Llywodraeth Cymru
Welsh Government

Introduction to Petroleum

(Oil and Gas)

1. What is petroleum?

Petroleum is a complex mixture of naturally occurring hydrocarbon compounds found in rock which has been formed over thousands of years by heat and pressure turning organic matter to oil and gas. Impurities such as sulphur, oxygen and nitrogen are common in petroleum. There is also considerable variation in colour, odour, sulphur content and viscosity in petroleum from different areas.

The Petroleum Act 1998 defines petroleum as:

- any mineral oil or relative hydrocarbon and natural gas existing in its natural condition in strata; but
- does not include coal or bituminous shales or other stratified deposits from which oil can be extracted by destructive distillation

The main petroleum product from Welsh reserves is natural gas, which is a source of energy for heating, cooking, electricity generation and chemical manufacturing.

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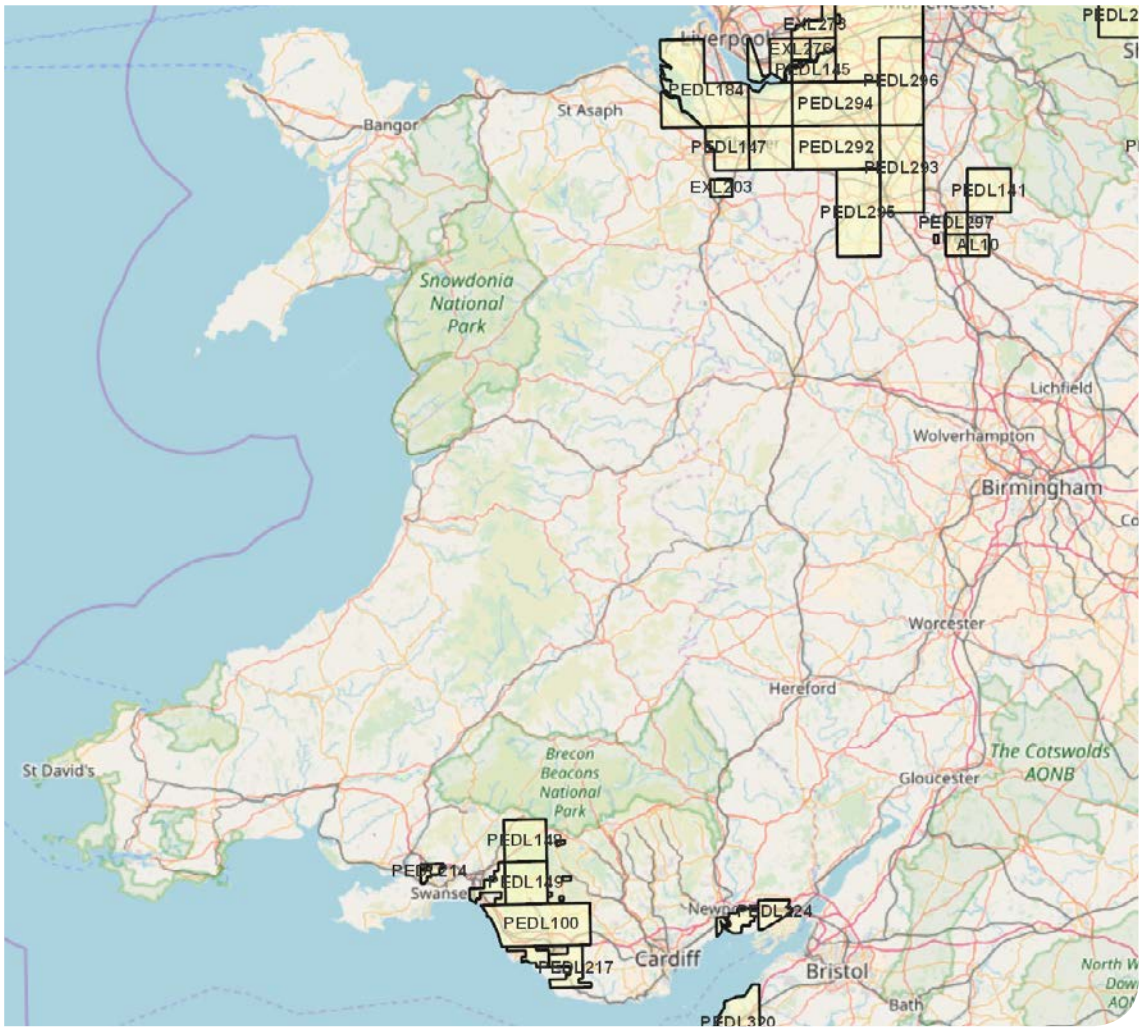
2. Petroleum (oil and gas) licensing and roles

A Petroleum Exploration and Development Licence (PEDL) grants exclusive rights to search and bore for, and get, petroleum within a specified area (a block).

There are currently 13 licensed blocks for oil and gas in Wales, all of which were issued by the UK Government (Figure 1). The licences do not give the licence-holder automatic permission to commence petroleum extraction operations. A range of additional planning and environmental permits are required before a development can commence.

Figure 1: **PEDL**



The location and extent of petroleum exploration and production development is strictly limited to the boundaries of the PEDL block. No development, including any horizontal drilling deep underground, is permitted outside of a PEDL block.

3. Regulation

A number of organisations are involved in assessing and regulating proposals for oil and gas developments in Wales (Table 1).

Table 1: Petroleum regulation in Wales

Organisation	Role
Welsh Ministers	A developer must obtain the relevant petroleum licence from Welsh Ministers before any further permissions can be obtained (except where a licensee already has a licence issued before 1st October 2018). Welsh Minister's consent is also required to appoint a licence operator (a person with responsibility for organising or supervising petroleum operations). For existing licences, the licensee must obtain the relevant well consent from Welsh Ministers before drilling or production can commence. Before a consent application is submitted to Welsh Ministers the operator must first obtain the additional consents or permissions outlined below.
Local Planning Authority	Companies must seek consent from the Local Planning Authority for all surface works associated with a petroleum development life-cycle (construction, operation, maintenance, decommissioning and abandonment). The local planning authority will consider issues such as noise, light, traffic, flood risk and air pollution.
Natural Resources Wales (NRW)	Companies must apply for the necessary environmental permits associated with any activity that is captured by the relevant environmental legislation. NRW regulates activities that may cause pollution or that pose other risks to the environment throughout the life cycle of a petroleum development.
Health and Safety Executive (HSE)	The HSE ensures the operator is managing the health and safety risks appropriately throughout the life cycle of a petroleum development. In particular, the HSE are responsible for ensuring the appropriate design and construction of a well.
The Coal Authority	The Coal Authority is responsible for granting consent for activity which cuts across, disturbs or enters coal seams.

4. Key environmental risks

A number of potential environmental impacts are associated with gas and oil exploration and production. These impacts may have short or long term implications for habitats, human health and landscapes, and include:

- Adverse effects on the groundwater environment arising from:
  - the escape of petroleum, chemicals or fluids, or the cross contamination of aquifers, due to inadequate well design or well failure.
- Contamination of surface water or soil by above-ground spills or leaks from storage tanks holding potential pollutants, including:
  - petroleum
  - liquid or solid waste
  - drilling muds and cuttings
  - naturally occurring radioactive material (NORM)
- Pollution of the air by:
  - fugitive (unplanned) emissions of methane
  - venting from the well or on-site tanks/equipment
  - flaring from the well (combusting waste gas)
  - site traffic, plant, generators etc
- Possible increased seismic activity during waste reinjection operations.
- Non-sustainable abstraction of water.
- Greenhouse gas emissions from fugitive releases.

Throughout the life cycle of a well it is generally recognised that protection of groundwater is the priority environmental issue for regulating onshore oil and gas, and the critical factor in protecting groundwater is well design and integrity.

5. What is the difference between conventional and unconventional gas?

Conventional petroleum deposits are contained in porous rocks with interconnected spaces, such as limestone and sandstone. These interconnected spaces give rise to permeability that allows oil or gas to effectively flow through the reservoir to the well. Conventional oil and gas reserves can typically be exploited by drilling a well into the reservoir, with oil or gas then flowing out under its own pressure.

The term unconventional gas refers to natural gas trapped in rocks that cannot be exploited using traditional methods. The low porosity and permeability of the rock formations, such as shale and coal, means that gas does not flow through them freely. In addition, shale and coal formations often occur in widely spread, thin layers, making the trapped gas difficult to access. Hence, techniques such as horizontal drilling, dewatering and hydraulic fracturing (fracking) may be needed to access and retrieve the natural gas contained within them.

As a further distinction between conventional and unconventional sources:

- For unconventional sources, the lack of permeability within the rock means that the petroleum does not migrate. Therefore, the petroleum source rock and reservoir rock are normally the same rock.
- For conventional petroleum resources, the petroleum migrates away from the source rock until it is trapped by an impermeable layer. Therefore, the reservoir rock is not normally the source rock.

What has qualified as unconventional at any particular time is a complex function of resource characteristics, the available exploration and production technologies, the economic environment, and the scale, frequency and duration of production from the resource. Perceptions of these factors inevitably change over time and often differ among users of the term. At present, the term is commonly used in reference to coalbed methane and shale gas.

Until recently, unconventional gas reserves have not been exploited because the cost was too high or the technology wasn't available. Technological advances mean it could now be economically viable to extract gas or oil from these sources.

6. What is Coal Bed Methane and how is it extracted?

Coal Bed Methane (CBM) is natural gas created during the formation of coal. CBM is adsorbed on to the surfaces within the coal formation and is held in place by the pressure of the water which resides naturally within the coal seam. CBM generally comprises over 95% methane, making the gas suitable for use as a direct replacement for conventional natural gas in pipeline networks.

CBM is recovered through an “intervention” including drilling from the surface down to the target coal seam and then often drilling horizontally along the seam to maximise the size of the coal seam that can be accessed from one surface facility. Water is then drained from the coal seam to release pressure, known as dewatering, which allows the methane to desorb and flow to the primary well along naturally occurring fractures “the cleat systems”and then to the surface. Hydraulic fracturing may be applied to increase the pathways, depending on local geological conditions.

In the UK, current pilot studies indicate that dewatering will generate in the range 1 to 40 m3/day per well of waste water.

7. What is Shale Gas and how is it extracted?

Shale gas, which is mainly methane, refers to gas held in fractures and pore spaces, or gas adsorbed on organic material within shale rock. Due to the very low permeability of shale rock, the gas will not flow to the production well without first applying the well stimulation technique known as hydraulic fracturing.

Hydraulic fracturing or 'fracking' is a well stimulation technique that is used to fracture rock to release the oil and gas trapped inside. Hydraulic fracturing uses fluid, usually water, pumped at high pressure into the rock to create narrow fractures which provide paths for the gas to flow into the well and then to surface. A well drilled for hydraulic fracturing for shale gas is usually between 1 and 3 kilometres deep.

The injected water contains sand (around 5%) to help hold open the fractures. Chemicals are also used (less than 1%) to reduce friction, protect the drilling equipment from corrosion, and to remove the accumulations of microorganisms and mud from drilling equipment. The number and type of chemical additives used will depend on the characteristics of the water and geology. Some fluid will return to the surface once the shale has been fractured. This fluid is known as flowback water, and must be treated and disposed of at a suitable waste treatment facility.

Hydraulically fracturing of conventional wells can help extraction by improving flow rates. Not all borehole wells will be subject to hydraulic fracking as it may not be appropriate for the local geology or required for the type of oil or gas being extracted.

8. Hydraulic fracturing

Hydraulic fracturing is used to increase the permeability of subsurface rocks and may be undertaken for a variety of purposes outside of petroleum developments, including:

- to stimulate groundwater wells;
- to measure stress in the Earth; and
- as part of a deep geothermal project.

9. Borehole drilling and core sampling

The drilling of a borehole well is common to all types of petroleum development. Protection of groundwater is the priority environmental issue. Well integrity, and therefore protection of groundwater, is achieved by lowering steel pipes, known as casing, into the borehole and then cementing them in to place. Figure 2 highlights a typical bore hole drilling operation, including the drilling rig.

Drilling a borehole for core sampling is a standard method of investigating what is underground. It produces a core of rock that allows the features of what is underground to be examined, including rock structure and viability for oil or gas production. Boreholes are drilled regularly across Wales for a variety of purposes, including civil engineering projects, water supply, and geothermal energy.

Figure 2: **Drilling rig**

10. Stages of an oil and gas development

Development of a petroleum reserve typically occurs in key stages:

- **Pre-development:** Refers to non-intrusive exploration, site characterisation and seismic surveys.
- **Exploration:** Refers to the initial phases of testing the commercial viability of a site. This will include the drilling of a borehole to assess the rock formations. Seismic surveys may be undertaken. A drilling pad, roughly the size of a football pitch, and roads must first be built. A drilling rig will be installed temporarily, and would typically measure 25-45 metres in height. The total time required to drill and complete a well is typically four to five weeks depending on target depth and underlying geological conditions.

  Flood lights may be installed to support safe working at night. The site would also house generators, sealed container units for chemicals and waste materials, and portable offices and work amenities.
- **Appraisal:** Refers to a period of limited petroleum production to assess the technical feasibility and costs of extracting the oil or gas at a specific site. The exploration and appraisal phase typically lasts between two and six years.
- **Production:** Refers to full-scale commercial extraction. If a site is suitable for production, more wells may be drilled with accompanying site activity. After around two years, the major on-site activity would cease and would be replaced by routine maintenance. The production phase typically lasts around 15 years. The pad would remain in place, alongside some small pieces of surface infrastructure and equipment.
- **Decommissioning and Restoration:** Refers to the permanent removal of wells and surface infrastructure. The well will be filled/plugged with concrete and the surface restored. This work could take place at any stage of a development if a decision is taken not to move to the production phase.

The total estimated lifespan of a site can be up to 20-30 years depending on whether the site is suitable for production.

Developers must obtain the relevant permissions and consents before progressing between the development stages.