Final submission to the All Party Parliamentary Group Shale Gas Regulation and Planning by John Busby on fracking wastewater revised 10 February 2017.

Preamble

The question of handling the flowback and produced water from fracking operations in the UK remains an unsettled question, unresolved by the Shale Gas Task Force, nor by the Cuadrilla Planning Inspector's appeal report.

The responsibility for nominating a waste disposal facility with the ability and capacity to take the flowback fluid is primarily the responsibility of the operator.

If the operator is unable to identify *"… somewhere to take the waste it would have to take the necessary measures to ensure that no further waste of this type is generated …"* (sic)*

The problem is that for every well the analysis of the flowback and produced water is unique for it and cannot be determined until the fracturing is complete. A large proportion of the injected production water, with its chemical additives, returns to the surface together with the minerals and metal salts (and possibly the radioactivity) it brings up from the shale with the gas, NGLs and oil.

If fracking is established then hundreds, if not thousands of wells, will be drilled and it will be impossible to specify a "bespoke" treatment solution for each one after it has been drilled and fracked. Operators would find their operations frozen just when gas production is needed to justify their investment.

What is needed is a universal treatment facility able to cater for all the possible variations in wastewater content. Also a mobile, universal treatment plant will be needed to cater for the wastewater arising from the exploratory well drilling to establish whether in a particular area fracking is viable. If trailer-mounted, as is available, it can then move to the next test drilling.

Once it is clear that an industry can be established, then the necessary capital can be raised for a centralised treatment facility.

EA's concession to Cuadrilla

Cuadrilla requested the non-applicability of the Mining Waste Directive for its test drillings. EA conceded that, *"The quantities of minerals present are not sufficient in themselves to require an environmental permit to store and dispose of the flowback water"* (sic).

There can be a range of toxic metal salts in the wastewater garnered from underground. Of particular significance being those of mercury and cadmium, the allowable discharge levels being <2 μg/l and <10 ug/l respectively. The standard method of adding lime to precipitate the metal salts from solution does not apply to all of those present and in any case would add to the already high salinity.

Over the course of the four Cuadrilla test wells the flowback and produced water amounts to 22,000 cubic metres per well, totalling 88,000 cubic metres.

EA's concession is clearly not acceptable as per test well around 4000 tonnes of suspended and dissolved solids, including 400 kg of toxic salts would be discharged without a permit.

Dilution

EA has nominated three inland treatment works and one on the Tees estuary, owned by FCC Environmental and Northumbrian Water. FCC Knostrop discharges into the River Aire and has suggested that the unacceptable salinity could be diluted with other discharges to reduce the salinity such that 300 tonnes/day of fracking wastewater could be treated.

However the initial wastewater flow from a test well could amount to 800 cubic metres per day and the plant could not cope with that from four test wells. Also although dilution together with chemical precipitation could in theory reduce the toxic metals concentration below acceptable limits there will still be a build up of them in river sediments.

In the case of mercury and cadmium, there is a requirement to monitor the content in fish and other organisms.

If fracking goes into full production providing say 15% of the current UK production, then 250 to 300 wells would be drilled per year discharging 250,000 cubic metres per day and the inland treatment works would be inadequate. A shore based treatment plant could pump the high saline discharge out at sea, but the toxic metal content, even though it might be below acceptable limits, will build up in fish and its feed.

Zero Liquid Discharge

The only practical, universal treatment method is "Zero Liquid Discharge" (ZLD) from which the only fluid leaving the treatment facility is distilled water for re-use from an evaporation and crystallisation process. It means that whatever the analytical content of the fracking wastewater in a particular shale location it can be treated with certainty and water provided for re-use.

If fracking is to expand to produce a realistic contribution to the UK's gas needs, then a suitable treatment plant has to be specified of an adequate size. As there is no need for liquid discharge it can be inland and separated from water resources.

ZLD providers

Antero Resources announced it is stepping up its recycling efforts in the Marcellus/Utica by hiring **Veolia** Water Technologies Inc. to build a new shale wastewater recycling facility in Doddridge County, West Virginia. The new facility, which will take two years to build and cost Antero $275 million, will process 60,000 barrels (9,500 m^3) of wastewater per day. A central ZLD treatment plant double this size would cater for 300 well drillings per year.

GE offers complete thermal and non-thermal ZLD solutions to manage tough-to-treat wastewaters. GE's proprietary evaporators, brine concentrators, and crystallisers can help recover more than 95% of your plant's wastewater while reducing the remaining brine as a product or solid.

Aquatech has an unparalleled depth of experience in ZLD, which include more than 160 installations, including stand-alone thermal/evaporative processes, membrane processes, or hybrid systems. Zero-liquid discharge (ZLD) is a water treatment process in which all wastewater is purified and recycled; therefore,

leaving zero discharge at the end of the treatment cycle. ZLD is an advanced wastewater treatment method that includes ultrafiltration, reverse osmosis, evaporation/crystallisation, and fractional electro-deionisation.

GEA Zero Liquid Discharge for Environmental Protection. A global environmental awareness and focus on conserving water and water pollution has led to increasingly stringent regulations on the use and discharge of industrial water. GEA's zero liquid discharge (ZLD) technology is ideally placed to enable many sectors of industry to clean and recycle their process water.

Associated landfill

The treatment plant is in each case associated with an adequately sized landfill into which the contaminated salt can be disposed. Ideally the treatment plant and the neighbouring pit should be inland in the geometric centre of operations, well away from a water course so that there will be no access to a waterway.

This is featured in the Antero treatment facility, which has both the ZLD and the landfill pit on the same site.

Energy usage

Enquiries have been made to two of the ZLD providers to assess the energy input to the wastewater processes. There is some reluctance to provide this essential parameter.

The energy in the natural gas produced over the well's economic lifetime is worked out by assuming an Ultimate Estimated Recovery (EUR) of 4 bcf, equivalent to 5.5 petajoules. The energy input to the ZLD should not exceed 20% of this.

All the operations before the wastewater is handled are energy intensive, so that before engaging in full scale fracking there should be an energy assessment of the entire operations.

Even with the lax regulation in the US, the foreign investing companies, BHP Billiton, BP, Statoil, Shell and BG have suffered huge balance sheet "impairments" of billions of US dollars. With the promised tight regulation in the UK, the profitability of fracking for gas is therefore suspect.

Conclusion

The only practical, universal method of ensuring that fracking wastewater can be satisfactorily treated is by Zero Liquid Discharge systems. If the test wells prove to be successful, then the establishment of full production would require an investment in an adequately sized, centralised treatment plant to serve the fracking locations.

Several international companies can offer these systems, though with the high chloride content of the wastewater, the construction materials will be expensive.

Statements as to the energy inputs to the ZLD from the providers are required.

Methane and Volatile Organic Compounds

The methane and other petroleum compounds come up in a mixture with the flowback and produced water. On the drill pad is a separation plant to route the gas

initially to the flarestack and then to the export pipeline. The process is not 100% efficient and there will be residual methane and VOCs in the wastewater.

It is recommended to connect the wastewater storage tanks to the flare stack. When being filled with flowback the tanks' atmospheres will be vented, creating an explosion and health hazard. Each tank should have a small heater to boil off the dissolved methane and VOCs to facilitate the destruction in the flarestack. The smoke, smells, flickering and noise from the flare can also be a health hazard, but less than if released unburned.

This should be done on the drill pad before the wastewater leaves to avoid safety problems at the receiving water treatment plant.

John Busby 10 February 2017