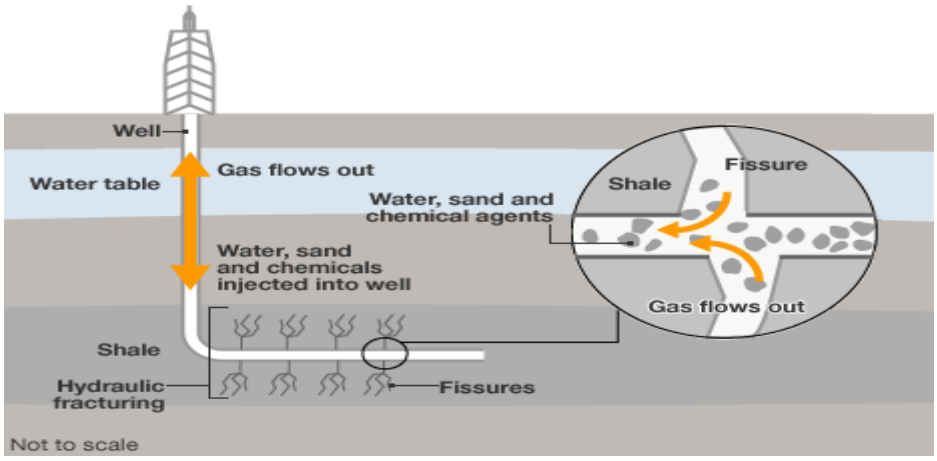
6 Hydraulic fracturing ad horizontal drilling

Hydraulic fracturing, commonly known as fracking, is the process of hydraulic fracturing used to recover natural gas from deep shale formations. It is called 'fracking' because it involves creating fissures or fractures in rocks to allow the gas to flow. The fractures are created by injecting a hydraulic fracturing fluid, usually consisting of water, sand and chemicals, down the well and into the shale gas formation. The sand keeps the fractures open and allows the gas to flow via the well to the surface where it is collected.

Fracking is invariably used in combination with horizontal drilling to access shale gas reserves. Fracking is therefore not a drilling process. It is applied *after* the drill hole has been completed. Horizontal drilling allows the well to penetrate along the hydrocarbon bearing rock seam, which maximises the rock area that, once fractured, is in contact with the wellbore and, therefore maximises well production.

Figure 1 provides an illustration of how fracking works in practice.

Figure 5: Shale gas extraction – hydraulic fracture[xlvii]



Source BBC

Hydraulic fracturing has taken place in Northern Ireland previously, according to the Minister for Enterprise, Trade and Investment hydraulic fracturing took place in three 'tight gas sandstone' exploration wells in Fermanagh in 2002:

- Slisgarrow No. 2, January 2002;
- Knock Beg No. 1, January 2002;
- Mullanawinna No. 1, February 2002.[xlviii]

7 Additional environmental risks associated with hydraulic fracturing

A consensus on the environmental impact of hydraulic fracturing has not been reached. As noted by the Tyndall Centre:

> *To date the only significant development and exploitation of shale gas has been in the United States. However, even there significant environmental issues remain unresolved.*[xlix]

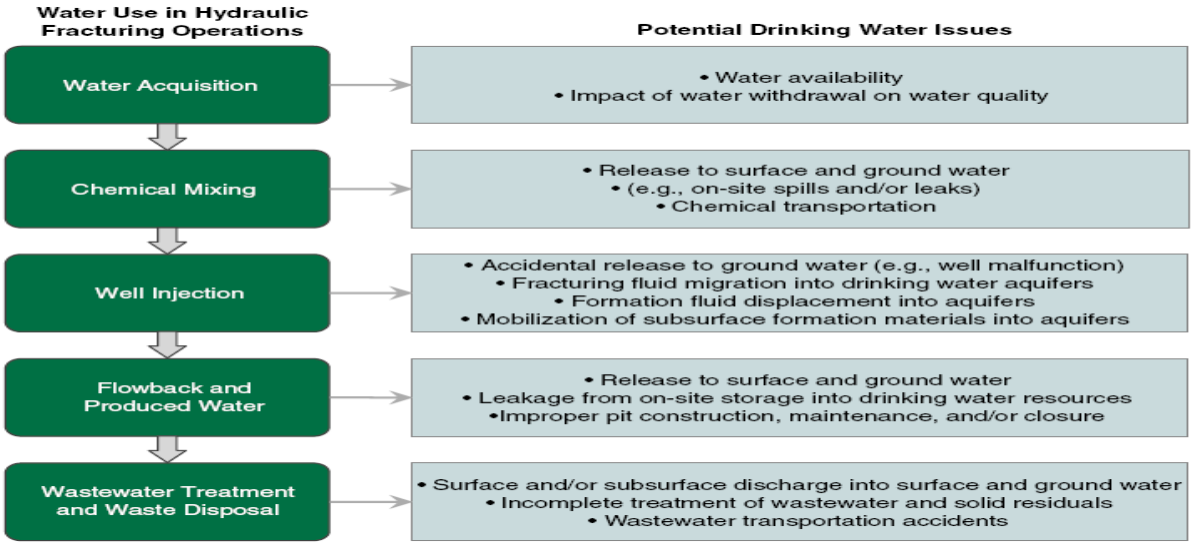
The situation is evolving, with important reports expected from the US Environmental Protection Agency later in 2012 and in 2014.

This section looks at two of the major environmental issues associated with hydraulic fracture – water pollution and seismic activity – and presents existing evidence.

7.1 Water Use in hydraulic fracturing operations

There are a number of associated risks from the use of water in the hydraulic fracturing process. The US Environmental Protection Agency identified the risks which are presented in a flowchart figure 4.

Figure 6: Water Use in Hydraulic Fracturing Operations[I]



Source: US EPA

Perhaps of particular concern in relation to water is the potential for pollution of groundwater aquifers. The fracking process consumes huge amounts of water, between 2 and 4 million gallons, depending on the nature of the extraction site.[li] As noted above this water comprises the large part of the fracturing fluid which also includes sand and other chemical additives. As many shale deposits are found under aquifers the process of drilling can potentially release this mixture of water and chemicals into the aquifer.

There has been concern in the USA that fracking has, in some cases, resulted in contamination of drinking water with chemicals and/or methane. A study by Duke University in the USA outlines the concerns:

> *Concerns for impacts to groundwater resources are based on (i) fluid (water and gas) flow and discharge to shallow aquifers due to the high pressure of the injected **fracturing** fluids in the gas wells); (ii) the toxicity and radioactivity of produced water from a mixture of **fracturing** fluids and deep saline formation waters that may discharge to the environment; (iii) the potential explosion and asphyxiation hazard of natural gas; and (iv) the large number of private wells in rural areas that rely on shallow groundwater for household and agricultural use.*[lii]

This is an important issue in the USA where nearly half the population relies on groundwater aquifers as their primary source of drinking water; rising in rural areas to around 95%.[liii] Groundwater aquifers may also discharge water into rivers, lakes and wetlands and therefore if the groundwater is contaminated surface waters may also be contaminated by these discharges.

However, while the study did indicate that there was evidence for methane contamination of some shallow drinking-water systems due to poor well construction

there was no evidence for contamination of drinking-water samples with deep saline brines or fracturing fluid.

A recent report by a House of Commons Select Committee on Energy and Climate Change, referring to the above, concluded that:

> *…hydraulic fracturing itself does not pose a direct risk to water aquifers, provided that the well-casing is intact before this commences. Rather, any risks that do arise are related to the integrity of the well, and are no different to issues encountered when exploring for hydrocarbons in conventional geological formations. We recommend that the Health and Safety Executive test the integrity of wells before allowing the licensing of drilling activity.*[liv]

In December 2011 US Environmental Protection Agency (EPA) released a draft report on the results of a study to assess ground water quality and identify potential sources of contamination associated with hydraulic fracturing at Pavillion, Wyoming. The draft report concluded that at the site in question:

> *…inorganic and organic constituents associated with hydraulic fracturing have contaminated ground water at and below the depth used for domestic water supply.*[lv]

In the press release that accompanied the draft report the EPA stress that:

> *The draft findings announced today are specific to Pavillion, where the fracturing is taking place in and below the drinking water aquifer and in close proximity to drinking water wells – production conditions different from those in many other areas of the country.*[lvi]

The Agency is currently undertaking a *'Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources'* with interim results expected at the end of 2012 and final results in 2014.[lvii]

Research published by the Tyndall Centre in November 2011 drew the following conclusions:

> *Concerns remain about the adequacy of current UK regulation of ground water and surface contamination and the assessment of environmental impact. Although amenable to stringent regulatory control, risk of contamination cannot be full eliminated. Consequently, if shale gas is to make a significant contribution to the UK's energy mix, a rigorous monitoring regime is essential to contain the risks of contamination, from thousands of wells* [hypothetically], *within 'acceptable' levels.*[lviii]

7.2 Increased Seismic Activity

There have been a number of reports in the media relating increased seismic activity with fracking. In the UK for example the energy company Cuadrilla Resources suspended its prospecting near Blackpool, Lancashire after concerns that the process had initiated two small earthquakes.[lix]

Other news reports in the USA suggest a correlation between fracking and increased seismic activity.[lx]

Commenting on this issue, the Minister for Enterprise, Trade and Investment has stated:

> *Measurements made on thousands of hydraulic fracture treatments have shown that these may trigger minor earthquakes, usually with a magnitude less than 0 on the Richter scale, which cause no damage at the ground surface. The two seismic events recorded near Blackpool (magnitude 2.3 and 1.5) are attributed to injected fluids penetrating and causing minor slip on a fault zone. Whilst the Blackpool seismicity is linked to unusual site-specific geological conditions, the specialists' report makes a number of recommendations for the evaluation and mitigation of seismic hazard. My Department will discuss these with DECC* [Department of Energy and Climate Change] *before making any decisions on seismic monitoring and mitigation protocols for Northern Ireland.*[lxi]

8 Conclusion

It is evident that that no consensus has been reached on the impact of shale gas and hydraulic fracturing. Similarly, the benefits to the Island of Ireland have not been independently verified. A number of key publications are forthcoming. This paper will be updated and amended as more information comes to light.

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