Low-Producing Wells are a Significant Source of Emissions
September 2016

Recent studies indicate that emissions from low production wells are disproportionately high relative to production, and because these wells account for the large majority of existing sources, it is critical that Control Techniques Guidelines for the sector include these sources as part of a leak detection and repair (LDAR) program. Below, we provide some additional evidence on the prevalence of low-producing wells in areas where CTGs will likely apply and the low cost of addressing emissions from these sources. We also describe, in greater detail, information from recent studies documenting emissions from low-producing wells.

Prevalence of Low-Producing Wells in Areas in which CTGs will likely Apply.

Of the almost 153,000 wells in areas that would likely be subject to CTGs, between about 105,000 and 122,000 (or between 70% and 80%) produce less than 15 barrels of oil equivalent per day (BOED).[1] Table 1, below, uses data from DI Desktop to identify wells that fall into each of the three model facilities EPA included in the final new source performance standards—gas wells and oil wells both above and below a gas-to-oil ratio (GOR) of 300. Within each of these categories, the table further identifies lower producing well counts. Table 1 also includes information specific to Pennsylvania, for which 89% of wells produce less than 15 BOED.

Table 1: Categorization of Wells in CTG Areas

Production Type - Wells Likely to be Subject to CTGs	Count[1]	% Total	Count[2]	% Total
Gas Well (>15 BOED)	20,545	13%	16,572	11%
Gas Well (<=15 BOED)	61,222	40%	65,195	43%
Oil Well Sites (GOR < 300; >15 BOED)	14,173	9%	7,044	5%
Oil Well Sites (GOR < 300; <=15 BOED)	21,033	14%	28,162	18%
Oil Well Sites w/ Assoc Gas (GOR > 300; > 15 BOED)	13,338	9%	8,222	5%
Oil Well Sites w/ Assoc Gas (GOR > 300; <= 15BOED)	22,616	15%	27,732	18%
TOTAL	152,927	100%	152,927	100%

Production Type - Pennsylvania	Count[1]	% Total	Count[2]	% Total
Gas Well (>15 BOED)	5,798	11%	5,392	10%
Gas Well (<=15 BOED)	45,860	85%	46,266	86%
Oil Well Sites (GOR < 300; >15 BOED)	3	0%	0	0%
Oil Well Sites (GOR < 300; <=15 BOED)	90	0.2%	93	0%
Oil Well Sites w/ Assoc Gas (GOR > 300; > 15 BOED)	402	1%	390	1%
Oil Well Sites w/ Assoc Gas (GOR > 300; <= 15BOED)	1,893	4%	1,905	4%
TOTAL	54,046	100%	54,046	100%

[1] These counts are based on BOED calculations using cumulative well production.
[2] These counts are based on BOED calculations using annual well production.

[1] BOED values for wells vary based on whether the calculation reflects the cumulative or annual well production. Regardless, low-producing wells account for about 70% - 80% total CTG wells and almost 90% wells in PA.

Using these well counts, in combination with the assumptions in EPA's Final OOOOa TSD for LDAR reductions and cost, applying CTG LDAR requirements to higher and lower-producing wells could secure 350,000 tons of annual methane reductions and nearly 100,000 tons of VOC reductions.[2] Excluding lower-producing wells from the requirements, however, would significantly lower reductions to about 100,000 tons methane annually and 30,000 tons of VOC.[3]

These reductions can be achieved at reasonable cost. Again using EPA's assumptions in the NSPS OOOOa TSD and updated CTG well counts, the VOC cost-effectiveness of semiannual monitoring at all wells—including low-producing wells—ranges from $2,700 - $3,500/ton VOC reduced.[4] These numbers are lower than the final NSPS estimates (due to a different mix of gas, low- and high-GOR wells in the CTGs), and below presumptive benchmarks used by states when evaluating RACT. For instance, in a 2015 rulemaking, Pennsylvania identified a presumptive RACT benchmark of $7,000/ton VOC reduced.[5]

Recent Studies

Zavala-Araiza, et al., (2015) "Toward a Functional Definition of Methane Super-Emitters: Application to Natural Gas Production Sites," Environ. Sci. Technol. 2015, 49, 13, at 8167−8174 ("Zavala-Araiza (2015)")

- The Barnett Shale study, which evaluated emissions from a sample made up mostly of natural gas wells, found that average emissions from low-producing wells were approximately 18.4 US ton/ year of methane – over 80% higher than the average emission rate for all wells included in the study.
- These are site-level emissions and include venting equipment like pneumatic devices and uncontrolled storage tanks that would not necessarily be addressed through an LDAR program. The data, however, suggest that improperly operating equipment are an important contributor to these high emissions. Indeed, many of the sites were functional super-emitters (with loss rates greater than 1% of production) and several of these sites had very high production normalized loss rates (greater than 50% of production) that would not be expected from properly operating facilities, even those with uncontrolled storage tanks. Moreover, preliminary analysis attempting to recreate site-level emissions measurements in the Barnett using site-level component counts and emissions factors suggests that there is a gap, with measured emissions higher than calculated component-level emissions. This suggests that improperly operating equipment or other abnormal

[2] This assumes the total CTG well count presented in Table 1. Using the Final NSPS OOOOa rule TSD OGI well pad spreadsheet, applying semi-annual LDAR monitoring would result in the reductions noted above.
[3] These reductions would be lower if BOED thresholds are calculated using annual production rather than cumulative well production.
[4] The range presented depends on whether or not the value of the captured gas is monetized.
[5] Pennsylvania Bulletin, VOL. 46, NO. 17, April 23, 2016. Rules and Regulations, Title 25: Environmental Protection, page 2044, *available at* http://www.pabulletin.com/secure/data/vol46/46-17/46_17_rr.pdf

site-level conditions that could potentially be addressed through an LDAR program were important contributors to overall emissions.
- The Barnett is located in an ozone non-attainment area, and many of the wells measured in the study fall within that area.

David R. Lyon et al., Aerial Surveys of Elevated Hydrocarbon Emissions from Oil and Gas Production Sites, 50 Envtl. Sci. & Tech. 4877 (Apr. 5, 2016).

- This study utilized helicopter surveys to document fugitive emissions from over 8,000 well sites in seven basins nationwide. The helicopter survey detection limit was 1 – 3 g/s total hydrocarbons, or approximately 30 to 100 tons per year, but it is likely that much of the observed tank emissions were VOCs. For instance, a study performed for TCEQ reported an average of 76% VOC in the flashing emissions of oil and condensate tanks.
- The study captured high-emitting sources and was not limited only to leaks. Similar to the Barnett, the authors concluded that not all emissions could be explained by tank flashing if all controls were operating properly. These sources could likely be addressed through a LDAR program to identify issues such as unlit flares and open hatches at controlled storage tanks.
- Based on an oil well definition of GOR ≤12,500 scf/bbl, marginal oil wells had a greater occurrence of observed hydrocarbon emissions (4.9%) compared to all wells (4.0%) in the helicopter IR survey.
- 34% of the high-emitting wells detected in areas with ozone design values above the 2015 standard were marginal wells. These wells were located in the Uintah and Barnett.

M. Omara et al 2016, Methane Emissions from Conventional and Unconventional Natural Gas Production Sites in the Marcellus Shale Basin, 50 Envtl. Sci. & Tech. 2099 (Feb. 16, 2016) (DOI: 10.1021/acs.est.5b05503).

- Site-level measurements of 35 well pads in the Marcellus found 85 times higher median production-normalized CH_4 emission rates from low production, conventional wells compared to high production, unconventional wells (11% vs 0.13%). Though these wells had lower absolute emissions rates, the average emissions of conventional wells was 0.82 kg/hr, which is equivalent to 7.9 TPY methane.
- Many of these sites were in the ozone nonattainment area or the ozone transport region.

ERG and Sage Environmental Consulting, LP, "City of Fort Worth Natural Gas Air Quality Study, Final Report" ("Fort Worth Study") (July 13, 2011)

- Though only 27 of the over 300 wells sampled in the Fort Worth study were marginal wells, there are specific data from these wells on leak emissions from components like valves and connectors.

- This study strongly corroborates EPA's conclusion in the final NSPS that low producing wells are similar in complexity to other wells, and therefore likely to have at least comparable emissions. In particular, as shown in Table 2 below, the average low-producing well in this study had a component profile that is very similar to EPA's gas well model facility, and much higher than the component count for EPA's oil well model facilities. The average well also had two tanks and 0.2 compressors, which are both sources of fugitive emissions excluded from EPA's model facility.
- Using EPA emission factors, we estimate that the average low-producing well in the Fort Worth study had annual methane emissions of 4.5 tpy, which is much higher than the emissions of oil well model facilities (2.5tpy/1.5tpy) and comparable to the annual emissions from the gas well model facility.

Table 2: Analysis of Site Complexity in the Fort Worth Study

Site ID	Wells	Valves	Connectors	Tanks	Compressors
Fort Worth Marginal Well Pad Average	**1.6**	**105**	**711**	**2**	**0.2**
EPA Model Natural Gas Well Site	*2*	*139*	*510*		

Boulder County Voluntary Oil and Gas Inspection Program (2016)[6]

- Boulder county officials surveyed 229 oil and gas facilities containing between 1 and 8 wells on site in Boulder County, Colorado.[7] The survey data show that, in 2014, 83% of facilities had production levels below 15 BOED, and that these low-producing facilities were more likely to be leaking than higher producing facilities. In particular, 44% of these low-producing facilities reported leaks, compared to only 27% of high-producing facilities with leaks.

[6] IR camera inspection data obtained from Boulder County for April 2014 thru August 2016; data is on file with EDF.
[7] This is 229 cumulative cites with some overlap and some sites surveyed only one or two years. There were 131 sites surveyed in 2014; 84 sites surveyed in 2015; and 93 sites in 2016.