Well Completions and Workovers with Hydraulic Fracturing

September 13, 2012
Well Completions and Workovers with Hydraulic Fracturing

- 3% of production sector emissions
- 1.8% of total natural gas emissions

2010 Emissions from Natural Gas Production, MMTCO2e

- Completions and Workovers with Hydraulic Fracturing
- Shallow water Gas Platforms
- Gas Engines
- Pneumatic Device Vents
- Liquids Unloading
- Other production sources
Background

- Well Completions – Process of finishing a well so that it is ready to produce natural gas
- Well Workovers – Refracturing a well

Emissions from Completions and Workovers with Hydraulic Fracturing, MMTCO₂e (2012 Inventory)

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated Potential</td>
<td>0.4</td>
<td>10.9</td>
<td>27.6</td>
</tr>
<tr>
<td>Regulatory Reductions</td>
<td>-(0.2)</td>
<td>-(5.5)</td>
<td>-(13.9)</td>
</tr>
<tr>
<td>Voluntary Reductions</td>
<td>0.0</td>
<td>-(0.2)</td>
<td>-(9.8)</td>
</tr>
<tr>
<td>Net Emissions</td>
<td>0.2</td>
<td>5.2</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Methodology prior to 2011

- Did not differentiate between completions/workovers with and without hydraulic fracturing
- Completions calculated as difference in total well numbers from year to year
- Workovers calculated as 4.35% of total well number for each year
- Emission factors from EPA/GRI (1996)
  - 733 scf/completion
  - 2,454 scf/workover
- Factors include assumption of 100% flaring, with 98% combustion efficiency (i.e. it is not a potential emission factor)

2010 Inventory calculated 0.02 MMTCO₂e CH₄ emissions (year 2008) from completions and workovers combined
Methodological Update (2011)

Inclusion of wells with hydraulic fracturing
- EPA/GRI (1996) study not representative of wells with hydraulic fracturing
- Hydraulically fractured well completions are more emissive than other types of completions
- Hydraulic fracturing increased dramatically since 1992 (30% of completions in 1992 to 85% in 2009)

Update
- Differentiated between wells with and without hydraulic fracturing
- Wells with hydraulic fracturing
  - Used new (9,175 Mcf) emission factor for completions and workovers with hydraulic fracturing
  - Updated workover frequency for wells with HF to 10%

Results
- 2012 Inventory estimated emissions of 3.8 MMTCO$_2$e (year 2010) from completions and workovers combined
Current Method for Wells with Hydraulic Fracturing

Step 1. Calculate potential methane
- 1a – Activity Data
- 1b – Emission Factor

Step 2. Compile reductions data
- 2a – Voluntary Reductions Reported to GasStar
- 2b – Regulatory Reductions

Step 3. Calculate Net Emissions
Step 1a. Potential Methane Calculations – Activity Data

- Total hydraulically fractured well count determined from state-level data
- Method for calculating # of completions with hydraulic fracturing
  - Wells with HF in 2010 minus Wells with HF in 2009 = # of completions in 2010
- Method for calculating # of workovers
  - Inventory assumes that 10% of all wells with hydraulic fracturing are worked over each year

Example for 2010 Activity Data (2012 Inventory)

<table>
<thead>
<tr>
<th># Completions</th>
<th># Workovers</th>
<th># Completions and Workovers</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,196</td>
<td>+ 5,043</td>
<td>= 9,212</td>
</tr>
</tbody>
</table>
Step 1b. Potential Methane Calculations – Emission Factor

- Factor developed from four data sets containing data for over 1,000 well completions
  - Industry data on gas capture from well completions
  - Included wells representative of U.S. formation types where hydraulic fracturing is typical, including shale, tightsands, and coal bed methane wells
  - Best publically available data at the time of development

- Factor of 9,175 Mscf per completion calculated by averaging data sets

- Factor is applied to both well completions and well workovers

- Factor is a potential methane factor--any emissions captured or flared must be deducted to calculate net emissions
Step 1 Results

(# of Completions + # of Workovers) × Emission Factor = Calculated Potential

Example for 2010 Calculated Potential (2012 Inventory)

<table>
<thead>
<tr>
<th># of Completions and Workovers</th>
<th>EF (Mscf whole gas/completion or workover)</th>
<th>Regional methane content (%)</th>
<th>Calculated Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,212</td>
<td>x 9,175</td>
<td>x (Ranges from 78.4% to 91.9%)</td>
<td>= 27.6 MMTCO₂e</td>
</tr>
</tbody>
</table>

*Inventory calculated potential is calculated by region, with regional CH₄ content
Step 2a. Reductions

Reductions reported to Natural Gas STAR
• GasSTAR Partners report annual emissions reductions from Reduced Emissions Completions (RECs) and flaring at wells with hydraulic fracturing

State regulatory reductions
• National-level percentage of regulatory reductions applied across all years of Inventory to estimate the percent of emissions controlled due to state regulations
  – Developed single year estimate of regulatory reductions known at the time
  – Estimated based on the share of wells with hydraulic fracturing in Wyoming, only state known to have relevant regulation at the time
    • Requires operators to flare or capture gas produced from gas well completions and workovers
  – EPA calculated percentage of gas wells with hydraulic fracturing in WY as compared to States without regulations (51%)
  – Result is Inventory assumption that 100% of gas is controlled for 51% of calculated potential
Step 3. Calculate Net Emissions

- Potential Methane – Reductions = Emissions
- Emissions presented in the GHG Inventory are net emissions

Example for 2010 Emissions (2012 Inventory)

<table>
<thead>
<tr>
<th>Calculated Potential (MMTCO2e)</th>
<th>Regulatory Reductions (MMTCO2e)</th>
<th>Voluntary Reductions (MMTCO2e)</th>
<th>Emissions (MMTCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.6</td>
<td>-13.9</td>
<td>-9.8</td>
<td>= 3.8</td>
</tr>
</tbody>
</table>
Updates Under Consideration

Step 1
- **Completions**
  - Use NEMS Oil and Gas Supply Module input data file to generate the number of completions, expanding coverage of Inventory for completions and workovers
  - Round emission factor, 9,175 MCF to 9,000 MCF, consistent with final NSPS analysis
- **Workovers**
  - Replace the current 10% workover rate with a 1% workover rate, consistent with final NSPS analysis

Step 2
- **State regulatory reductions**
  - Recalculate reductions from state regulations
  - Use updated data to determine the number of completions and workovers occurring in states with regulations
  - Adjust start year for state regulations from 1990 to state-specific start years
  - Investigate additional data on state regulations
- **NSPS**
  - Consider how to reflect impact of NSPS in future Inventories
Questions for Stakeholders

Feedback on Updates Under Consideration?
• Refracture frequency rate update (10% to 1%)
• Updates to state regulatory reductions
• Are other data available on completions, workovers, or emissions reductions (both voluntary and regulatory)?
• Are there opportunities to generate new well-level data?

Time series
• Are all unconventional wells completed with hydraulic fracturing throughout the 1990-2011 time series?
• Will the workover rate change over time?

Presentation of information in the Inventory
• Options for updated presentation of information in the GHG Inventory?