Methane Leakage from Old Wells in Pennsylvania

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Outline

• Old Wells in Pennsylvania and Methane Measurements
• Identification of High Emitters
• Current Status and Paths Forward
Abandoned Wells in Pennsylvania:

12,000 on PA DEP Website
300,000 – 500,000 (Oil and Gas Wells)
900,000 Total (Oil, Gas, and Water Injection Wells)
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Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania

Mary Kang\textsuperscript{a,1,2}, Cynthia M. Kanno\textsuperscript{a}, Matthew C. Reid\textsuperscript{a,3}, Xin Zhang\textsuperscript{b}, Denise L. Mauzerall\textsuperscript{a,b,1}, Michael A. Celia\textsuperscript{a}, Yuheng Chen\textsuperscript{c}, and Tullis C. Onstott\textsuperscript{c}

Abandoned oil and gas wells provide a potential pathway for subsurface migration and emissions of methane and other fluids to the atmosphere. Little is known about methane fluxes from the millions of abandoned wells that exist in the United States. Here, we report direct measurements of methane fluxes from abandoned oil and gas wells in Pennsylvania, using static flux chambers. A total of 42 and 52 direct measurements were made at wells and at locations near the wells ("controls") in forested, wetland, grassland, and river areas in July, August, October 2013 and January 2014, respectively. The mean methane flow rates at these well locations were 0.27 kg/d/well, and the mean methane flow rate at the control locations was $4.5 \times 10^{-5}$ kg/d/location. Three out of the 19 measured wells were high emitters that had methane flow rates that were three orders of magnitude larger than the median flow rate of $1.3 \times 10^{-3}$ kg/d/well. Assuming the mean flow rate found here is representative of all abandoned wells in Pennsylvania, we scaled the methane emissions to be 4–7% of estimated total anthropogenic methane emissions in Pennsylvania. The presence of ethane, propane, and n-butane, along with the methane isotopic composition, indicate that the emitted methane is predominantly of thermogenic origin. These measurements show that methane emissions from abandoned oil and gas wells can be significant. The research required to quantify these emissions nationally should be undertaken so they can be accurately described and included in greenhouse gas emissions inventories.
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Mean Leak Rate: 0.27 kg/day/well
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Table 1: Summary of sampling campaigns

<table>
<thead>
<tr>
<th>Sampling Campaign</th>
<th>Number of Flux Measurements</th>
<th>Locations (Counties)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wells</td>
<td>Controls</td>
</tr>
<tr>
<td>July 17-18, 2013</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>July 24-25, 2013</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>July 31-August 1, 2013</td>
<td>8</td>
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<tr>
<td>October 8-11, 2013</td>
<td>13</td>
<td>25</td>
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<td>January 26-31, 2014</td>
<td>14</td>
<td>15</td>
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<tr>
<td>March 18-21, 2014</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>June 19-22, 2014</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>July 22-27, 2014</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>October 26-30, 2014</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>
Number of Wells Measured: 70

Mean Leakage Rate: 0.21 kg/day/well

Best Estimate of Total Number of Wells: 890,000

Fraction of Wells that are “High Emitters: 13% (9/70)

Number of “High Emitters” that are Oil Wells: 0

Number of “High Emitters” that are Gas Wells: 6

Number of “High Emitters” that are Combined Oil/Gas Wells: 3
Flux of Wells and Distance to Natural Gas Storage Sites
Conclusions

• Additional well measurements confirm our earlier observations:
  • Cumulative well leakage is up to 10% of estimated total statewide anthropogenic emissions.
  • High emitters are 10-20% of the total number of wells and dominate emissions.
• Data lead us to focus on Gas Wells, with the underlying driving forces remaining to be determined.
Additional Comments

- We have used the leakage rates to infer effective permeability values for leaking wells.

- The permeability values are in the range of other estimates made in association with CO$_2$ injection, and add confidence to a low leakage risk for large-scale CCS.
Thank you for your Attention