Shale Gas Produced Water Management and Reuse

DEVELOPING SUSTAINABLE AND ECONOMIC SOLUTIONS

GTI Innovations

Since 1990, Gas Technology Institute (GTI) has worked with the natural gas industry to improve the economics of produced water management.

- Coordinated over 32 field demonstrations of environmental engineering solutions.
- Developed more than 20 advanced technologies in partnership with universities, national labs, engineering firms, and small businesses.
- Supported evaluations of third-party technologies with data acquisition, modeling, and reporting.

This experience has given GTI a unique perspective on water management issues and options in the natural gas industry.

GTI understands the chemical character of produced water, treatment options, and long-term management solutions.

We also understand that an energy company's decision-making framework needs to be taken into account when designing a strategy for deploying solutions in shale gas markets.

Strategically, produced water reuse provides the energy industry with an effective path to environmental acceptability that is needed for industry sustainability.

Rapid development of shale plays paired with nationwide droughts and unpredictable water availability challenges the oil and gas E&P industry to find economical and sustainable solutions for managing produced water (PW). All water generated during drilling and hydraulic fracturing can be considered produced water and this makes up the largest waste stream associated with the industry.

GTI Understands PW Chemistry and Designs Treatment and Management Solutions

GTI has conducted detailed analyses on PW geochemistry and management from more than 30 hydraulically fractured oil and gas wells in the Marcellus, Barnett, and Permian basins. From this work, a water-based lifecycle computer model was generated based on robust characteristic descriptions of the development area. The model forecasts water output, water reuse capacity, salt generation, and solid waste output.

An assessment of market opportunities for water management in association with the expansion of the natural gas industry was conducted to understand the management flow schemes, regulatory drivers, and risk factors determining economics for various PW reuse and management solutions. Results were used to produce a report on the techno-economic assessments of water re-use and disposal of several PW management strategies in the Marcellus.

GTI Develops and Tests Technologies for PW Reuse/Disposal

Co-Gen Wastewater Treatment: Leveraging rocket science, GTI developed and tested a direct compact steam generator to clean produced water, reduce emissions, and generate positive revenue. The technology removes minerals and organics while generating electrical power or steam as a byproduct. Systems of 3 MWth and 12 MWth have been tested, and solids loading of up to 110,000 total dissolved solids (TDS). Results are illustrated in Figure 1. A system can be configured to maximize power or clean water production.

Figure 1. Raw and treated PW

Mechanical vapor recompression (MVR) was field tested in a full-scale (6,000-6,800 bbl/day), detailed 8-week evaluation operated by Fountain Quail at a Devon Energy water reuse facility under highly varied influent conditions. The influent TDS to the MVR's averaged just under 50,000 mg/l. More than 97.5% of the TDS was captured in the concentrate stream. The overall treatment (entire facility) required 72 SCF per barrel treated, or 100 SCF per barrel distillate produced. MVR technology can cost $3-$5/bbl, including labor, chemicals and equipment.

Electrodialysis (ED): Implementation of modified electrodialysis systems into field-scale engineered water reuse systems by GTI and Environmental Process Dynamics reduced energy costs by more than 40% and chemical costs by greater than 65%. The process has an estimated cost of about $1 per barrel for water at 50,000 mg/l TDS treated to a target of 10,000 mg/l.

Advanced membrane coatings: Ultrafiltration (UF) and reverse osmosis (RO) membranes treated with polydopamine (PDOPA) or polyethylene glycol (PEG) were bench-scale tested and proven to reduce fouling by more than half, double membrane life, and reduce energy requirements by more than 35%. At field scale, operated by GeoPure at Devon Energy, PDOPA-coated membranes enhanced salt rejection >99.9%. A two-stage nanofiltration or nano/RO membrane system with an optimized UF membrane is expected to enable purification of produced water while maximizing water productivity and minimizing maintenance and energy costs.

Granular activated carbon based fluidized-bed reactor (GAC-FBR): An integrated system consisting of biological degradation of hydrocarbons followed by membrane separation of dissolved salts. GAC particles of 2 mm in diameter coated with microbial films are fluidized in the reactor; as the water flows upward past the particles, organics in the water are oxidized to carbon dioxide. This technology handles a wide range of total organic carbon (TOC) (2-300ppm) with removal up to 95% and a footprint of less than 10% conventional aerobic treatment. Benzene, toluene, ethylbenzene, and xylenes (BTEX) degradation is greater than 99.6%.

Alternative sources for frack water: Technical and logistical feasibility testing of pilot-scale ultrafiltration and nanofiltration for cleaning abandoned main drainage (AMD) water for use in unconventional shale gas well operations was tested in the Marcellus. Removal of over 99% of sulfate, calcium, magnesium, nickel, and selenium in AMD water was achieved with a 98% removal efficiency of TDS and greater than 90% for TOC and chloride.

GTI Evaluates the Environmental Impact of Water Sourcing and Disposal

Project examples:

- Identification and evaluation of alternate sources of water in the Barnett that may be useful as replacements for groundwater or surface waters that serve as community water supplies.
- Potential environmental impact of shale gas development in Poland.
- Evaluation of the bioavailability of hydrocarbons in soils for environmentally acceptable endpoints related to the natural gas and oil industries. Results of this effort have been incorporated into a risk-based decision framework by ASTM and contributed to the establishment of ecological soil screening levels by the Environmental Protection Agency (EPA).
- Techno-economic and environmental feasibility evaluation of a new produced water containment system patented by DA Nolt.
- Building a conceptual site model to generate a probabilistic risk index for subsurface transport of brine or gas to environmental receptors such as freshwater aquifers.
- Understanding the role of microorganisms found in produced water that degrade oil, create sour gas, and cause corrosion that risks the integrity of the natural gas infrastructure.

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