Sustainable treatment of flow back water from fracking operations for conventional and unconventional gas recovery - Summary

The objective of this project is to make a preliminary selection of appropriate technologies for the treatment of flow back water from fracking operations of conventional and unconventional gas production. Three options are considered after treatment: reuse for fracking, injection into empty gas or oil wells and disposal on inland surface water. Advanced water treatment systems for the treatment of flow back water during the first days after a fracking operation (clean up phase) may be installed. These could be temporary, mobile (container-sized) systems.
Conventional fracking typically needs several hundreds of cubic meters of water (on average 200-300 m^3) per well for each fracturing process. Hydraulic fracturing in shale gas formations consumes several thousands of cubic meters of water per well. For viscous fracking, typically, 90% of the fracturing fluid is water, 9.5% is sand and 0.5% are chemical additives. This fracture fluid contains water-soluble gelling agents, pH buffers, breakers, surfactants, biocides, de-emulsifiers, stabilisers and cross linkers. The percentage of fracking liquid that returns to the surface is estimated on 20 to 70%. The fracking liquid typically returns to the surface during the first days to weeks after the fracking operation. In addition to the fracking chemicals and other production chemicals, the flow back water may contain suspended solids, sand/clay particles, oil and grease, heavy metals, naturally occurring radioactive material and salts.
Three treatment trains were designed for the treatment of flow back water at an assumed constant flow rate of 300 m^3 in 6 days (2 m^3/h). Removal efficiencies of the technologies for specific compounds were estimated. The maximum concentrations of ions found in the flow back water (data of operators) were used as starting concentrations. Technologies were selected based on their capability to remove fracking chemicals, suspended solids, microorganisms, organic matter, oil and grease, heavy metals, divalent and monovalent salts. The three treatment trains are:

A. Electrocoagulation – dissolved air flotation – ultrafiltration – nanofiltration
B. Multimedia filtration - activated carbon – membrane distillation
C. Corrugated plate interceptor – centrifuge (well injection)/ hydroclone (discharge) – pertraction – ion exchange – membrane distillation (optionally).

The treatment trains were all capable of treating the flow back water down to the requirements for injection in an empty gas or oil well. The limits for discharge on inland surface water for chloride, calcium, iron, sulphate and some heavy metals are not met in treatment train A. For treatment train B, it is calculated that the limits for zinc and orthophosphate may not be met for surface water discharge. In treatment train C, lead may not meet the limits for inland discharge. In all three treatment trains, an aqueous waste stream of approximately 0.4 m^3/h (20% of total flow) has to be further treated. This small waste stream can be disposed at a commercial waste(water) plant.
It was estimated that treatment train B has the lowest investment and operational costs of the three options. The investment cost of option B were estimated on 200 k€ and the operational costs on 1.47-1.90 €/m^3 (onshore situation). Based on 5 years of depreciation, and 5 fracks per year of 300 m^3, the investment costs for option B were estimated on 27 €/m^3. Extra costs are taken into account for disposal of concentrated waste/sludge, 28 €/m^3 flow back water, making a total cost of 57 €/m^3.

These costs are only lower than treatment in a commercial salt water WWTP (20 €/m^3 + 23 €/m^3 transport) if the treatment train is used for more than 5 fracking operations. The costs for the treatment train (5 fracks) are already lower than disposal at a commercial waste(water) treatment facility (80 €/m^3 + 60 €/m^3 transport). The other two treatment trains have about double investment and treatment costs per m^3 and will not easily be competitive to current disposal costs. If the treatment trains can be used for the treatment of produced water after all flow back water has been treated, the treatment trains become financially more promising.

Validation of removal efficiencies of the proposed technologies must be done in laboratory experiments. After that, costs and removal efficiencies can be recalculated and the proposed treatment trains can be reevaluated and adjusted if needed.