UNCONVENTIONAL GAS EXPLORATION & EXPLOITATION IN SOMERSET & MENDIP

TECHNICAL BRIEFING NOTES

Unconventional hydrocarbons are non-renewable, alternative fossil fuels obtained using very different extraction techniques from those in conventional oil, coal or gas exploitation.

Fraccing / Fracking

The technical term 'fraccing' developed in North America (spelled 'fracking' in the UK) refers to **hydraulic fracturing of deep rocks to enhance release of natural gases**. Public and media use has expanded to refer to both shale gas and coal bed methane extraction using a variety of techniques.

The industry considers 'fracking' to mean only hydraulic fracturing of shales under high pressure. To extract methane from coal, hydraulic or nitrogen gas fracturing, and other enhancement techniques are often combined.

The Exploration Companies

In 2008 Petroleum Exploration Drilling Licences (PEDL's) for the Bath-Bristol-Mendip area were granted to UK Methane Ltd, based in South Wales. Eden Energy Ltd, an Australian company, holds a 50% joint venture interest in these coal bed methane rights. Neither company apparently has experience of shale gas drilling. UK Methane have explored for Coal Bed Methane (CBM) in Wales.[1]

The joint venture recently showed interest in 3 sites: UK Methane applied for planning permission to drill at Keynsham, withdrawing that application in 2012. At a recent Bath debate, they confirmed they are considering exploration at Ston Easton and Compton Martin on Mendip. The current 13th Round PEDL's expire in 2014 unless drilling has started. The 14th Round Licences will be tendered in 2014.

Unlike much of North America and Australia where 'simpler' rock strata occur, the Carboniferous Coal Measures of the Bristol-Bath Basin form **the most tectonically complex area of the UK** (ie the rocks are highly fractured, folded, contorted and faulted). Very little data on likely gas contents or strata continuity exists. So gasfield exploration and exploitation in this district will be commercially and technically 'high risk'. [1, 9-14]

Shale Gas

Mudstones and shales were previously considered too 'tight' (impermeable) for economic recovery of trapped methane gas. Deep drilling and hydraulic fracturing technology now allows release of that gas. Carboniferous Age shales and Jurassic Age mudstones in Somerset may potentially contain shale gas.[2]

Fluid is injected at high pressure to fracture the rock at depth. Sand and chemicals are added to hold fractures open and allow gas to flow. Fracturing is repeated perhaps every 2-5 years to restimulate flow. Boreholes are drilled vertically to between several hundred and 1-2 kms depth, then continued at an angle or horizontally up to several hundred metres (by 'deviated' or 'directional' drilling). Multiple angled or horizontal drilling allows maximum gas recovery from each well. Geophysical techniques are used to target the fracturing. [2,3]

Coalbed Methane (CBM)
Methane gas within deep coal seams is held on the coal surface (adsorbed) by pressure of surrounding water and rock. If pressure is released, gas can flow through rock fractures, and be extracted from boreholes.

In Somerset, coalbed methane could potentially be present within the north Mendip boundary zone of the Bristol-Bath Coal Basin, the Chew Valley and Keynsham areas, amongst others.[1,8] The main target zones are unworked coal seams thicker than 400mm at between 200-1200m depth. [2,3]

Techniques to release gas include:

- dewatering (pumping large amounts of water out of the coal seam over several months)
- nitrogen gas fracturing/fracking by injection of nitrogen under pressure into the coal seams
- higher pressure hydraulic fracturing / fracking
- a series of techniques may be necessary to reactivate flow, as the initial gas pressure decreases.

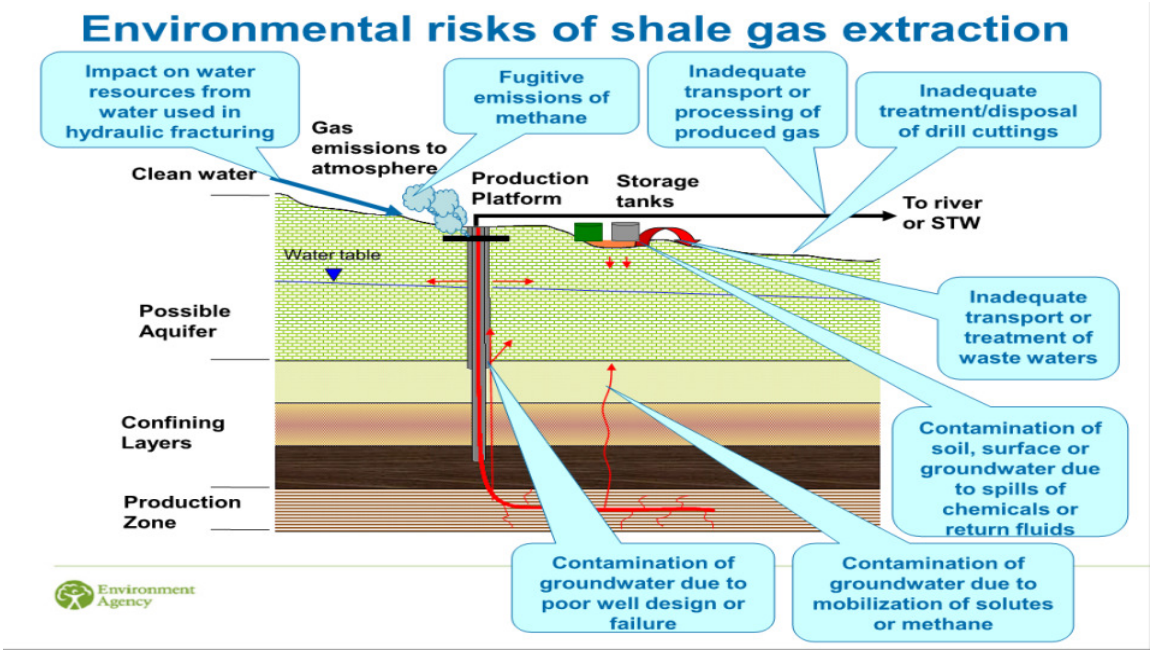
At exploration stage, its not possible to predict what production techniques will be, and hydraulic fracturing is required in most cases. [1,2,3,5]

Enhancement techniques aim to dewater and fracture the coal seams, and not surrounding rock, to stop too much water ingress, which would prevent successful gas recovery.[1,2] But control of water and gas flow depends on specific coal seam orientations and thicknesses, and simplicity of folds and faults within the source rock zone. Deviated or directional drilling is also required therefore.

Potential Risks to Environment & Communities

Specific environmental risks from this industry include:

- Groundwater boreholes impact by gas operations (agricultural boreholes within overlying rocks)
- Surface water springs and streams impact (e.g Chew Head spring at Chewton Mendip, Bristol Water Line of Works & Chew Valley Lake)
- Enhanced radon migration into unprotected houses due to gas regime changes below ground
- Enhanced seismicity (minor earthquakes) due to hydraulic fracturing
- Induced fractures can extend 350-600m from fracking depth, natural fractures extend 200-400m [7]
- Local availability of water supply [3,4,6,7]
- Overground pipeline security
- Contaminated Produced water treatment and disposal operations
- Lack of formal exclusion zones from wells or residential properties
- Complex, unforeseen geology at depth. [1,12,14]



Potential Issues - Common concerns for communities and regulators include:

Numbers of Boreholes & Gas Wells

- Several initial exploration boreholes needed to sample, test & pump collectively.
- Production wells **roughly 1km apart**.
- Clusters of 4 to 10 wells linked to a **central gas gathering station by pipelines**.
- Each well needs facilities at ground level of **0.5-1hectare in plan.**
- Each well may operate for **20-25 years.**[3,5]

Water Supplies & Waste Fluids

CBM wells require large-scale dewatering

- water contaminated in natural salts, metals, hydrocarbons, drilling fluids, injected chemicals and Naturally Occurring Radioactive Materials (NORM).
- water stored in lined water/mud lagoons or metal tanks, treated for disposal to water courses, or tankered off-site for treatment and disposal. [1,3]

Shale gas wells require large-scale injection of drill and fracking fluids

- highly variable amounts quoted - 'several million litres per day', '10-20,000 m^3 per fracturing stage per well'. [1,2,4,6,7]
- Tankers bring water and chemicals to site for temporary storage prior to use.
- 20-80% of injected fluid returns to surface - this 'flowback' water requires tankering off-site for treatment and disposal. [1,4]

Traffic

- Supply vehicles for drilling, fracturing and re-treatment of wells create periodic peaks in vehicle movements on-off well pad sites.
- Continuous water supply and removal tanker **movements create potential pressures on existing** transport infrastructure and communities.

Plant and Pipelines

- Produced gas is processed on-site or separated prior to storage.
- Methane leaves the site via overground pipelines or used on site to generate electricity.
- Waste storage areas for chemicals, produced water etc. needed. [2,3,7,8]

Venting, Fugitive Gases & Flaring

- Before commercial production, methane and nitrogen are **Vented** to atmosphere ('fugitive emissions'), or **Flared** (releasing carbon dioxide). [4, 7,16]
- For nitrogen fracking of coal, gas cannot be Flared until nitrogen reduces and gas has a sufficient energy content, so Venting is used. Other gases or 'heavier' hydrocarbons mixed with the methane are also flared.
- Introduction of 'green completion technologies' in US not yet agreed in UK. [7]

Other Noise & Light Pollution

- Industry works round the clock eg compressors work **24/7.**
- Each exploration borehole takes several months
- **Periodic peaks** in site activity, eg during refracturing stages
- Security considerations required **lighting** well sites [2,3]

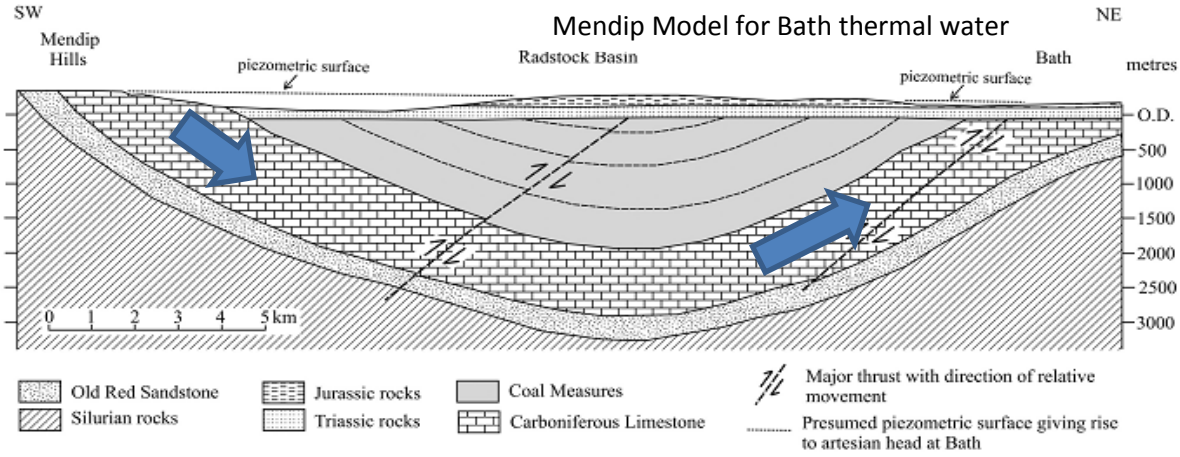
Visual Impact

- Each operational zone or well pad means industrial development of an area of **0.5-1 hectare.**
- Well pads at c.1km spacings link to pipeline network.
- Height of drilling rigs at least 12-25m above ground level. [3,5]

Bath Thermal Waters World Heritage Site

The source zone and dynamic model for the Bath World Heritage Site Thermal Waters remains unknown despite prolific research.[1,11] The likely source is Mendip rainfall, percolating through the Carboniferous Limestone. The head of groundwater on this higher ground appears to flow northeastwards, down below the Coal Measures, to at least 2.5kms depth, being heated in the process. Seismic surveys near Bath show the limestone rises steeply up and ultimately the thermal waters penetrate through younger rocks at the Hot Spring Locations.[15]

A British Geological Survey report commissioned by Bath & Northeast Somerset Council concluded that hydraulic fracturing within Carboniferous shales would make it impossible to guarantee the impact on those strata in which the thermal waters are migrating, or to resolve any problems.[1]



Factors Unique to Bath, Mendip & Somerset

- Gas exploration and exploitation in Somerset is commercially and technically 'high risk'.[1,12,14] The risk of unforeseen ground conditions or events, potentially impacting environment and communities, is greater than other parts of the UK, with simpler geology.
- The unique combination of the Mendip Area of Outstanding Natural Beauty, surrounding rural landscapes, the Bath World Heritage Site, the local importance of tourism and agriculture result from specific geological circumstances of the Mendip Carboniferous strata. The impact of modern industrialisation on this zone may be unacceptable.
- The source for the Bath Thermal Waters remains unknown. The British Geological Survey report to Bath & Northeast Somerset Council concludes that hydraulic fracturing within the Carboniferous rocks would 'pose an undefinable risk to the springs'. [1]

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