Background

• New USGS estimates indicate 84 TCF of recoverable natural gas
• Pennsylvania is the only state actively drilling in the Marcellus Shale gas play
• Hydraulic fracturing, or "hydrofracking," and horizontal drilling allow for extraction of previously unrecoverable natural gas

The Drilling Process

• Vertical well drilled 6000 to 8000 feet
• Turn drillhole 90 degrees for horizontal drilling
• Inject water and chemicals to create fractures allowing gas-permeable pathways
• Wells can be re-hydrofracked

Water Concerns

• Hydrofracking requires nearly 5 million gallons of water per drill
• Water is considered totally consumed:
  • Roughly 90% never returns to surface
  • Returning 10% is flowback and must be treated

Water Consumption in Pennsylvania's Marcellus Shale Region

The Present and Future of Water Withdrawal in the Extraction of Natural Gas

William Hogan, M. Eng. Energy Systems Engineering
Mentor: Dr. Andrew Coleman, Marketing Mgr., Env and Renewables, EPRI

Research Goals

• Determine any real statewide risks due to increasing water consumption
• Quantify total water consumption to compare to industries that withdraw water
• Use equivalencies to illustrate industry comparisons
• Project future water consumption in PA
• Explore breakthrough technologies that can limit water consumption in natural gas drilling

Consumption Estimates

Marcellus Shale Estimates

<table>
<thead>
<tr>
<th>No. Wells in 2011</th>
<th>2300</th>
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</thead>
<tbody>
<tr>
<td>Gallons Per Well Frac</td>
<td>490,000</td>
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<tr>
<td>Total Gallons Per Year</td>
<td>1,090,000,000</td>
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<tr>
<td>in billion gal/year</td>
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</tbody>
</table>

Industry Comparison

<table>
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<tr>
<th>Industry</th>
<th>Water Consumed/TWh/hr</th>
<th>Water Consumed/Industry Total</th>
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<tbody>
<tr>
<td>Natural Gas</td>
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<td>Thermal</td>
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<tr>
<td>Other</td>
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Projections

• Data from a PSU study makes drilling projections for the next decade
• By 2020, there could be 2500 new wells drilled annually

• Graphs show steady increase in water consumption per year
• These are high estimates—assume each well can be re-hydrofracked
• Takeaway: though natural gas plays a minor role in statewide water consumption, local watersheds could potentially suffer from increased withdrawal for hydraulic fracturing

Breakthroughs

New breakthrough technologies are being explored to minimize water consumption in drilling:

• GasFrac: Canadian company with fracturing process that uses no water—fractures created using gelled Liquefied Petroleum Gas

• RapidFrac: Halliburton system enabling highly accurate placement of fractures—reduces water requirements

• Water Re-use: Many drilling operators re-use flowback water for future hydrofracks

Future Research

• Further analysis of breakthrough technologies
• Alternatives to hydrofracking
• Damages to local watershed due to hydrofracking
• Model to minimize water consumption in the Marcellus Shale gas play

References:


-equivalencies to illustrate industry comparisons

结论：increased hydrofracking will not be damaging to PA's water supply

Equivalencies

Assuming 4.5 million gallons of water is required to frack a natural gas well, this is equivalent to the water withdrawals by:

• A 1000 MW nuclear reactor running for 11.25 hours
• The Nevada Solar One 64 MW site running for 76 hours
• The Brunner Island coal-fired generation plant running for approximately 6 hours
• 29% of the entire water used by PA agriculture in one day

Water withdrawn in hydrofracking is a small percentage of total industry withdrawals—BUT, it is fully consumed, unable to return to its source.