Liquids Unloading

- 68.0% of production emissions
- 39.8% of total natural gas systems 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

Liquids Unloading – Removal of accumulated fluids from well bore either by venting (“blowing down”) or using artificial lift techniques (e.g., plunger lifts).

2012 Inventory Liquids Unloading Emissions (MMTCO$_2$e)

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated Potential</td>
<td>55.7</td>
<td>69.9</td>
<td>95.5</td>
</tr>
<tr>
<td>Voluntary Reductions</td>
<td>N/A</td>
<td>-(1.5)</td>
<td>-(9.9)</td>
</tr>
<tr>
<td>Regulatory Reductions</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Net Emissions</td>
<td>55.7</td>
<td>68.4</td>
<td>85.7</td>
</tr>
</tbody>
</table>
Methodology Update (2010 to 2011 Inventory)

2010 Methodology:
• EPA/GRI (1996) emission factor (49,570 scf/yr-well)
  – Factor based on assumptions of venting using average gas production rates

2011 Update:
• Updated factor uses engineering calculations and actual well-level production data from the Lasser® and GASIS databases
  – Sample of basins nation-wide to calculate NEMS-region specific emission factors
• Updated emission factor by NEMS region (ranging from 690,000 to 2,500,000 scf/year-well)
Current Inventory Method

Step 1. Calculate Potential Methane
   • 1a – Activity Data
     o NEMS regional data
   • 1b – Emission Factor
     o NEMs regional factors

Step 2. Compile Reductions Data
   • Voluntary reductions reported to GasSTAR

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

- The activity data (i.e., number of wells that conduct liquids unloading) is based on the following data and calculation:

\[ W_{WO} \times F_{LU} \]

- \( W_{WO} \) = number of wells without hydraulic fracturing
  - As outlined in Well Counts presentation
- \( F_{LU} \) = fraction of gas wells conducting liquids unloading (41.3%)
  - From the 1996 EPA/GRI study

Example for 2010 (2012 Inventory)

<table>
<thead>
<tr>
<th>( W_{WO} )</th>
<th>( F_{LU} ) (%)</th>
<th># wells requiring LU</th>
</tr>
</thead>
<tbody>
<tr>
<td>434,361</td>
<td>x 0.413</td>
<td>= 179,391</td>
</tr>
</tbody>
</table>
Step 1b. Potential Methane Calculations – Emission Factor

- The liquids unloading emission factor represents the per well blowdown potential emissions per year.
- A factor was developed for each NEMS region, adjusted to reflect the average methane content of each region shown in the table below.
- Factors applied every year of the time series to wells requiring liquids unloading in each NEMS region

### Potential Methane Factors for Liquids Unloading (scf CH₄/well)*

<table>
<thead>
<tr>
<th>NEMS Regions</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>North East</td>
<td>1,364,054</td>
<td>1,315,230</td>
<td>1,359,535</td>
</tr>
<tr>
<td>Mid-Continent</td>
<td>666,452</td>
<td>701,932</td>
<td>703,273</td>
</tr>
<tr>
<td>Rocky Mountain</td>
<td>610,744</td>
<td>717,251</td>
<td>690,440</td>
</tr>
<tr>
<td>South West</td>
<td>691,827</td>
<td>864,819</td>
<td>864,999</td>
</tr>
<tr>
<td>West Coast</td>
<td>1,222,737</td>
<td>1,491,925</td>
<td>1,491,925</td>
</tr>
<tr>
<td>Gulf Coast</td>
<td>2,272,696</td>
<td>2,524,927</td>
<td>2,519,264</td>
</tr>
</tbody>
</table>

*CH₄ content updated annually for each NEMS region
Step 1b. Emission Factor
Derivation of NEMS Emission Factors

- Developed emission factors for a sample of AAPG basins nation-wide using well-level data:
  - Volume of emissions from well casing (MCF/blowdown) per each sample basin
    - Using the well depth and shut-in pressure (GASIS and Lasser®) and 5 inch casing diameter
  - Blowtime of continued venting after liquids have been removed
    - Blowtime (3 hours per well per blowdown)
    - Average gas production rate (Mcf per hour per well) from Lasser® for each sample basin

- Developed basin-level emissions estimates by applying emission factors to number of blowdowns per year in each basin, calculated with:
  - Estimated blowdowns per year per well (38.73) EPA/GRI (1996)
  - Number of conventional wells for each basin (GASIS and Lasser®)
  - Percentage of conventional wells requiring liquids unloading (41.3%) (EPA/GRI 1996)

- NEMS region-specific emission factors were developed by summing basin emissions for use with available annual activity data at NEMS region level:
  - Total potential methane release for each sample basin summed across each NEMS region
  - NEMS region-level emissions divided by number of wells requiring liquids unloading in each region
Step 1 Results

• The NEMS-specific well counts and emission factors are used to calculate Region-level emissions
• Potential methane per NEMS region = Wells Conducting Liquids Unloading × Regional Emission Factor
• Resulting regional potential methane estimates are then summed to the national level

Example of 2010 Potential Methane (2012 Inventory)

<table>
<thead>
<tr>
<th>Wells with LU</th>
<th>EF (scf/yr-well)</th>
<th>Emissions (MMTCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>179,391</td>
<td>x (Ranges from 690,000 to 2,500,000)</td>
<td>= 95.5 MMTCO2e</td>
</tr>
</tbody>
</table>
Step 2. Reductions Reported to Natural Gas STAR

- Gas STAR Partners report annual liquids unloading emissions reductions associated with artificial lifts
  - Equipment installation: plunger lifts, pumpjacks or rod pumps, velocity tubing strings
  - Operations: pressure swabbing, capillary strings, compression, pumping unit, blowtime reductions
Step 3. Calculate Net Emissions

- Net Annual Emissions = Potential Methane Emissions – Reported Reductions
- In 2010, reductions reported to Natural Gas STAR reduced calculated potential emissions by 9.9 MMTCO$_2$e, or 10.4%

Example of 2010 Net Emissions (2012 Inventory)

<table>
<thead>
<tr>
<th>Potential Methane (MMTCO$_2$e)</th>
<th>Voluntary Reductions (MMTCO$_2$e)</th>
<th>Net Emissions (MMT CO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.5</td>
<td>- 9.9</td>
<td>= 85.7</td>
</tr>
</tbody>
</table>
Updates Under Consideration

Activity Data

• Expanding population of potential wells conducting liquids unloading to include wells in unconventional formations

Emissions Reductions

• Update assumptions on use of artificial lift technologies (e.g., plunger lifts)
  – Vendor information indicating 150,000 plunger lifts are in use (as of 2008)

New Sources of Data

• Review of new reports studies with information on activity data, emission factors or reduction activities
Questions for Stakeholders –

Activity Data:
• Which types of wells practice liquids unloading?
• Is data available on wells conducting liquids unloading in different reservoir types?

Emission Factor:
• Is it reasonable to use a constant whole gas emission factor (from 2006) across the time series?
• Were assumptions used in the development of the emission factor reasonable?
  – 39 blowdowns/well-year
  – Blowtime of 3 hours

Reduction Data:
• Are other sources of data available for reduced emissions from liquids unloading?
• Is it realistic to assume that there were zero plunger lifts in operation prior to 1990?
• Is data available on control efficiency of plunger lifts?