

PROPOSED TERMS of REFERENCE for EPA/DCENR/NIEA Research Programme on Environmental Impacts of Unconventional Gas Exploration & Extraction (UGEE)

1. Background - Unconventional Gas Exploration & Extraction

In the context of the proposed research outlined in this document, Unconventional Gas Exploration & Extraction (UGEE) refers to the use of high volume hydraulic fracturing (fracking) of previously impermeable rock to permit the extraction of natural gas on a commercial scale from unconventional sources such as shale gas deposits, coal seams and tight sandstones.

Hydraulic fracturing, or 'fracking', is a method used by drilling engineers to stimulate or improve fluid flow from rocks in the subsurface. In brief, the technique involves pumping a water-rich fluid into a borehole until the fluid pressure at depth causes the rock to fracture. The pumped fluid contains small particles known as proppant (often quartz-rich sand) which serve to prop open the fractures. After the fracking job, the pressure in the well is dropped and the water containing released natural gas flows back to the well head at the surface. The boreholes themselves are often deviated away from the vertical, into sub-horizontal orientations, to ensure better and more efficient coverage of the targeted shale gas reservoir. The fracking fluid also contains small amounts (typically < 2% in total by volume) of chemical additives such as acid to help initiate fractures, corrosion and scale inhibitors to protect the borehole lining and gelling agents to alter the fluid viscosity¹.

2. Unconventional Gas Exploration & Extraction on the Island of Ireland

At present, there is no exploratory or commercial drilling underway in relation to UGEE on the Island of Ireland. However in both the Republic of Ireland and Northern Ireland, there a number of activities planned.

In the Republic of Ireland, DCENR announced in February 2011 that it was offering Onshore Petroleum Licensing Options to:

- (i) Tamboran Resources PTY Ltd over 986 sq km in the Northwest Carboniferous Basin.
- (ii) Lough Allen Natural Gas Company Ltd over 467 sq km in the Northwest Carboniferous Basin.
- (iii) Enegi Oil Plc over 495 sq km in the Clare Basin

These 'options' are valid for a period of up to a maximum of 24 months and give 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. The three options outlined above are due to expire in February 2013, by which time the licence holders will have to decide whether to apply for a licence or relinquish the acreage.

In Northern Ireland, Tamboran Resources PTY Ltd, has secured a Petroleum Licence from the Department of Enterprise, Trade and Investment (DETI) to explore for shale gas reserves over 746 sq km of the Northwest Carboniferous Basin in Co. Fermanagh. The licence runs from 1st April 2011 and has a 'drill or drop' work programme. In the first three years the company is expected to carry out pre-drilling exploration (although this may include the drilling of stratigraphic boreholes) and, before the end of Year Three, either commit to drilling an exploration well within the following two years or relinquish the licence. Additional consents are required before the company can drill the exploration well and any operations involving hydraulic fracturing would require an Environmental Impact Assessment which would consider potential cross-border (transnational) impacts.

¹ http://www.epa.ie/downloads/pubs/research/sss/UniAberdeen_FrackingReport.pdf

3. Previous Research on Unconventional Gas Exploration & Extraction

In May 2012, the EPA released the report from a preliminary study “*Hydraulic Fracturing or ‘Fracking’: A Short Summary of Current Knowledge and Potential Environmental Impacts*”. This short desk study was conducted for the EPA by the University of Aberdeen and provided an introduction to the environmental aspects of fracking including a review of regulatory approaches used in other countries and areas for further investigation and research. In brief, some of the key findings of the study were:

- The importance of knowledge of local geology regarding potential impacts on groundwater quality and possibility of induced seismic activity.
- The importance of well integrity for preventing groundwater contamination.
- The uncertainty regarding the “carbon footprint” of shale gas in comparison to conventional natural gas. This is an important climate change issue.
- Baseline studies are needed before drilling begins (surface water; groundwater; seismic)
- The small number of published, peer reviewed, scientific studies in the area.

Further research is required to fully understand the potential impacts on the environment from the use of this technology. The key questions this research needs to answer are:

- 1) Can this technology be used whilst also fully protecting the environment and human health?

If the answer is yes, then:

- 2) What is best environmental practice in using the technology?

The question of whether the existing EU environmental regulatory framework is adequate for proper control of unconventional fossil fuels projects is also important. Outputs from this research will assist regulators (North and South) in fulfilling their statutory roles regarding this activity.

The information provided by the preliminary research project was used along with other sources such as European Commission reports to develop the Terms of Reference for a more comprehensive study which is being co-funded by the EPA, DCENR and NIEA. While elements of the research will relate to specific regions where petroleum licensing options or licences have been granted from the DCENR/DETI, it is the intention that the study will generally be applicable to the island of Ireland.

4. Funding Organisations

The Environmental Protection Agency (EPA) is an independent statutory body, established under the Environmental Protection Agency Act with a wide range of responsibilities including regulation of large scale industrial and waste facilities, monitoring and reporting on the state of the environment, overseeing local authorities’ environmental responsibilities, coordinating environmental research in Ireland, promoting resource efficiency and regulating Ireland’s greenhouse gas emissions. Through the Department of Environment, Community and Local Government (DECLG), the EPA has provided funding for environmental research since 1994. The current research programme ‘STRIVE’ has been running since 2007. The purpose of the STRIVE Programme is to protect and improve the natural environment, by addressing key environmental management issues by the provision of high quality scientific knowledge generated through a vibrant, competitive programme of research.

The Department of Communications, Energy and Natural Resources (DCENR) has responsibility for the Telecommunications, Broadcasting, Energy sectors. It regulates, protects, develops and advises on the Natural Resources of Ireland. Of particular relevance is the role of the Petroleum Affairs Division to maximise the benefits to the State from exploration for and production of indigenous oil and gas resources, while ensuring that activities are conducted safely and with due regard to their impact on the environment

and other land/sea users. The Geological Survey of Ireland (GSI) is also within DCENR and provides advice and guidance in all areas of geology including geohazards and groundwater and maintains strong connections to geoscience expertise in Ireland.

The Department of the Environment of Northern Ireland's (DOENI) aim is to protect and improve the environment, promote well-being, and deliver a strong and effective local government to support a thriving economy. As an executive agency of DOENI, the Northern Ireland Environment Agency (NIEA) seeks to safeguard the quality of the environment as a whole through effective regulation of activities that have the potential to impact on the environment. High Volume Hydraulic fracturing (fracking) is considered by the Agency to be such an activity. DOENI will regulate fracking through the relevant planning permissions and/or the required environmental permissions informed by this research.

5. Further Research

In order to assist government bodies in making informed decisions about future licensing and management of UGEE on the island of Ireland, comprehensive knowledge of the potential environmental impacts of this process is required. This knowledge will be generated from a number of sources including EU and international research and through a programme of research being commissioned by EPA and other bodies through this call.

This programme of research is being administered by the EPA STRIVE Programme, and steered by a committee with representatives from DCENR, DECLG, the Commission for Energy Regulation (CER), An Bord Pleanála (ABP), GSI, the Northern Ireland Environment Agency (NIEA) and the Geological Survey of Northern Ireland (GSNI).

It is proposed to award funding for research in three areas as described below:

Project-A: Baseline Characterisation:

Geology is the science comprising the study of solid Earth, the rocks of which it is composed, and the processes by which it evolves. Hydrogeology is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers). A comprehensive understanding of both these topics is a basic requirement in order to make an informed decision in relation to the potential environmental impacts which UGEE may present.

The subject of water contamination is one of the most contentious local environmental issues relating to UGEE. The risks to groundwater include those coming from the injected fluid, natural gas, the surface storage/management of flowback and formation water and other substances, such as radioactive materials and metals that may naturally occur within, and could potentially be released from, the shale. The risks to surface water and ecosystems include those to groundwater via the groundwater discharge to surface water as well as via the overland pathway. The risks not only relate to these potential contaminants, but also to additional subsurface preferential flow pathways that may be created during the fracking process. In addition large volumes of water are required to carry out the process and sourcing such volumes could have major implications for local water resources – both surface and groundwater.

Hydraulic fracturing inherently involves geomechanical risks – i.e. the injection of large volumes of pressurised water at depth will, by design, alter the in situ stress state and change the propensity of existing fractures to open or faults to slip, and possibly result in seismic activity (i.e. earthquakes).

This research shall be framed in a national context such that the resulting methodologies can be applied to other locations on the island of Ireland. Given that there are advanced license applications in three areas (Co. Clare, Co. Leitrim & Co. Fermanagh), these areas shall be used as 'case studies areas', through which the methodologies can be developed, applied and evaluated. The three areas should provide some

geological variation to test the robustness of the methodologies, as well providing region-specific information that will inform future decisions within these specific areas.

Project A-1 (groundwater, surface water and associated ecosystems):

For potential impacts on groundwater, surface water and associated ecosystems, particular research issues for consideration in this area would, inter alia, include:

- The importance of geology and hydrogeology in environmental protection and considerations of human health (e.g. drinking water).
- Assessment of existing baseline monitoring in order to inform best practice in an Irish context.
- Increasing geological and hydrogeological knowledge and developing a conceptual understanding, in the context of the three case study areas.
- Geological assessment of the existing fracture networks and networks that are likely to be produced by fracking operations and the implications for water flow and pollutant transport.
- The vulnerability of groundwater resources from both surface *and* subsurface UGEE activity related (including fracking) potential hazards and pathways.
- An assessment of the direct (e.g. abstraction) and indirect impacts (e.g. drinking water, other receptors) of using of local water sources for UGEE and specifically, fracking.
- The scope for, and implications of, recycling the flowback and produced water for reuse in further fracturing operations.

Based on the above, specific tasks relating to groundwater, surface water and associated ecosystems are required as follows:

1. Assessment of existing baseline monitoring (best) practices including the location and installation of monitoring points with specific regard to geological/hydrogeological conditions to inform best practice for an Irish geological context. This assessment should also outline/make reference to the legislative requirements to develop an environmental monitoring programme.
2. Development of sub-regional geological/hydrogeological characterisation and conceptual model based on all of the available existing data for the case study areas. General principles of data requirements, acquisition and assessment should enable application in a national context.
3. Preparation of a technical specification for a sub-regional baseline monitoring study that will be informed by the geological and hydrogeological characteristics of the case study sites i.e. taking specific regard of the conceptual understanding of local/regional groundwater flow regimes in these areas. This should take into consideration existing monitoring infrastructure and identify if, and where, additional monitoring points are required. Any additional monitoring locations will be installed to a high standard in line with best practice and with full (Steering Committee approved) hydrogeological supervision.
4. Baseline groundwater monitoring shall be undertaken for a minimum period of 12 months using appropriate existing monitoring points from the outset of the project and/or additional monitoring borehole(s) upon installation.
5. Assessment as to which elements of baseline monitoring should be undertaken by the state versus by the industry - making reference to best practice for other similar industrial activities in Ireland and other EU countries.
6. Assessment of the vulnerability of groundwater resources from both surface *and* subsurface UGEE activity related (including fracking) potential hazards and pathways.
7. An assessment of the direct (e.g. abstraction) and indirect impacts (e.g. drinking water, other receptors) of using of local water sources for UGEE and specifically, fracking.

8. The scope for, and implications of, recycling the flowback water for reuse in further fracturing operations on the case study areas, the results of which will inform potential impacts to other locations.

It is envisaged that throughout the project there will be a refinement of the conceptual model and technical specifications for monitoring as additional data are gathered (in discussion with the steering committee).

Outputs (subject to gaining appropriate land access for monitoring installation):

- Within **two months** - report on existing baseline monitoring (best) practices, sub-regional geological/hydrogeological characterisation and conceptual model, existing regional monitoring, technical specification for a baseline monitoring study.
- Within **three months** - monitoring programme begun at appropriate existing monitoring points.
Within **six months** - installation of additional monitoring points and commencement of monitoring (for 12 months).
- Within **12 months** - interim reports on conceptual model and monitoring.
- Within **20 months** – final reports on all elements.

Project A-2 (Seismic Impacts)

For potential seismic impacts, particular research issues for consideration in this area would, inter alia, include:

- A review of historical and modern records of natural seismicity in Ireland. An assessment of the nature and magnitude of induced seismicity associated with hydraulic fracturing operations, with reference to North America and UK.
- Review of seismic risk control regimes and make recommendations for systems applicable to Ireland, with particular reference to case study areas.
- Assessment of the capability of existing seismic monitoring network(s) to allow detection and xyz location of seismic events down to target magnitude threshold. If necessary, design and install additional monitoring stations to achieve aforementioned detection capabilities in at least one of the target areas, in order to inform best practice in an Irish context.
- Assessment of microseismic monitoring methodologies to enable real-time monitoring of fracture growth during, and immediately after, fracking operations in order to minimise risks from induced seismicity associated with hydraulic fracturing.

This assessment should review how the existing seismic network(s) can be integrated, what resources are required to analyse these existing data, and what regions/sub-regional monitoring locations would be required for the specific case study areas.

Based on the above, specific tasks relating to potential seismic impacts are required as follows:

1. Assessment of existing baseline monitoring to inform best practice for an Irish geological context. This assessment should also outline/make reference to the legislative requirements to develop an environmental monitoring programme.
2. Assessment of all existing Irish seismic data (North and South). This assessment should include an analysis of magnitude with regard to actual damage as well as perceived negative impacts.
3. As assessment of the likely seismic effects that may be induced with this activity. The actual and perceived impacts should make reference to/inform those in in the previous point.

4. Preparation of a technical specification for a sub-regional baseline monitoring study that will be informed by the geological/seismological characteristics of the case study sites taking into consideration existing monitoring infrastructure and identify if, and where, additional monitoring stations are required relating back to the area-specific geological/seismological conceptual understanding.
5. Identify if additional monitoring stations are required and install the additional monitoring stations according to best practice guidelines with full (Steering Committee approved) supervision.
6. Seismic monitoring shall be undertaken for a minimum period of 12 months, with provision for the ongoing operation and maintenance of the network. Where appropriate, this shall use the existing network from the outset of the project and, if required, monitor the correctly installed additional monitoring stations upon installation. Monitoring of the existing network and any newly installed station(s) will require discussion with, and approval from, the Steering Committee.
7. Following the assessment of the initial monitoring results, the network and procedures should be reviewed in discussion with the Steering Committee.
8. Assessment should be undertaken of what baseline monitoring should be undertaken by the state versus by the applicant. This assessment should make reference to best practice for other similar industrial activities in Ireland and other EU countries.
9. Examination of global experience of seismic events stimulated by or otherwise related to fracking and other UGEE activities with recommendations for likely impacts and appropriate mitigation measures within the geological context of Ireland.

Timelines for Seismic Outputs (subject to gaining appropriate land access for monitoring installation)

- Within **three months** - report on existing baseline monitoring practices, available seismological data, potential seismic effects from hydraulic fracturing, sub-regional geological/seismological characterisation and conceptual model, existing regional assessment of existing monitoring network(s), identify need for and specification of additional stations, installation and operation of additional monitoring stations (ongoing),
- Within **six months** - interim reports on conceptual model, and analysis of monitoring data.
- Within **20 months** - final reports on all elements, including monitoring results of natural seismicity from national and locally enhanced networks.

Project-B: Fracking Operations, Impacts & Mitigation Measures

This project should comprise a detailed examination of the potential environmental impacts and successful mitigation measures, associated with fracking that have come to the fore worldwide using published reports and other sources. Where appropriate, findings should be accompanied by reference to experiences in other countries. Specific issues to be addressed in the project are given below:

1. **Water Impacts and Mitigation Measures:** This work package should examine potential environmental impacts of UGEE on groundwater and other water bodies, including methane and chemical and other contaminant migration, both from surface as well as subsurface potential sources. Findings should be informed by an objective assessment of the risks and hazards posed by UGEE, supported by a literature review and experience from other jurisdictions. Mitigation measures to address water impacts (including effluent management/treatment) should be critically reviewed and presented.
2. **Other Potential Impacts and Mitigation Measures:** This work package should employ similar approaches to Task-B1 to examine impacts from UGEE operations on other areas, which shall include, but not be limited to human beings, flora & fauna, air, – both local and global (i.e. CO₂) impacts, climatic factors, landscape, material assets and cultural heritage. Mitigation measures to address these potential impacts should be critically reviewed and presented.

3. Life-Cycle Assessment: A comprehensive assessment of the cumulative environmental impact of unconventional exploration gas should be conducted and compared with similar published assessment of other energy sources.
4. Chemicals: Typically, chemicals such as biocides and dyes, among others, are used in UGEE however there are also indications that the successful use of chemical-free UGEE is also a possibility in some circumstances. This work package should examine UGEE techniques, including the purposes of individual additives, to ascertain current and emerging practices in the context of avoidance of the use of additives that have the potential to harm the environment.
5. Research into identifying best practice for monitoring both physical and environmental during the exploratory and extraction and close down phases. Identification of best practice in self-regulation during all phases of UGEE.
6. Examination of validity and range of existing and potential monitoring and mitigation techniques, to include but not be limited to geophysical techniques (down-hole and surface) for use in monitoring, control, horizon selection, and injection management.
7. Any other issues that become apparent in the course of the project and will contribute to the required knowledge base of this topic should be considered².

Outputs:

Within **nine months** of starting work, this sub-project shall produce a **detailed final report** on the issues listed above. A short **summary-type report** is also required which should be written in a style accessible to non-technical readers. The findings should also be disseminated to key stakeholders via a **seminar** or equivalent means.

Project-C: Regulatory Framework for Environmental Protection

Best environmental practice for UGEE would entail using the most effective techniques in achieving a high general level of protection of the environment and human health as a whole, by demonstrating strict adherence with all relevant environmental legislation. The European Commission has concluded that Directive 2006/21/EC on the management of waste from the extractive industries applies to shale gas projects using UGEE. As such, Article 4 of Directive 2006/21/EC places an obligation on Member States to ensure that competent authorities follow or are informed of developments in best available techniques. The European Commission may produce guidance for shale gas projects in the future and projects must take cognisance / build-on this work.

This project comprises of a number of issues/tasks listed below that should be undertaken and which will identify all regulatory requirements and best operational practices associated with the establishment and operation of a “UGEE development” in an Irish context.

1. Detailed information on the regulatory approaches of other countries that have extensive experience with this activity. This should include where possible a review of case studies where UGEE covered two jurisdictions (transboundary activities). Examination of the potential role of Health Impact Assessment in regulation of UGEE should be considered. A minimum of five countries should be examined including at least one country where a moratorium on unconventional gas exploration has been introduced.
2. Best practice for UGEE operations: This work package should examine the best practice in relation to UGEE operations including but not limited to: water resources management, risk management/minimisation and treatment, avoidance or mitigation of detrimental seismic events, use of chemicals, well-head construction, residuals management and air emissions management.

² Additional work to be agreed in advance with project steering group

3. Public engagement: This work package should examine a minimum of five case studies of public engagement in UGEE projects (or other similar projects) to identify best practices and recommend the most appropriate strategy in the Ireland / Northern Ireland context.
4. Any other issues that become apparent in the course of the project and will contribute to the required knowledge base of this topic should be considered³.

Outputs:

Within **nine months** of starting work, this project shall produce a **final project report** detailing the findings from the research issues outlined under items 1-5 above, setting out best-practice approaches for management of UGEE operations, to protect the environment and *inter alia* human health, complying in full with all relevant environmental legislation..

6. Contractor Experience and Conflict of Interest Issues

Applicants shall be required to demonstrate in-depth knowledge of a range of legal, environmental, socio-economic and technical issues including knowledge of mineral and fossil fuels (preferably unconventional gas) extraction practices and technologies.

Applicants shall also be required to declare, on their honour⁴:

1. they have no conflict of interest in connection with the contract; a conflict of interest could arise in particular as a result of economic interests, political or national affinities, family or emotional ties or any other relevant connection or shared interest;
2. they will inform the contracting authority, without delay, of any situation considered a conflict of interest or which could give rise to a conflict of interest;

7. Indicative Timeframe:

Jan – March 2013	Public Consultation on UGEE research programme
April 2013	Announcement of research funding opportunity via e-Tenders
May 2013	Deadline for submission of Tenders
May/June 2013	Evaluation and Negotiation Process
June 2013	Award of Successful Tenders

³ Additional work to be agreed in advance with project steering group

⁴ Text as used by the European Commission for Tender ENV.F.1/SER/2012/0033