Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Liquid Unloadings

URS

Need for Study

- Methane, the primary constituent of natural gas, is a potent greenhouse gas
- Liquid unloadings are estimated to account for 14% of methane emissions from the natural gas production sector; very few measurements are available and those measurements indicate that a small subset of wells dominate emissions
  - Average emissions per well with unloadings (all types) in most recent US EPA national inventory (273.6 Gg/60,810 wells = 4.5 Mg per well/yr = 234,000 scf)
  - Regional average emissions/(well-yr) for unloadings of wells without plunger lifts = 78,000 to 2,000,000 scf (http://www.epa.gov/airquality/oilandgas/whitepapers.html)
  - Regional average emissions/(well-yr) for plunger lift unloadings = 3,000 to 1,100,000 scf (http://www.epa.gov/airquality/oilandgas/whitepapers.html)
- To better inform policy, measurements are needed to (i) quantify methane emissions from unloadings at a diverse set of sites, and (ii) characterize the population of high emitting wells.

Liquid Unloadings

Operation of plunger lift wells

(see animation available on YouTube)

If the above link doesn't work, please copy this URL into a new browser window:
http://youtu.be/hH-Q1JMX4_M

Well Unloadings with plunger lift

- 23,503 venting plunger lift wells in U.S. according to US EPA (40% of all venting wells); 32,225 venting plunger wells reported through the 2012 GHGRP (55% of venting wells reported through the GHGRP)
- In this work, plungers lift wells categorized as “manually triggered” (generally vent less than once per week) and “automatically triggered” (can vent multiple times per day)

Liquid Unloadings

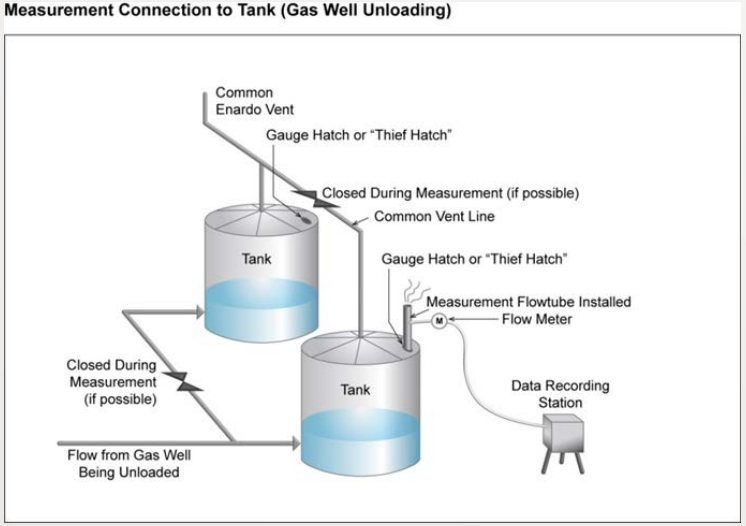
Unloadings clear operating wells of liquid to increase gas production

(see animation available on YouTube)

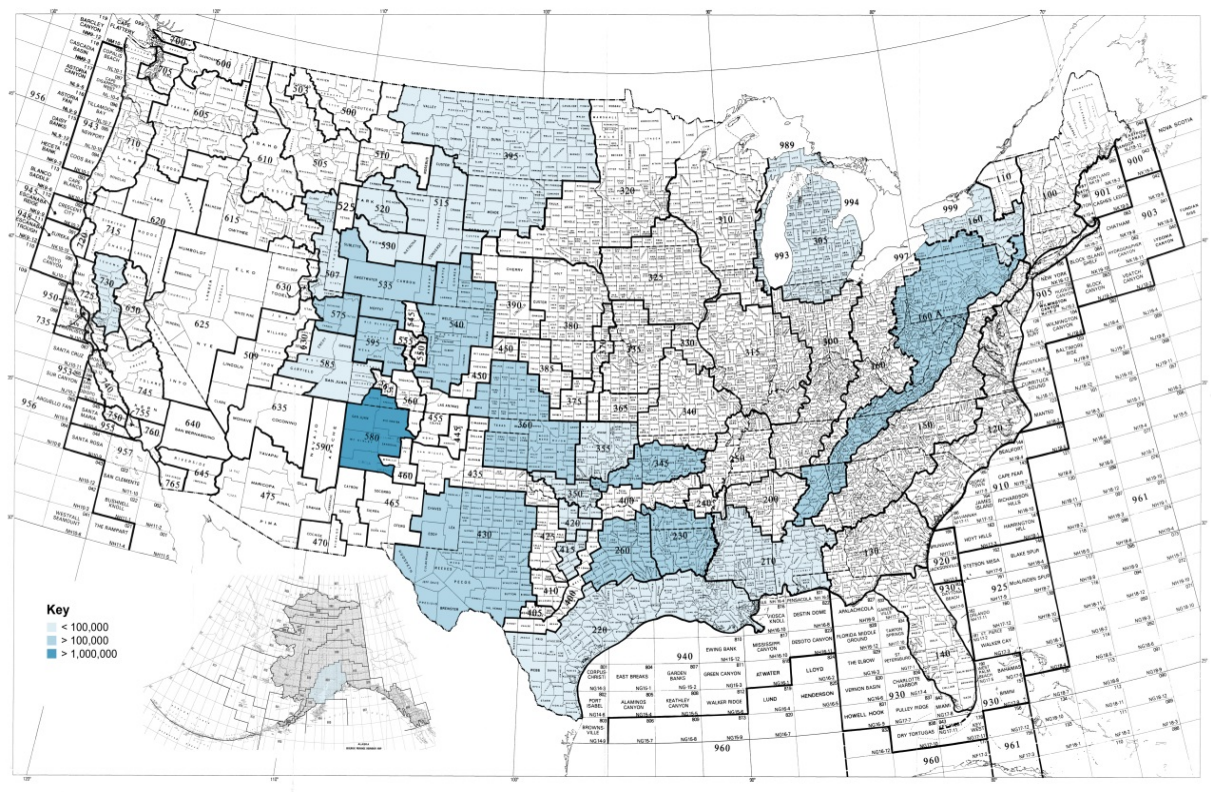
If the above link doesn't work, please copy this URL into a new browser window:
http://youtu.be/tup1SICEXGY

Unloadings of wells without plunger lift

- 37,307 venting wells without plunger lift in U.S. according to US EPA national emission inventory (61% of all venting wells); 26,438 venting wells without plunger lift reported through the 2012 GHGRP (45% of venting wells reported through the GHGRP)
- In this work, 99% of the wells without plunger lifts were “manually triggered” (generally vent less than once per week); approximately 1% of wells unload more than once per week and approximately 0.1% are automatically triggered

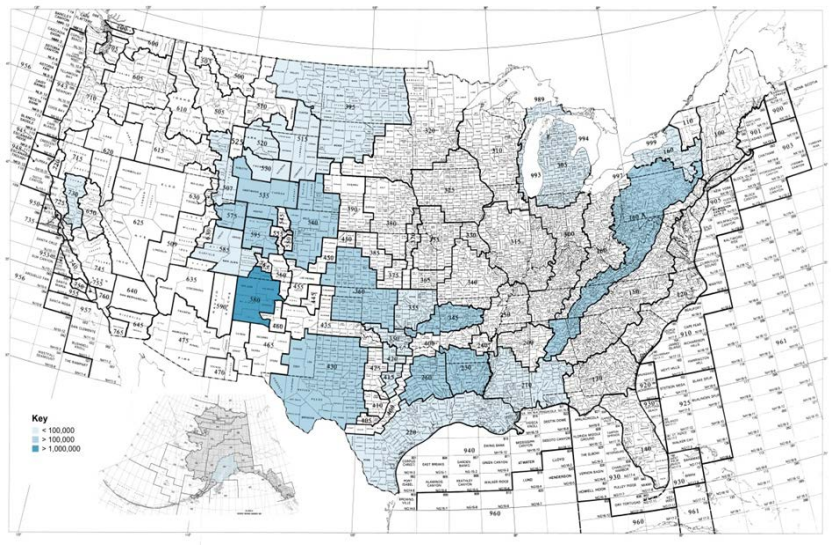


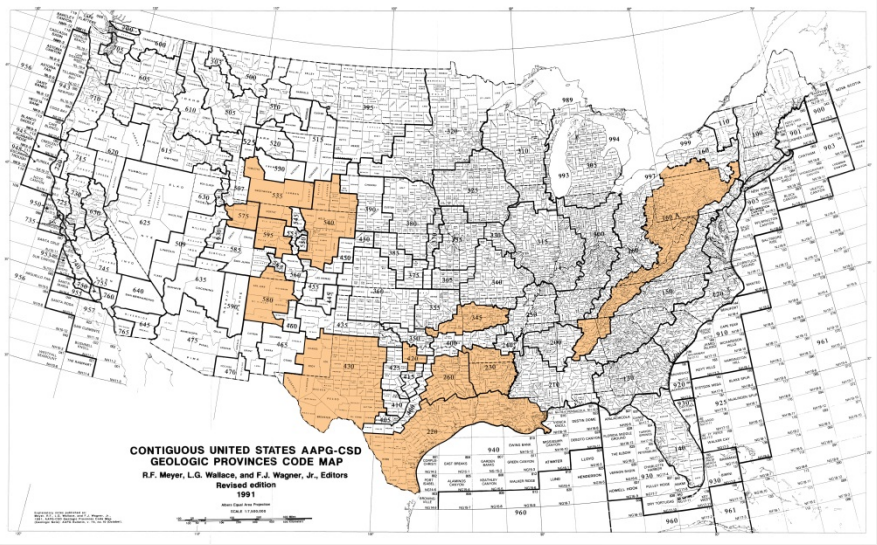
Reported emissions (Greenhouse Gas Reporting Program) are concentrated in some regions



Light blue: <100,000 MT CO_2e (~5 Gg CH_4; EPA estimate of US inventory is 274 Gg)
Medium blue: 100,000-1,000,000 MT CO_2e
Dark blue: 1,000,000+ MT CO_2e

Spatial distribution of unloading emissions vs. regions sampled

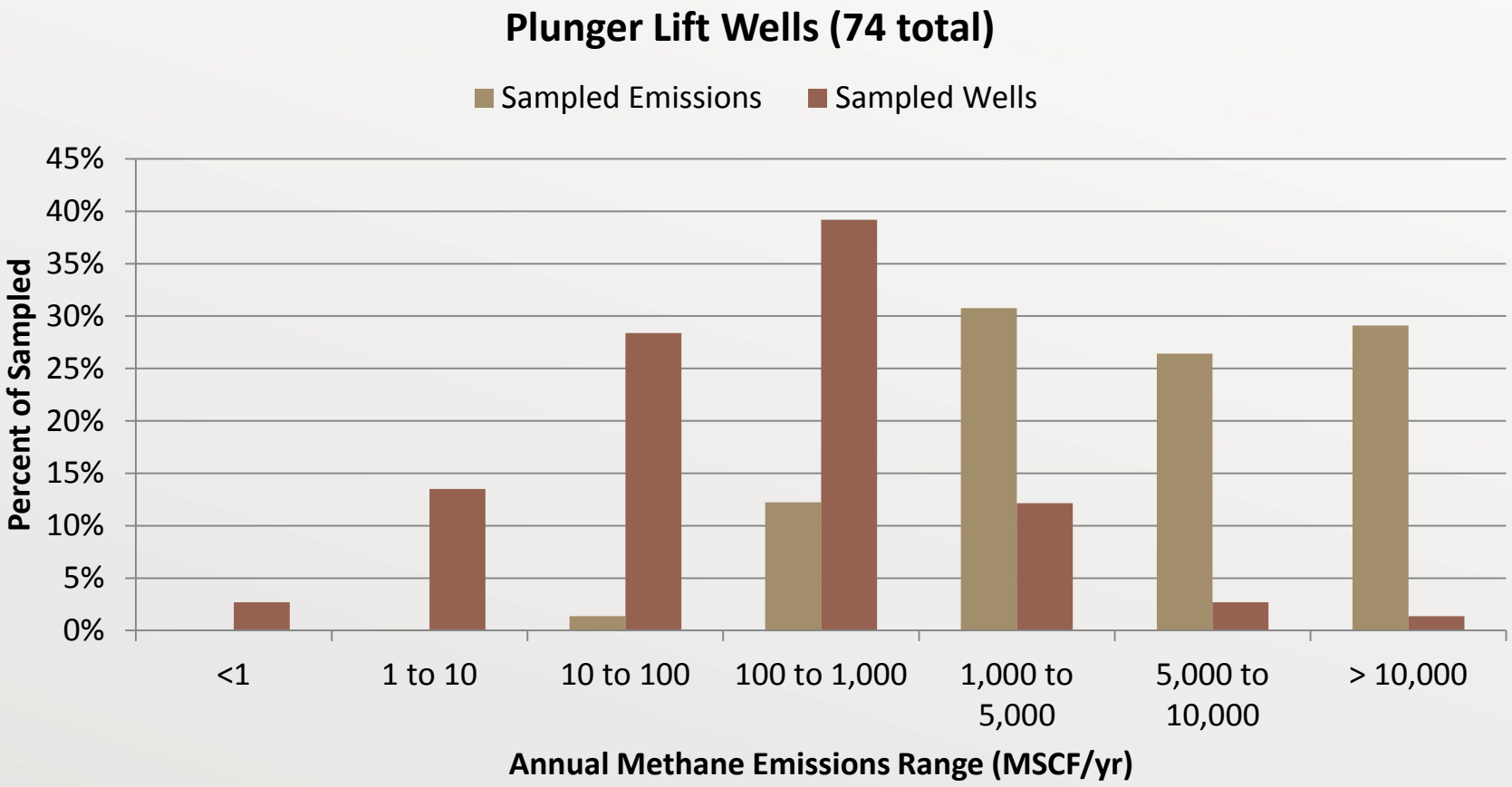




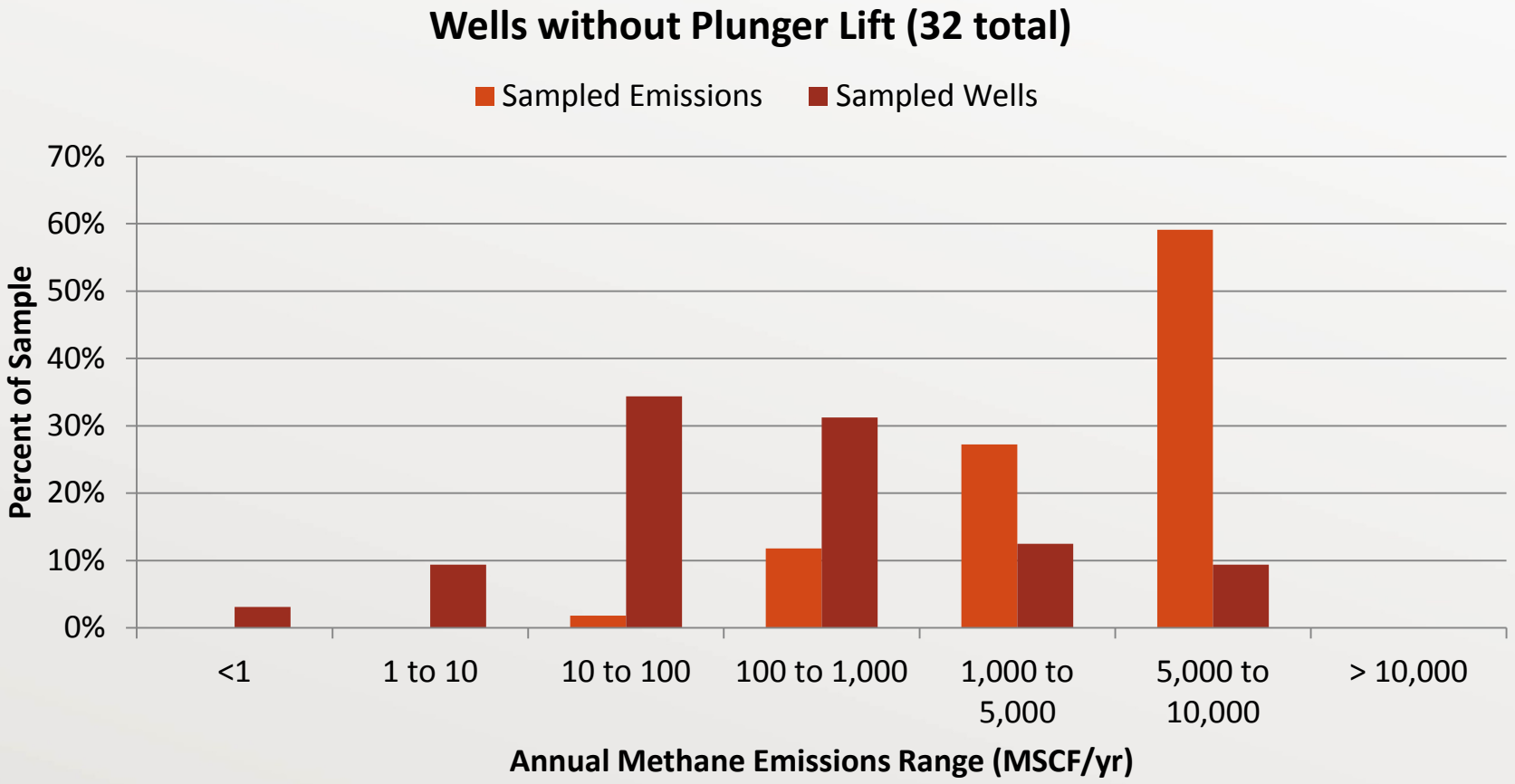
Findings

- For plunger and non-plunger wells, a small subset of wells dominate emissions
- Measured emissions per well per year depend most strongly on the number of venting events that occur per year
- For wells without plunger lifts, the 1.2% of wells that vent more than weekly account for 25% of estimated annual emissions from wells without plunger lifts
- For plunger lift unloadings, the subset of wells that vent more than once per day (typically several times per day), account for 80% of emissions from plunger lift wells that vent during unloadings
- The central estimate of emissions from unloadings (270 Gg/yr) based on measurements made in this work are within a few percent of the emissions estimated in the EPA 2012 Greenhouse Gas National Emission Inventory, however, confidence bounds are large based on variability in emissions per event and uncertainty in event counts

Plunger lift wells



Wells without plunger lifts



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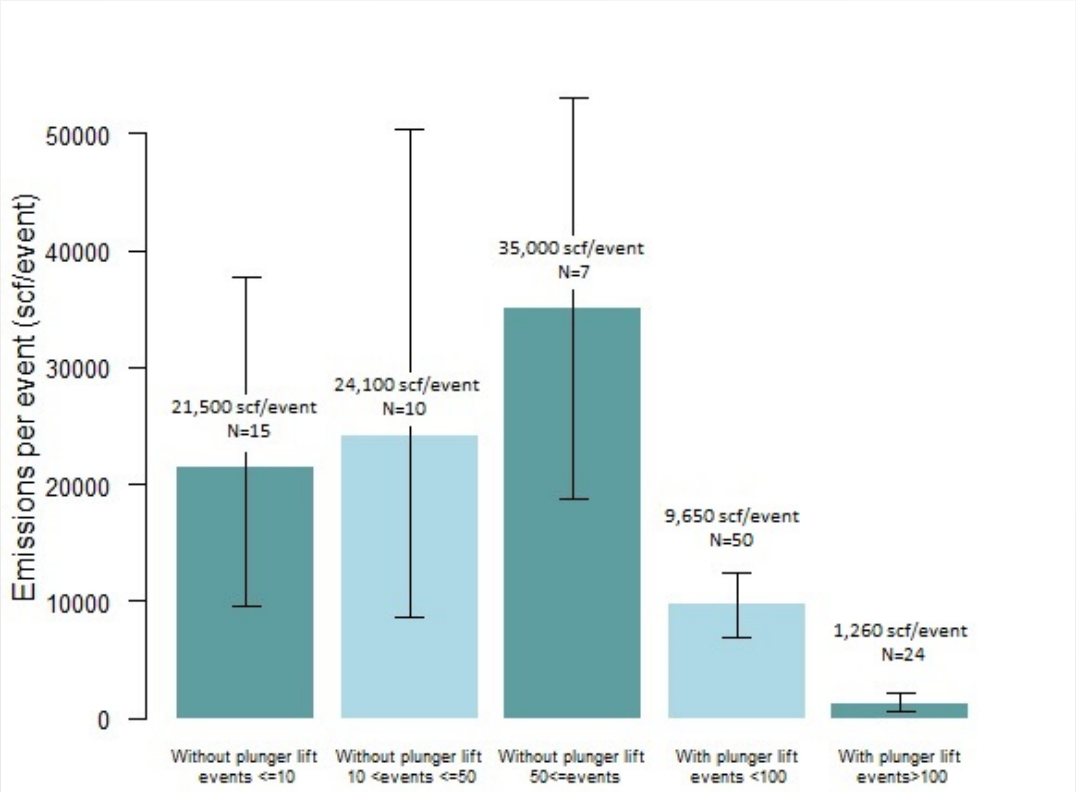

Emissions per event have a much small range (21,500-35,000 scf/event for wells without plungers; 1,260-9,650 for wells with plungers) compared to the range in numbers of events (up to three orders of magnitude)

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Estimates of event counts

- Participating companies provided data on event counts for 8772 wells with plunger lifts and 7481 wells without plunger lift, approximately 28% of all wells with unloadings that vent in the U.S.
- For some categories of wells (especially non-plunger wells with high event frequency) company survey data show different distributions than other sources of event data
- Company survey data were used as the primary data source and the study team conducted rigorous quality assurance of the data

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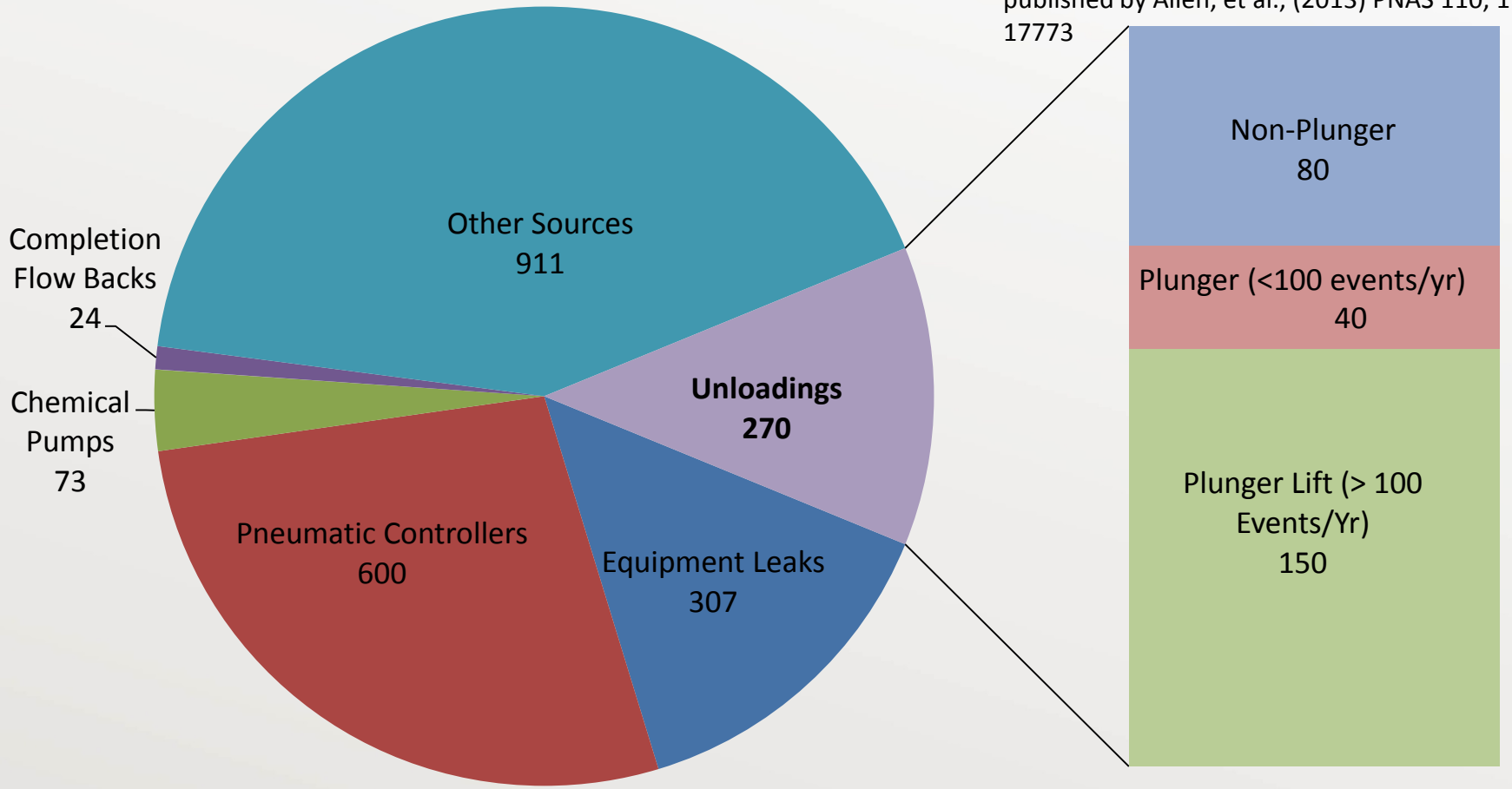
Implications for National Emissions:

- Wells with plunger lift that vent during unloadings
  - 83% of the 32,225 wells nationally (GHGRP) have less than 100 events per year with average emissions of 73,000 scf methane per well, for total emissions of 40 Gg (2 bcf/y).
  - The remaining 17% of wells have emissions of 1,440,000 scf methane per well, for total emissions of 150 Gg/y (7.9 bcf/y).
- Wells without plunger lift that vent during unloadings
  - ~99% of the 26,438 wells without plunger lift nationally (GHGRP) have average emissions of 123,000 scf methane per well, for total estimates emissions of 60 Gg/y (3.3 bcf/y).
  - The remaining 1.2% of wells, with emissions of 3.5 million scf methane per well per year, result in emissions of 20 Gg (1.1 bcf/y).
- Regardless of the exact national total of emissions, wells with high frequencies of unloadings emit at average rates that are an order of magnitude or more greater than wells with low frequencies of unloadings

Estimated Annual Emissions from Upstream Natural Gas Production Sector in the United States (Gg Methane)

Estimate for unloadings: Emission factors based on measurements in this work with activity data based on survey of participating companies in this work. Estimate for pneumatic controllers: From updated measurements on controllers, published in parallel with this work. All other categories: Previously published by Allen, et al., (2013) PNAS 110, 17768-17773



Total of 2180 Gg or 0.38% of 2012 U.S. natural gas withdrawals and production

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