‘Oil and Gas Emissions Simulator’

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Overview

• We have developed a high temporal resolution simulator of VOC and CH$_4$ emissions from oil and gas production pads.

• Simulator is driven by gas composition, liquids and gas production volume, in-place production equipment, operational setup, and control equipment.
Our simulation includes emissions from:
- Dehydrators
- Tank Flashing
- Pneumatics
- Liquids Unloading

We track chemical speciation (Methane, Ethane, Propane and Butane) from each source. Other VOCs can be easily added.

We vary:
- Gas composition
- Production volume (function of well age and decline curve)
- Separation pressure
- Control equipment
- Separator dump volume
- Pneumatic types (intermittent, high-bleed, low-bleed)
- Dehydrator pump (gas & electric)
- Duration and frequency of liquids unloading for low production wells
Emission Estimates

• Annual tank flashing emissions are calculated as a function of gas composition, separation pressure and production volume using the NIST REFPROP database (Peng-Robinson EOS).
  – Emissions are then distributed annually using a parameterized tank flashing curve, where the number of dumps=total liquids production/dump volume and the integrated total is equal to the total annual emissions.

• Annual dehydrator emissions are calculated as a function of pump type, gas composition and production volume using GRI GLYCALC 4.0.
  – These are distributed evenly throughout the year

• Four pneumatics are randomly chosen for each well-pad. Emission curves are taken from the UT Pneumatic Study published in 2013

• Liquids unloading emissions only occur for wells with gas production < 100 MMSCF/year. Frequency and duration of liquids unloading is parameterized based on the API/ANGA study on liquids unloading
Example of Emissions from an Individual Well

- Simulation is run at 1s time-step over 1 year
- Randomly chooses from an assortment of production characteristics
  - Separation pressure
  - Separator dump volume
  - Production volume
  - Gas Composition
  - Pneumatic emission shapes and types (from UT study)
Example Frequency Distribution for Individual Well

Fat tail distribution driven by routine temporal variability in emissions
Simulating Thousands of Wells (5 Different Ways)

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Production Description</th>
<th>Liquids</th>
<th>Controls</th>
<th># Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td>General Production Decline Curve</td>
<td>18 BBL Liquids/MMSCF Gas</td>
<td>None</td>
<td>3000</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>Production Decline Curve Sampled According to Well Age, beginning at month 89 (peak of new wells)</td>
<td>18 BBL Liquids/MMSCF Gas</td>
<td>None</td>
<td>3000</td>
</tr>
<tr>
<td>Experiment 3</td>
<td>Production Decline Curve Sampled According to Well Age, beginning at month 1</td>
<td>18 BBL Liquids/MMSCF Gas</td>
<td>None</td>
<td>3000</td>
</tr>
<tr>
<td>Experiment 4</td>
<td>Same as experiment 1</td>
<td>5 BBL Liquids/MMSCF Gas</td>
<td>None</td>
<td>3000</td>
</tr>
<tr>
<td>Experiment 5</td>
<td>Same as Experiment 1</td>
<td>18 BBL Liquids/MMSCF Gas</td>
<td>Tanks with &gt; 40 tons/year VOC production are controlled. Assume 98% control efficiency</td>
<td>3000</td>
</tr>
</tbody>
</table>
Fat tail distribution in populations driven by routine temporal variability in emissions and variability in production
Methane:Ethane Ratios

- Methane:Ethane ratios have been used by several researchers to partition out oil and gas derived methane from other sources.
- The methane:ethane ratio of different emitters is highly variable (as expected) and this translates into some variability over time across a 3000 well experiment.
Implications and Impact

• Simulator is a ‘work in progress’, but is a new method to estimate emissions from oil and gas production pads
• We have not compared emission estimates to existing inventories such as WRAP or EPA Oil and Gas Emission Tool
• Will hopefully be extended to midstream sources in the near future (need funding for this, though)
• A portion of the fat-tail distribution described by a wide variety of researchers may be explained by routine variability in emissions + variability in production.
  – Measurements should be taken over a long enough time period to capture full range of variability, rather than just peak emissions.
  – Using methane:ethane ratios as a tracer of oil and gas emissions is not straight-forward
  – Measurement networks to detect high emissions may be difficult to implement – will be difficult to tell whether you are seeing routine episodic emissions or actual operational upsets.