CONSIDERATIONS FOR USE OF PRODUCED WATER AT COAL-FIRED POWER PLANTS

Presented by:
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Project Overview

- Develop the Alternative Water Source Information System (AWSIS)
  - GIS-based internet application which allows for the identification of potential alternative water sources for coal-fired power plants throughout the United States.
  - Will aid in reducing freshwater withdrawal and consumption at coal-fired power plants by locating potential alternative water sources in the vicinity of the power plant.
  - Part of NETL’s program to reduce freshwater demands at coal-fired power plants.
Acknowledgements

- Funding provided by the National Energy Technology Laboratory
- Project directed by ALL Consulting with support from GWPC
Fresh Water Supply Concerns

- Forecasted national increase of 70 million people in next 25 years.
- Approximately 180 trillion gallons of groundwater have been depleted in the U.S. during the 20th Century alone.
- Domestic, industrial, and agricultural users are left to compete for the nation’s diminishing freshwater resources.
- Reduced surface water volumes during the 2007 drought caused the TVA to curtail production at, or entirely shut down, power plants in the southeast U.S.
## Power Plant Water Usage

<table>
<thead>
<tr>
<th>Cooling System</th>
<th>Withdrawals (gpm)</th>
<th>Cooling Tower Blowdown</th>
<th>Consumption (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Down-River</td>
</tr>
<tr>
<td>Once-Through</td>
<td>78,600-196,500¹</td>
<td>-</td>
<td>1179¹</td>
</tr>
<tr>
<td>Closed-Loop</td>
<td>1965-2358¹</td>
<td>389²</td>
<td>-</td>
</tr>
</tbody>
</table>

¹ EPRI 2002, ² DOE 2007

The gpm data is calculated from the gallons per megawatt hour (gal/MWH) data listed by the cited source. The calculation is based on the approximate average MW (aMW) output of a 500 MW coal-fired power plant as derived from Platts 2006.

- Once-through cooling systems withdraw up to 195,000 gpm more water than closed-loop systems.
- Closed-loop cooling systems consume 700 gpm more than once-through systems.
Power Plant Water Needs

Maximum Recommended Values:
- pH: 6-9
- TDS: 2,000 ppm

- Require long-term water sources with consistent quantity and quality.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Recommended Value (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (unit-less)</td>
<td>6-9</td>
</tr>
<tr>
<td>TSS</td>
<td>50</td>
</tr>
<tr>
<td>BOD5</td>
<td>30</td>
</tr>
<tr>
<td>Silica</td>
<td>110</td>
</tr>
<tr>
<td>Chloride</td>
<td>425</td>
</tr>
<tr>
<td>Sulfate</td>
<td>4200</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>500</td>
</tr>
<tr>
<td>Iron</td>
<td>3</td>
</tr>
<tr>
<td>TDS</td>
<td>2000</td>
</tr>
<tr>
<td>Total Alkalinity</td>
<td>400</td>
</tr>
<tr>
<td>Nitrates</td>
<td>700</td>
</tr>
<tr>
<td>Sodium</td>
<td>725</td>
</tr>
</tbody>
</table>

Source: ¹ Vidic 2007, ² Superchill, ³ Gill 2008
Alternative Water Sources

- Reduce demand on fresh water supplies.
- Allow for full capacity operation when conventional water sources become scarce.
- Could supplement or replace fresh water sources
- Should provide about 20% of water needs to be economically feasible.

Potential Alternative Sources:
- Produced Water
- Saline Groundwater
- Abandoned Mine Pools
- POTW Effluent
Produced Water as an Alternative Source

- Produced water - brought to the surface during oil and gas development.
- The quantity and quality of produced water can vary greatly from basin to basin, from well to well, and over time from the same well.
- Produced water is generated for long periods of time and has the potential to provide water for the life of the power plant.
- Large quantities of produced water are available in many regions throughout the U.S.
- As the need for fresh water becomes more acute and treatment technologies improve, produced water may serve as a valuable source of cooling water.
Produced Water Considerations

- Availability
- Quality
- Quantity
- Temperature
- Proximity/Transportation
- Access
Produced Water Availability

• 2.3 billion gallons generated on-shore every day
  - Enough to meet the water demand at 380 closed-loop, 500-MW power plants
Quantity

- 2.3 billion gallons generated on-shore every day
- In 2007, about 60% was being injected for EOR – 40% available
  - Enough to fulfill the raw water needs of 155 closed loop, 500 MW coal-fired power plants
- Due to the large volume of water required at the power plant, produced water will have to be collected from multiple tanks.
Produced Water Quality

<table>
<thead>
<tr>
<th>Average pH</th>
<th>TDS Range</th>
<th>Average TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.14</td>
<td>1,000-400,000</td>
<td>77,670</td>
</tr>
</tbody>
</table>

- Maximum recommended TDS value is 2,000 mg/l.
- Water Treatment: de-oiling, TDS reduction.
- Produced water quality varies from basin to basin and even from well to well within a given basin.
Effect of Produced Water TDS Concentrations on Blended Water Quality

Effect of Produced Water TDS Concentrations on Blended Water Quality

* TDS$_1$ (V$_1$) + TDS$_2$ (V$_2$) = TDS$_F$ (V$_F$)
* Fresh Water Quality = 500 mg/L TDS
* PW volume = 20%
## Analysis of Oil and Gas Basins

<table>
<thead>
<tr>
<th>Basin</th>
<th>Median TDS (mg/L)</th>
<th>Percentage of Produced Water with ≤50,000 mg/L TDS</th>
<th>Number of Power Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anadarko</td>
<td>132,158</td>
<td>29%</td>
<td>1</td>
</tr>
<tr>
<td>Arkoma</td>
<td>88,115</td>
<td>42%</td>
<td>2</td>
</tr>
<tr>
<td>Bighorn</td>
<td>4,891</td>
<td>99%</td>
<td>0</td>
</tr>
<tr>
<td>Denver</td>
<td>10,243</td>
<td>91%</td>
<td>9</td>
</tr>
<tr>
<td>E. TX &amp; LA-MS Salt Basins</td>
<td>110,894</td>
<td>21%</td>
<td>17</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>151,192</td>
<td>6.6%</td>
<td>1</td>
</tr>
<tr>
<td>Greater Green River</td>
<td>6,455</td>
<td>88%</td>
<td>5</td>
</tr>
<tr>
<td>Illinois</td>
<td>92,283</td>
<td>27%</td>
<td>42</td>
</tr>
<tr>
<td>Michigan</td>
<td>298,037</td>
<td>6%</td>
<td>13</td>
</tr>
<tr>
<td>North Central Montana</td>
<td>4,111</td>
<td>99%</td>
<td>0</td>
</tr>
<tr>
<td>Permian</td>
<td>87,612</td>
<td>27%</td>
<td>2</td>
</tr>
<tr>
<td>Powder River</td>
<td>7,376</td>
<td>93%</td>
<td>6</td>
</tr>
<tr>
<td>Uinta-Piceance</td>
<td>13,813</td>
<td>87%</td>
<td>5</td>
</tr>
<tr>
<td>Western Gulf</td>
<td>50,100</td>
<td>50%</td>
<td>8</td>
</tr>
<tr>
<td>Williston</td>
<td>149,748</td>
<td>26%</td>
<td>7</td>
</tr>
<tr>
<td>Wind River</td>
<td>5,349</td>
<td>99%</td>
<td>0</td>
</tr>
</tbody>
</table>

Data Source: USGS 2002
TDS Concentration by Basin

Geographic Trend of Median TDS Values (West to East)

O&G Basins

North Central Montana  Williston  Powder River  Big Horn  Wind River  Greater Green River  Uinta-Piceance  Denver  Anadarko  Permian  Fort Worth  Arkoma  E TX & LA-MS  Western Gulf Coast  Michigan  Illinois
Power Plant-Produced Water Map

Power Plants with Potentially Usable PW within 15 miles

Legend
- Coal-Fired Power Plants within 15 miles of a Usable Produced Water Source
- Operating Coal-Fired Power Plants
- Produced Water Source (>50,000 mg/L TDS)

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Temperature

• Produced water temperatures ranges from 60° to 200° F.
• The required cooling water temperature at coal-fired power plants is approximately 85°.
• Warmer cooling water has a reduced cooling capacity.
• Once-through cooling systems do not typically contain temperature control mechanisms, while closed-loop systems may employ blending and cooling towers to reduce cooling water temperatures.
Proximity/Transportation

• Fifteen miles is an estimated maximum economical transportation distance.
• Power plants located close to oil and gas fields will have reduced produced water transportation costs.
• Transportation costs would include the cost of gathering produced water from the field and piping it to the power plant.
• Pumping and treatment stations must be adaptable to changing field locations and water characteristics
Access Considerations

- Access/Use agreements with producer(s)
  - Liability concerns
- Water Rights
- State and Federal beneficial use and/or disposal laws
Produced Water Data

• Publicly available data is limited and hard to gather
• Varies substantially by state
• USGS data is eight years old
• Data for alternative sources in general is limited
Power Plant Information

Plant Name: Valmont (PSCO)
Operator: PSC of Colorado
Nameplate Capacity (MW): 245.2
Within 15 miles of a water source: Y

View Plant & Water Summary Data
Alternative Water Source Information System

Power Plant Overview
Power Plant Name: Valmont (PSCo)
Operator: PSC of Colorado
Nameplate Cap. (MW): 242.2 Latitude: 40.019616 Longitude: -105.201685

Water Records Available
Produced Water: 4 Mine Discharge: 0
POTWs: 10 Saline Groundwater: 3

Water Search Radius (in miles) 15 • Return to Map

<table>
<thead>
<tr>
<th>Name</th>
<th>Street 1</th>
<th>Street 2</th>
<th>City</th>
<th>State</th>
<th>Zip Code</th>
<th>Flow Rate (mgd)</th>
<th>Latitude</th>
<th>Longitude</th>
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<tbody>
<tr>
<td>LAFAYETE CITY OF</td>
<td>750 EAST COUNTY LINE ROAD</td>
<td></td>
<td>LAFAYETE</td>
<td>CO</td>
<td>80026</td>
<td>4.4</td>
<td>40.002778</td>
<td>-105.057778</td>
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<td>CO</td>
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<tr>
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<tr>
<td>75TH STREET WWTB</td>
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<td>LONGMONT CITY OF</td>
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<td>17.0</td>
<td>40.157500</td>
<td>-105.087500</td>
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<tr>
<td>BOULDER CITY OF WWTB/RRS</td>
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<td>BOULDER</td>
<td>CO</td>
<td>80301</td>
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<td>LOUISVILLE CITY OF</td>
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<td>39.979444</td>
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</table>
Summary

Produced Water as an Alternative Water Source

- Due to its widespread availability, produced water may be an alternative water source for power plant cooling water.
- As energy demands increase and fresh water supplies decrease, treating and transporting produced water will become more economically feasible.
- Site-specific analysis is necessary to determine if the quality, quantity, and location of produced water is feasible for use.

Alternative Water Source Information System:

- Internet-based application with a Google-Earth interface that allows for easy identification of potential alternative water sources available to coal-fired power plants.
Contact Information

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AWSIS