Produced Water Treatment for Beneficial Reuse

2018 Mastering the Subsurface Through Technology Innovation Partnerships and Collaboration: Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Image from: Integrated Decision Tool for Produced Water Treatment and Reuse Project (SDSU, CSM, NMSU)
Produced Water Treatment

Goal: Develop water management strategies and technologies for oil and gas produced waters that result in new revenue streams and reduce the need for deep well injection for disposal.

Transportation and Storage
Safe and reliable transmission, storage, and distribution

Footprint Reduction
Develop resources efficiently

Methane Emissions
Protect the air we breathe

Water Quality and Availability
Protect water resources and prevent water shortages

Subsurface Science
Understand the reservoir

Induced Seismicity
Understand and mitigate earthquake risks

NETL RIC Onshore Unconventional Resources Portfolio
Task 14: Produced Water Management
TPL: Alexandra Hakala
PI: Nicholas Siefert
Potential Markets

• Potential to increase value and create a salable product from the previous waste stream
  • Fresh water
  • Oilfield use: fracking
  • 10-lb brine for Chemical industry
  ~17 Million metric tonne per year

• Mediate water stress in arid regions
• Reduce fresh water costs through increased recycling
• Reduce dependence on salt domes for brine production
• Reduce the volume of re-injected brine
• Potentially decrease induced seismicity
  • Comply with rules mandating reduction in volumes

Original produced brine

Freshwater for agricultural/industrial use

Concentrated brine for re-sale

Image from Gradiant Corp.
2015 USGS Minerals Yearbook
Subtask #1: Produced Water Reuse Gap Analysis

To provide context for current R&D needs

Goal: Complete near-term analysis to identify important research gaps based on topics addressed by prior Oil & Gas R&D

Plan of Action:
(1) Determine current status of technology developed in each project
(2) Make a preliminary assessment of why the project is/isn’t commercially successful
(3) Determine the most promising areas of R&D that would be required to improve the economic viability of produced water management technologies

Associated Steps:
(1) Analyze prior water treatment research funded by Coal R&D
(2) Analyze 2017 DOE/FE/Oil&Gas Request for Information (RFI)
Prior Research on Water Associated with Unconventional Formations

Projects Supported through FE-Oil and Gas

Water Produced from Unconventional Operations

- Reduce Water Needed for Fracturing/Mitigation of Fracturing-Induced Seismicity
  - Alternative Fracturing Fluids
  - Improved Reservoir Management and Control
- Prevent Contamination to Surface and Groundwater Resources
  - Control Surface Management (Surface Spills) and Wellbore Integrity (Subsurface Migration)
- Treatment of Water for Injection or Beneficial Use/Mitigation of Disposal-Induced Seismicity
  - Treatment to Quality Standard for Waste Disposal Wells
  - Treatment to Quality Standard for Use in New HF Operations
  - Treatment to Quality Standard for Use in Other Industries
  - Treatment of other Water Waste Streams (e.g., AMD) for Use in new HF Operations

Results from projects focused on these topics may have the most direct applicability for near-term wins in developing approaches/technologies with net revenue streams.
Breakdown of Prior Projects and Thematic Areas

<table>
<thead>
<tr>
<th>Thematic Area</th>
<th>Number of Prior Projects</th>
<th>Regions/Basins</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reduce Water Needed for Fracturing/Mitigation of Fracturing-Induced Seismicity</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>1A. Alternative Fracturing Fluids</td>
<td>5</td>
<td>Primarily lab-based studies; will need to review results in detail for basin-specific information</td>
</tr>
<tr>
<td>1B. Improved Reservoir Management and Control</td>
<td>11</td>
<td>Haynesville, Marcellus, Utica, Barnett, Multiple Basins</td>
</tr>
<tr>
<td>2. Prevent Contamination to Surface and Groundwater Resources</td>
<td>10</td>
<td>Marcellus, Multiple Basins</td>
</tr>
<tr>
<td>3. Treatment of Water for Injection or Beneficial Use/Mitigation of Disposal-Induced Seismicity</td>
<td>31 (17*)</td>
<td>Barnett, Appalachian, Marcellus, Uintah, Multiple Basins; States: NY, PA, WV, CO, MT, NM, UT, WY</td>
</tr>
<tr>
<td>3A. Treatment to Quality Standard for Waste Disposal Wells</td>
<td>1</td>
<td>Northern Appalachian Basin</td>
</tr>
<tr>
<td>3B. Treatment to Quality Standard for Use in New HF Operations</td>
<td>3</td>
<td>Upstate NY, Fayetteville</td>
</tr>
<tr>
<td>3C. Treatment to Quality Standard for Use in Other Industries</td>
<td>5</td>
<td>Marcellus, Multiple Basins; NM</td>
</tr>
<tr>
<td>3D. Treatment of other Water Waste Streams (e.g., AMD) for Use in New HF Operations</td>
<td>5</td>
<td>Appalachian, Multiple Basins</td>
</tr>
</tbody>
</table>

Other: Coalbed Methane (2 projects), Constructed Wetland (1 project), Transportation in Arctic (3 projects)
Example of Prior FE Oil & Gas as Research:

Integrated Decision Tool for Produced Water Treatment and Reuse (SDSU, CSM, NMSU)

- Value tool for both brine composition and treatment costs
  - But limited data for Eagle Ford and Frio as well as limited ability to chose outlet salinity
The largest number of responses to the 2017 RFI were in the following two categories:

- **Category#1**: Mitigate Environmental Impacts of Unconventional Oil & Gas Development via Dedicated Unconventional Oil and Gas Field Labs

- **Category#5**: Beneficial Reuse of Water Produced from Unconventional Oil and Natural Gas Wells
# Water Management for the Top Ten Producing States

<table>
<thead>
<tr>
<th>State</th>
<th>Injection for EOR</th>
<th>Injection for Disposal</th>
<th>Surface Discharge</th>
<th>Evaporation</th>
<th>Offsite Commercial Disposal</th>
<th>Beneficial Reuse</th>
<th>Total Produced Water Managed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MMbbl/ year</td>
<td>% total</td>
<td>MMbbl/ year</td>
<td>% total</td>
<td>MMbbl/ year</td>
<td>% total</td>
<td>MMbbl/ year</td>
</tr>
<tr>
<td>Texas</td>
<td>3,718</td>
<td>48%</td>
<td>2,923</td>
<td>37%</td>
<td>371</td>
<td>5%</td>
<td>-</td>
</tr>
<tr>
<td>California</td>
<td>1,412</td>
<td>46%</td>
<td>623</td>
<td>20%</td>
<td>60</td>
<td>2%</td>
<td>649</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>1,098</td>
<td>47%</td>
<td>1,087</td>
<td>47%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wyoming</td>
<td>856</td>
<td>73%</td>
<td>313</td>
<td>27%</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Kansas</td>
<td>276</td>
<td>26%</td>
<td>785</td>
<td>74%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Louisiana</td>
<td>31</td>
<td>3%</td>
<td>857</td>
<td>92%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alaska</td>
<td>652</td>
<td>85%</td>
<td>85</td>
<td>11%</td>
<td>33</td>
<td>4%</td>
<td>-</td>
</tr>
<tr>
<td>New Mexico</td>
<td>381</td>
<td>50%</td>
<td>381</td>
<td>50%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Colorado</td>
<td>124</td>
<td>32%</td>
<td>124</td>
<td>32%</td>
<td>40</td>
<td>10%</td>
<td>35</td>
</tr>
<tr>
<td>North Dakota</td>
<td>52</td>
<td>18%</td>
<td>162</td>
<td>56%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

NR = Not reported in full

• Unconventional resources:
  • Eagle Ford
  • Haynesville-Bossier
  • Tuscaloosa

• Frio – aging oil wells generate high ratios of water to oil

• Close proximity to chemical industries that need brine

• Areas with clean water needs
Conclusions

- Gap Analysis will be completed this Fall to determine key areas where R&D focus could create the best value for converting produced water into net revenue positive products.