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UK SHALE GAS PROCESSING: PART ONE

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UK SHALE GAS PROCESSING: *Part One*

Matthew Last and Adrian Finn, Costain, UK,
discuss processing technology for UK shale gas.

Sunset over Durdle Door.

The development of horizontal drilling and hydraulic fracturing in the US has enabled methane rich gas to be extracted from shale formations at commercially viable flow rates. Since 2007 US shale gas production has increased from 5 to 33 billion ft^3/d and now represents 40% of US natural gas production.[1] There are several reasons why the UK has yet to initiate commercialisation of its shale gas reserves. The development of US shale gas is a factor as cheap gas has replaced coal for power generation so US coal has been imported into Europe to generate power, despite associated high carbon emissions. As a result, European gas prices have fallen and gas developments have been postponed. LNG export plants on the US eastern seaboard

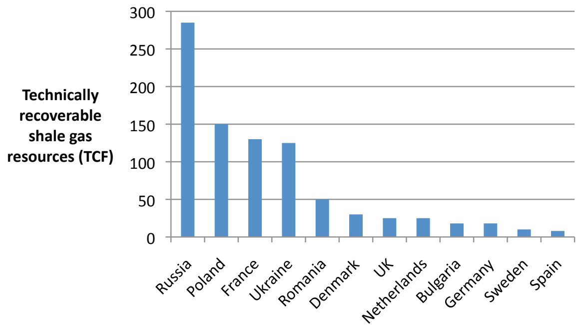

Figure 1. Technically recoverable European shale gas reserves.[3]

could lead to further suppression of European gas prices. So the development of UK shale gas reserves requires a long term perspective. It will take several years to realise production but shale gas does offer the UK important benefits in energy security and economic opportunity.

This article considers issues which affect the commercialisation of shale gas in the UK and particularly the application of well proven gas processing technology.

Exploration and extraction

UK shale bearing geological formations are more complex than those in the US and comprehensive test drilling is required to generate accurate data, both on the actual amount of recoverable gas and the nature of the surrounding rock. This is important as shale gas extraction relies on greater understanding of geological formations than conventional gas production does to ensure fracturing safely liberates the maximum amount of gas. It is proving difficult to initiate drilling in the UK, mainly due to public lobbying against it on suspected environmental grounds.

Shale gas is contained in relatively soft fine grained sedimentary rock in which organic matter was embedded at formation. To bring it to the surface needs stimulation by water injection to fracture the rock so significant water supplies are needed and this is a key environmental issue. Water requirements are strongly dictated by the geology and ease or not of fracture, again highlighting the need for investigation by site drilling to acquire good enough data for assessment of well commercialisation. Multiple gas extraction points are needed requiring more wells to be drilled than a conventional gas development, adding to the level of environmental safeguarding that will be necessary.

UK perspective

Western European countries mandate that any shale gas development must meet rigorous environmental requirements. The UK government has enacted legislation to prohibit any developments in national parks, areas of outstanding natural beauty or World Heritage sites unless of 'exceptional circumstances or in public interest'. France and the Netherlands have taken a blanket approach and applied moratoria. From a positive perspective the UK government has attempted to streamline the planning process by only consulting with landowners if there will be any drilling activity less than 300 m from the surface of their property. However final decision will likely be made at a local authority level and therefore require local support. To incentivise drilling in the UK, changes in mineral ownership rights may be required. The UK government has proposed incentive schemes which will return shale gas revenues to the local communities. Ineos[2] has gone further in committing 4% of shale gas revenues to landowners whose property produces gas from their planned well sites. A further 2% of Ineos' revenues will be paid to local communities. These arrangements are common in the US where shares of the revenues are returned directly to the landowners.

The UK government recently invited applications for the 14th Landward Licensing Round which is the first UK onshore licencing activity to be held in six years. The awarding of these exploration and development rights, including large areas of northern England and the Scottish lowlands, is expected in early 2016. To encourage exploration activity, it is required that licence owners carry out a defined work programme in the first five year term in order for the licence to continue into a second term and on to production.

While experience from shale gas development in the US can readily be applied in the UK, issues including planning, safety and environmental regulations and frameworks are quite different. Early engagement between all stakeholders (shale gas owner, drilling and engineering contractors, operator, land owner (potentially), the Health and Safety Executive (HSE), Environment Agency (EA) and local authorities) will be key in turning a shale gas opportunity into a viable commercial project that delivers significant volumes of natural gas.

Plant designer's experience in delivering UK gas projects in environmentally sensitive areas will be very important. Costain has been heavily involved in underground gas storage projects that meet stringent environmental requirements including those in North West England at Stublach, for GDF Suez, and Holford, for E.ON. These facilities are located near working farms and residential villages and this required a plant design and construction plan that minimised impact on the local transport infrastructure, population and environment.

Gas flows from shale gas wells are lower than from conventional gas wells but shale gas reserves tend to be extremely large compared to conventional gas reserves. The UK's technically recoverable shale reserves are estimated to be 25 trillion ft^3.[3] While initial development costs will be relatively high, the cost of gas production can be relatively low and gas production can last considerably longer than with conventional gas.

European potential

Europe imports approximately 30% of its natural gas consumption from Russia, with a similar amount imported from the Middle East and North Africa as LNG. Norway makes up the balance. In parts of Eastern Europe all gas is imported from Russia. As many countries have limited gas storage capacity they are sensitive to gas supply disruption or price volatility. All countries in Europe with shale gas reserves could reduce their balance of payments deficits while ensuring security of supply of clean and reliable energy so there is widespread interest in the first potential shale gas projects and the issues that need to be tackled for commercial success.

Transporting gas over long distances, whether by pipeline or by LNG is capital intensive and incurs losses. Security of supply concerns exist for pipelined gas crossing national borders. Some of the world's major LNG producers have political instability worries and increasing demands to maintain indigenous gas resources for local use. Strategic investment in shale gas (potentially alongside, rather than instead of, renewables) would reduce reliance on LNG and gas imports.

Exploration, drilling and proving of shale gas reserves will take time and shale gas may not be commercialised in Europe until post 2020. Although shale gas production has mushroomed in the last seven years in the US this is due to a gradual build up in engineering expertise over the last two decades. Rock formations in Europe appear to be complex and located deeper than in the US so will require more expertise and effort to produce, though many European shale gas basins are actually thicker than those in the US, potentially resulting in greater reserves. Shale gas processing will be similar to conventional natural gas processing. Clearly the lower the gas processing cost the more commercially viable the gas development so gas with minimal inerts and contaminants is favourable. It is expected that most fields will be lean in any hydrocarbons heavier than methane with only moderate amounts of inert carbon dioxide and nitrogen and with minor levels of sulfur compounds.

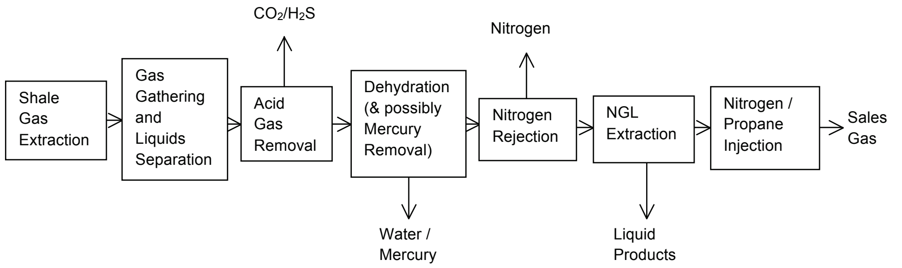

Figure 2. Shale gas processing block diagram.

Table 1. NTS specifications[4]

Hydrogen sulfide	≤ 5 mg/m³
Total sulfur	≤ 50 mg/m³
Hydrogen	≤ 0.1% (molar)
Oxygen	≤ 0.001% (molar)
Hydrocarbon dewpoint	≤ -2 °C at any pressure up to 85 barg
Water dewpoint	≤ -10 °C at 85 barg
Wobbe number (real gross dry)	In the range of 47.20 to 51.41 MJ/m³
Carbon dioxide	≤ 2.5% (molar)
Radioactivity	≤ 5 Becquerels/g

Developing the conceptual design

As with conventional natural gas, shale gas can be used for localised power generation or as sales gas, usually being piped into a national gas distribution system. Any shale gas will require at least some local processing to meet water and hydrocarbon dew point limits (to avoid condensation in pipelines/piping for transmission to a centralised processing facility). The gas processing facilities required at the wellhead may be significant in cost, size and environmental impact, but this is no different to conventional natural gas processing. A central processing facility could then perform the required gas processing, including acid gas removal (if necessary) and blending, to meet the required specifications for either the National Transmission System (NTS) or power generation.

In the UK, the NTS has well defined contaminant limits (Table 1) whereas gas for power generation does not need as high a heating (calorific) value and can contain more inerts. Power generation tolerates higher sulfur levels though there are limits to avoid sulfur oxide formation during combustion. In addition, NTS gas pressure will usually need to be as high as 70 barg whereas approximately 35 - 45 barg is sufficient for power generation via gas turbine. This indicates that the gas processing capital cost will be higher to deliver NTS specification gas. However it is expected that capital costs associated with the infrastructure and equipment specific to generating and distributing power will far outweigh this. In terms of the overall site development costs, these capital costs for processing the gas, produced water and possible power generation, will contribute a relatively low proportion as the bulk is in the well pad itself (approximately £333 million for a single pad including 10 vertical wells; 40 lateral wells).[5]

Proximity to existing infrastructure for gas or power transmission will be advantageous for commercialising a shale opportunity. In this regard, densely populated and heavily industrialised countries such as the UK may have an advantage in having a well developed gas transmission infrastructure. This consideration would particularly favour shale gas development in North West England and the Scottish lowlands due to the pipeline infrastructure and relatively local existing gas processing plants.

Building gas processing plants close to shale gas reserves will be challenging in the UK even for minimal facilities that just condition gas to meet dewpoint specifications. Notwithstanding public opposition and planning, small satellite plants could suffer from economies of scale, increasing processing costs (and therefore gas sale price). However, compared to the well pad cost, the impact would be relatively limited. In the US, the extensive supply chain and availability of resources, including human capital for design, fabrication and installation, makes for low plant design and fabrication costs. To repeat this in Europe will mean experienced plant designers taking the best lessons from the US while ensuring plants are designed in line with appropriate design codes and standards as well as European safety and environmental legislation and practice.

US experience shows there can be wide variations in shale gas composition, even from well to well let alone from one geological area to another. One of the major shales in the US, the Barnett Shale, shows large variation in ethane and propane content as well as increasing nitrogen content and decreasing carbon dioxide content to the west of the formation. Acid gas content tends to increase during the well life. Any shale gas development will frack multiple wells so depending on whether development is phased there could be step changes in the required gas processing capacity. Setting an optimal process and plant design strategy for variations in composition and capacity will be very important. This justifies careful assessment, particularly during the development of the plant concept, with experienced gas processing designers and contractors who have good experience in all appropriate process technologies coupled with execution and construction capability in the specific territory.

Conclusion

In general, shale gas will require the same core processing technologies proven in delivering conventional gas to market: acid gas removal, dehydration, hydrocarbon dewpointing and heating value adjustment as dictated by the composition of the raw shale gas.

For each of the process steps in Figure 2, several process technology options are available. Ensuring the right choice is made heavily influences project costs and can improve reliability, availability, maintenance and operability. This will be discussed further in Part 2 of this article.

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