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June 5, 2017

Pennsylvania Department of Environmental Protection, Policy Office
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Re: ONE Future Comments Regarding General Operating Permit for Unconventional Natural Gas Well Site Operations (GP-5A)

To the Pennsylvania Department of Environmental Protection:

Our Nation's Energy Future Coalition, Inc. (ONE Future) appreciates the opportunity to comment on the proposed Air Quality Draft General Permit (GP-5A). Our members have operations in Pennsylvania in the production, gathering and transmission and storage segments of the natural gas value chain providing safe, reliable natural gas to the state and our nation while providing for high paying jobs. Our members are committed to reducing methane emissions and have championed methane measurements and mitigation technologies and policies. Therefore, we are not only impacted by the proposed GP-5A regulations but also offer our science-based technical and policy expertise to the Pennsylvania Department of Environmental Protection (PADEP) on this consequential rule-making. Our comments focus primarily on the leak detection and repair (LDAR) cost analysis as presented in Appendix E of the Technical Support Document[1] and recommend performance-based options as an alternative compliance standard.

ONE Future is a unique coalition of leading companies[2] with operations across every part of the natural gas supply chain. Formed in 2014, ONE Future develops innovative policy and technology solutions to environmental and operational challenges across the natural gas industry. We believe natural gas has a foundational role in the energy transition to a lower carbon economy and with prudent development and distribution, we can provide a safe, secure and stable energy source to the U.S. and the rest of the world. ONE Future member companies aspire to continuously improve the energy delivery efficiency of the

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[1] PADEP, Technical Support Document, General Plan Approval and General Operating Permit for Unconventional Natural Gas Well Site Operations and Remote Pigging Stations (BAQ-GPA/GP-5A) and for Natural Gas Compressor Stations, Processing Plants, and Transmission Stations (BAQ-GPA/GP-5), February 4, 2017.

[2] ONE Future members currently include: Apache, BHP Billiton, Hess, Statoil, Southwestern Energy, Kinder Morgan, TransCanada, Southern Company Gas, Summit Utilities and National Grid. More information can be found at http://www.onefuture.us/

natural gas supply chain by reducing total methane emissions to less than one percent of gross production, a scientifically developed performance-based target. By promoting smarter policy approaches and working to identify solutions across every segment of the natural gas supply chain, our members can deliver better results to their customers, increase value to their shareholders, and improve our environment.

ONE Future recommends employing past PADEP permitting and regulatory precedence with respect to LDAR programs under GP 5A.

One Future members offer a "rational middle" approach that achieves the same end-goal of reducing methane emissions by employing our collective operational and environmental experiences. Methane leaks have often been employed in scientific literature to encompass *all* emissions at the site. The proposed GP 5A includes standards for a variety of emission sources and events. There has been significant confusion and focus on the role of LDAR programs and assumptions by some that *all* methane *fugitive* emissions are *stochastic* (i.e. random) in nature and would continue forever without a high-frequency LDAR program prescribed by regulations. LDAR programs support corporate operating and maintenance programs in identifying *methane leaks* at various sites. With respect to LDAR, we recommend focusing *first* on a company's standard operating and maintenance programs as the primary indicator of operational excellence in this area, with LDAR viewed as an "audit tool," and not the primary indicator of a well operated, low methane emitting facility. We have a shared commitment and goal to minimize the loss of natural gas (mostly methane), our product, and thereby improve efficiencies of our natural gas production and delivery systems. Our members have internal standard operating and maintenance practices that are aimed to ensure our facilities operate efficiently and minimize product loss, *regardless of the price of natural gas*. We believe such programs are paramount to minimize *fugitive methane emissions* at our facilities. We find that the proposed quarterly LDAR requirements are not supported by peer-reviewed science or our collective experience. Therefore, we recommend annual LDAR (with step-up to semi-annual monitoring at certain sites) along with monthly audio-visual-olfactory (AVO) surveys in lieu of the proposed LDAR programs.

ONE Future commends the PADEP for considering ICF-ONE Future's economic analysis (ICF 2016)[3] in the development of the proposed air permitting requirements. Our collective experience shows that emission mitigation cost and performance are highly site specific and variable. The values used in the ONE Future economic analysis of methane reduction opportunities are estimated average national values based on our collective knowledge. However, PADEP applied higher reduction rates (50% and 60% compared to ONE Future's estimate of 40% reduction which was based on our collective experience with LDAR programs) and different repair costs, resulting in the cost of reduction in terms of $/ton to be 40%-

[3] Economic Analysis of Methane Emission Reduction Potential from Natural Gas Systems, ICF International on behalf of ONE Future Inc., May 2016.

64% lower, respectively, than what would result using ONE Future's analysis. In fact, our assessments are supported by latest research from Stanford University.[4]

ONE Future believes that operators should be given the freedom to select the sites and frequency of inspection based upon their knowledge of the operations and the propensity for particular components to develop significant fugitive emissions leaks. Standard operating practices coupled with LDAR findings can be employed to develop Directed Inspection & Maintenance (DI&M) programs that target high emitting facilities and components. These, along with advancements in methane monitoring technologies and data analysis, can eventually be employed to develop predictive monitoring tools to improve operational efficiency and lower methane emissions. Therefore, ONE Future recommends flexibility to add new leak detection technologies that are demonstrated to be technically effective and cost efficient. Additional information supporting ONE Future's recommendations is provided below.

ONE Future also recommends development of performance-based standards as an *alternate* to the current proposed technology-based standards. When companies are allowed to set a goal and develop the most efficient and cost-effective method to achieving that goal, the overall impact will be greater than if companies are forced to subscribe to a prescriptive, command and control approach. We believe strongly that the flexible, performance-based approach will accomplish deeper emission reductions more quickly, and at a lower cost, than a one-size-fits-all mandatory program.

We hope that the PADEP considers these comments in finalizing the LDAR requirements under GP-5A. We appreciate the opportunity to provide comments on behalf of the ONE Future Coalition. If you have any questions, please do not hesitate to contact me at 832-397-8501.

Sincerely,

Richard Hyde

Richard Hyde

Executive Director
ONE Future Coalition Inc.

cc: Krishnan Ramamurthy, Acting Director, Bureau of Air Quality

[4] Ravikumar, A. and A.R. Brandt. Designing better methane mitigation policies: the challenge of distributed small sources in the natural gas. Environmental Research Letters, 2017. https://doi.org/10.1088/1748-9326/aa6791

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RECOMMENDATION 1: GOOD MAINTENANCE PRACTICES ARE THE KEY TO LOW METHANE EMISSIONS

There has been significant confusion and focus on the role of LDAR programs and assumptions by some that *all* methane *fugitive* emissions are *stochastic* in nature and would continue forever without a high-frequency LDAR program prescribed by regulations.

There is growing consensus that the majority of the emissions at oil and gas sites are from a small fraction of the emission sources or events. However, there is limited literature that characterizes these *high emitting*[5] events or sources. Typically because they are infrequent events and they are generally addressed immediately upon discovery as discussed further below. This small fraction of "high emitting" events are also seldom associated with fugitive component leaks which is the focus of the high-frequency LDAR programs. Ultimately, more frequent LDAR becomes less effective at reducing or eliminating the highest emitting events.

[5] Please refer to Recommendation 2 on specific high emitting rates used in scientific literature.

As an alternative, a robust operations and maintenance program that has been implemented by a company results in more effective methane management that focuses on “product delivery efficiency” (i.e., minimizing the loss of our product-oil or natural gas) and safety while also minimizing or eliminating the highest emitting methane events or sources. This is further explained in the following bullets.

- In general, production facilities are visited by field personnel at least once a week and we believe leaks are also identified during these visits, if not earlier.
- For the compressor stations and other facilities downstream from the production sites, they have operations personnel onsite full-time and are inspected multiple times a day. For the facilities that do not have operations personnel onsite full-time, these typically are visited and inspected on a regular basis consistent with a company’s operations and maintenance (O&M) procedures or a similar set of operations management procedures.
- All manned and unmanned compressor stations are also monitored continuously by the company’s gas control center. Any unusual operational issues or malfunctions discovered at the time of a facility inspection or discovered by the monitoring being performed by Gas Control are addressed immediately. This would be done either through an operational adjustment, a repair of the affected equipment or safely shutting down and isolating the equipment of concern until it is determined what is causing the issue so it can be addressed appropriately before operating again.
- Audible, Visual, and Olfactory (AVO) surveys are conducted by field personnel (e.g. pumpers) when they visit each location to check the operational status of the facilities (e.g. daily/weekly checks) and are incorporated into standard operating and maintenance practices. The AVO surveys allow the operator to identify the presence of leaks from components (e.g. valves and connectors) and equipment (e.g. stuck dump valves) based on sound, sight and odor. Although AVO surveys are an efficient and effective means of identifying and fixing leaks, the AVO surveys only identify the presence of a leak and provide no quantification of the leak.
- Reviewing operating conditions and electronic records for indications of abnormal or out of range pressure, temperature or flow conditions. Facilities may have control systems in place (Iconics or Scada) that provide an indication of improper operations prompting further review by an operator. For example, a stuck dump valve that causes the pressure to drop in a sales line would trigger an alarm or alert. These types of activities provide ongoing monitoring of process conditions indicative of equipment leaks, particularly significant leak events.

Typically high emitting events at production sites or compressor stations may potentially include

1. Manual episodic venting;
2. Failure of a pressure safety valve;
3. Failure of a stuck dump value;
4. Rupture of a flow-line;
5. High emitting events at condensate or petroleum liquid tanks attributable to design considerations with vapor recovery system and/or operating practices;
6. Scheduled station blowdowns;
7. Emergency shutdowns of stations;
8. Failure of station block valves or isolation valves; or
9. Leakage through unit isolation valves or unit blowdown valves.

The high volume emissions from such events are either known episodic events (e.g. manual unloadings) or may be large enough to cause production or throughput volumes to decrease significantly which would activate triggers and alarms for Operations personnel to immediately address the abnormal operating issue at the site. Therefore, it is very unlikely that such large events would "continue leaking large volumes" of methane emissions without being detected immediately or within the course of the onsite inspection or remote monitoring being done by a company's Gas Control center.

ONE Future believes these routine operating and maintenance practices are effective in identifying significant methane emission events and should be relied on as the foundation to reducing methane emissions with LDAR serving as an *audit tool* or secondary mechanism as noted in Recommendation 2.

RECOMMENDATION 2: THE FREQUENCY OF LDAR MONITORING SHOULD BE ANNUAL WITH THE REQUIREMENT FOR SEMI-ANNUAL MONITORING BASED ON PROGRAM EFFECTIVENESS

The proposed GP-5A regulations requirements under Section A.2.K, require monthly AVO and quarterly LDAR using "an OGI camera, a gas leak detector that meets the requirements of 40 CFR Part 60, Appendix A-7, Method 21, or other leak detection methods approved by the Division of Source Testing and Monitoring." The owner or operator can reduce the frequency of LDAR from quarterly to semi-annual "if the percentage of leaking components is less than 2.0% for two consecutive quarterly LDAR inspections." PADEP in the Technical Support Document (TSD) accompanying the rulemaking, employs the higher detection level of the HiFlow device (8 cubic feet per minute (cfm) or 11,520 cubic feet per day (cfd) or 9.2 kg/hr of methane) to define the term "super-emitters", and employs the fractions stated in a few peer-reviewed scientific papers and interviews with vendors to justify the cost-effectiveness of LDAR in the proposed rule.

ONE Future supports an initial LDAR survey and we recommend the PADEP consider annual LDAR, with the potential for moving towards semi-annual monitoring based on program-effectiveness coupled with monthly AVO based on our comments below.

Scientific Assessment

Many field studies have found that emissions are not homogeneous throughout a population, but that there is a skewed distribution of emissions. The small segment of any population that accounts for the majority of emissions are sometimes called "super-emitters"[6]. The term super-emitters is quite confusing and may have been misapplied by some to provide an indication that **all** "supermitters" are stochastic in nature and because of their unpredictability and their outsized contribution to the total emissions, rigorous LDAR is needed. We use the term "high-emitting" facilities or components in the rest of these comments in lieu of "super-emitters". The facts and recent peer-reviewed science by respected universities and experiences of operators provide insights that must be considered by PADEP in this rulemaking.

[6] Brandt A R et al 2014, Methane leaks from North American natural gas systems Science 343 733–5. Brandt et al.

The concept of "high-emitting" components or facilities is not new. In fact, the 1996 EPA-GRI report[7] states the following:

> *"Although components with large leaks typically account for only a small fraction of the total components at a facility (often 2% or less), their emissions can contribute over 90% to the total emissions from the facility."*

More recent science from Brandt et al (2016) [8] reviewed about 15,000 measurements from 18 prior studies and concluded that methane leaks from natural gas systems follow a "statistically heavy-tailed" distribution and the "largest 5% of leaks typically contribute over 50% of the total leakage volume". Another recent study by Zavala-Araiza et al (2017)[9] attempted to apply a numerical value to high-emitting facilities and defined a rate above 26 kg of methane per hour (kg/hr) as "higher-emitting sites". Zimmerle et al. [10] collected measurements from 677 facilities and classified two facilities as "super-emitters" with emissions "greater than 200 standard cubic feet per minute (scfm)" or about 230 kg/hr. This indicates significant caution needs to be applied to using the term "super-emitters" or "high-emitting site" and use of a numerical value must be sector-specific even within the natural gas industry. Either way, both the Zavala-Araiza and Zimmerle numerical values are significantly higher than the values employed by PADEP. In the same study that PADEP cites in justifying the LDAR cost effectiveness, Brandt et al. (2016) warns that "cross-study" aggregation of datasets and subsequent analysis is not recommended. In other words, employing the HiFlow higher detection rates and the fraction of "super-emitters" from other studies to arrive at "baseline" annual emissions as noted in Table 27 in the TSD, may not be sound.

Many regulations and scientific papers have estimated baseline emissions or have created statistical models that have over-estimated the frequency of occurrence of these sources or have included previously unassigned emission sources regardless whether they are episodic or vented/uncombusted methane emissions, and in most cases have assumed the leaks/emissions continue throughout the year. In reality, no study has fully characterized these high-emitting sites and cause of the high emissions[11]. It has been ONE Future member experiences that "high-emitting" sites may fall into the following categories:

1: **Episodic emission events:** These are known events that have large emissions at rates that may be considered "high emitting". Examples of these events are compressor station blowdowns, liquids

[7] Hummel, K.E., L.M. Campbell, M.R. Harrison. Methane Emissions from the Natural Gas Industry, Volume 8: Equipment Leaks, Final Report, GRI-94/0257.24 and EPA-600/R-96-080g. Gas Research Institute and U.S. Environmental Protection Agency, June 1996

[8] Brandt A.R. et al. 2016, Methane leaks from natural gas systems follow extreme distributions, DOI: 10.1021/acs.est.6b04303, *Environ. Sci. Technol*

[9] Zavala-Araiza et al., 2017, Super-emitters in natural gas infrastructure are caused by abnormal process conditions, Nature Communications, | 8:14012 | DOI: 10.1038/ncomms14012 |

[10] Zimmerle et al., 2015, Methane Emissions from the Natural Gas Transmission and Storage System in the United States, Environ. Sci. Technol. 49, 9374−9383, DOI: 10.1021/acs.est.5b01669

[11] Zavala et al. (2017) employs a Monte Carlo model and employs results from prior studies (within and outside Barnett Shale) to develop component-based emissions.

unloading, and pigging operations. Engineering calculations provide a reasonable estimate of the emissions and these events are not considered “fugitive emissions”.

2: **Chronic emission sources:** These are emission sources that routinely emit at high emitting thresholds due to either facility/source design (e.g. an under-sized vapor recovery unit (VRU)) or due to the fact that these are large facilities within the sample population or large compressor stations with higher total uncombusted emissions relative to smaller facilities. Once identified and quantified, it is reasonable to develop appropriate mitigation measures related to facility design. It should be noted, like episodic events, several of these chronic emission sources may not be traditional “fugitive” emission sources such as uncombusted methane emissions from compressors.

3: **“Routine Fugitive” High emitting sources:** We characterize these sources as “traditional” fugitive emissions sources (e.g. valves, flanges, open-ended lines, pressure relief valves) that may malfunction as part of routine operations and are stochastic in nature.

As noted earlier, most studies and regulations have not attempted to discern classification of these higher emitting sources.

Zavala et al. (2017) in estimating component-based emissions, concluded that condensate/oil tank flashing and liquids unloadings are the two events that have potential for high methane emissions greater than 26 kg/hr. In fact, equipment leaks contributed to 13% of the total emissions and had a central estimate of 0.15 kg/hr per site with a maximum emission rate of 9 kg/hr/site below the 9.2 kg/hr “super-emitter” threshold employed in the TSD. Both the Brandt et al. (2016) and Rella et al. (2015) studies used in Table 27 in the TSD do not further evaluate the “super-emitter” fractions. While Brandt et al (2016) was a meta-analysis of prior measurements, studies such as Rella et al. measured methane emissions from “nearly 200 wells” from “public roads” and concluded that the highest 6.6% of the well-pads contributed to 50% of the total emissions within the distribution. However, without site-access and data, these studies do not ascertain the cause of the methane emissions – i.e. whether the “high emitting” sites were episodic, chronic or routine. There seems to be an implicit assumption in these studies that all such emissions are indeed “routine fugitive” emissions and therefore are unpredictable. In reality, all episodic events are known and uncombusted methane emissions are well quantified in emissions inventories. Therefore, without further characterization of these events, employing the percent of super-emitters (P_{SE}) or percent of total emissions (P_E) in determining the cost-effectiveness of the LDAR program in Table 27 is not recommended.

Some proponents of frequent LDAR have recommended frequent monitoring of emissions due to the “unpredictable nature of when and where a super-emitter will be located.” But examining the key data that goes into these conclusions finds that the measurements were not made onsite and the studies lack onsite details of whether the “high emitting” observations were episodic versus chronic (design versus uncombusted) versus routine fugitive emissions. Further use of differing statistical tools on the same dataset can result in about 80% difference in results and this illustrates the limitations of use of statistical tools and offsite data collection to characterize emissions at a site[12]. In a very recent paper[13], NOAA scientists highlighted the outsized influence of episodic events like manual liquids unloading emissions and the role of "mid-day peak emissions" in "top-down" estimates, and avoided statistical models to explain average emission rates and "fat-tails". Schwietzke et al. (2017) measurements were done as part of a set of comprehensive studies to improve the understanding of "top-down vs. bottom-up" estimation method using temporal and spatially resolved methods.

Practically, it is incorrect to assume that leaks continue throughout the year nor is it appropriate to consider all "high emitting" or super-emitter sources are "fugitive" emissions that warrant quarterly LDAR. Typically, large leaks- or high emitting facilities are identified within hours of occurrence (due to various warning systems and shut-down devices associated with natural gas flows) or at the latest within a week (when the field operator/pumper checks the well).

A recent publication[14] examined emissions reductions as a function of imaging distance and survey frequency. Reductions can vary from 7% (imaging annually at 100 m) to as high as 70% (imaging quarterly at 5 m) and are a function of key variables including viewing distance, wind speed and temperature (See Figure 1).

The incremental benefit of going from annual to semi-annual LDAR inspections at certain emission sources (e.g. thief hatches on tanks) that are inaccessible may be marginal. For example, Figure 1 shows that at a viewing distance of about 30 meters, the emission mitigation potential of annual surveys is about 20% and increases by 7% for semi-annual surveys. These results are consistent with a study by Carbon Limits[15] that concluded increasing the frequency of LDAR will have a positive impact on the emission reductions that can be achieved, but fewer leaks will be detected per survey and the program costs will increase. When conducting cost analysis, it is important to conduct an incremental cost-benefit analysis

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[12] Lyon DR, et al. (2015) Constructing a spatially resolved methane emission inventory for the Barnett Shale region. Environ Sci Technol 49(13):8147–8157. The emission factor derived in the 2015 (Zavala et al.) study for a production site was 1.76 kg/hr (rounded up to 1.8 kg/hr) versus Lyon's 1.0 kg/hr). Both studies use the same dataset for the same region but arrive at different results due to the statistical methods employed. Zavalla et al. (2017) developed a "component-based" inventory estimate of the key emission sources at oil and gas production sites in the Barnett Shale play (17,400 sites, 25,700 wells) using a Monte Carlo model and compared it to the "site-based" estimates derived using the statistical method developed in Zavala et al. 2015. The component-based inventory CH_4 estimate is 1.2 kg/hr (1.1-1.3 kg/hr) per site versus the 2015 study which was estimated at 1.8 kg/hr (1.3-2.5 kg/hr). Therefore the author's claim the 52% difference between the two is due to the existence of "super emitters" and "frequent or better yet continuous site-level monitoring of emissions or process conditions would reduce the duration of super-emitting behavior." However, if the results from Lyon et al. (2015) were employed as the site-based inventory, the fundamental conclusion would be that the component-based inventory (1.2 kg/hr) would be less and therefore the "gap" between the two are not due to "super-emitters" (high, unintended emissions) that are "characterized by stochastic, spatio-temporally dynamic [behavior]". This also highlights the limitations on use of novel statistical tools to arrive at site-level emissions.

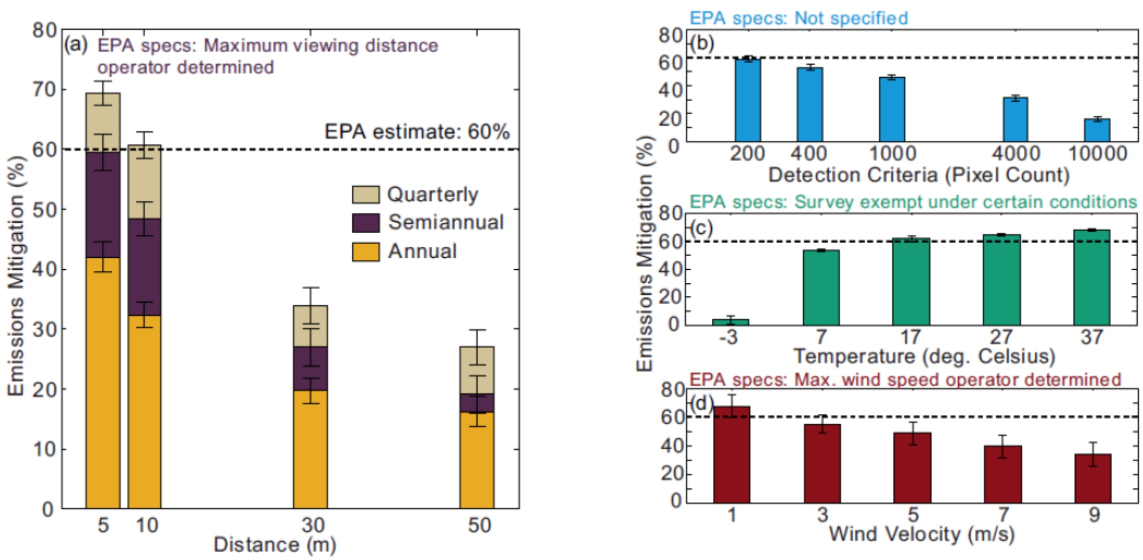
[13] Schwietzke, S.; G. Petron; S.A. Conley; C. Pickering; I. Mielke-Maday; E.J. Dlugokencky; P.P. Tans; T. Vaughn; C.S. Bell; D. Zimmerle; S. Wolter; C. King; A.B. White; T. Coleman; L. Bianco; and R. Schnell, Improved mechanistic understanding of natural gas methane emissions from spatially-resolved aircraft measurements, May 2017, *Environ. Sci. Technol,* **DOI:** 10.1021/acs.est.7b01810

[14] Ravikumar, A. and A.R. Brandt. Designing better methane mitigation policies: the challenge of distributed small sources in the natural gas. Environmental Research Letters, 2017. https://doi.org/10.1088/1748-9326/aa6791

[15] Carbon Limits, "Quantifying Cost-effectiveness of Systematic Leak Detection and Repair Programs Using Infrared Cameras", CL-13-27, March 2014.

to assess various reduction options. While not linear, we expect semi-annual monitoring to be significantly more expensive than annual monitoring.

Figure 1: Performance Parameters impacting OGI-based leak detection (Ravikumar et al. (2017))



Define components consistent with the GHGRP Subpart W

Methane leaks have often been employed in scientific literature and other materials to encompass *all* emissions at oil and gas facilities[16,17]. The 1996 GRI/EPA report[18] defined equipment leaks as "typically low-level, unintentional losses of process fluid (gas or liquid) from the sealed surfaces of above-ground process equipment. Equipment components that tend to leak include valves, flanges and other connectors, pump seals, compressor seals, pressure relief valves, open-ended lines, and sampling connections. These components represent mechanical joints, seals, and rotating surfaces, which in time tend to wear and develop leaks."

EPA's greenhouse gas reporting program (GHGRP)[19] Subpart W defines equipment leaks as valves, connectors, open ended lines, pressure relief valves, pumps, flanges, and other components (such as instruments, loading arms, stuffing boxes, compressor seals, dump lever arms, and breather caps, but does not include components associated with reciprocating compressor venting or centrifugal compressor

[16] Brandt A.R. et al. 2016, Methane leaks from natural gas systems follow extreme distributions, DOI: 10.1021/acs.est.6b04303, *Environ. Sci. Technol*

[17] http://powersource.post-gazette.com/powersource/policy-powersource/2016/02/16/Environmental-regulators-tackle-methane-leaks-at-oil-and-gas-well-sites-Pennsylvania/stories/201602120218

[18] Hummel, K.E., L.M. Campbell, M.R. Harrison. Methane Emissions from the Natural Gas Industry, Volume 8: Equipment Leaks, Final Report, GRI-94/0257.24 and EPA-600/R-96-080g. Gas Research Institute and U.S. Environmental Protection Agency, June 1996.

[19] Code of Federal Regulations, Title 40 EPA, Part 98 Mandatory Greenhouse Gas Reporting.

venting and have discrete emission component leaker factors for valves, connectors, flanges, open ended lines, pressure relief valves, meters, and other.

The final NSPS OOOOa rule[20] defines "*Fugitive emissions component* means any component that has the potential to emit fugitive emissions of methane or VOC at a well site or compressor station, including but not limited to valves, connectors, pressure relief devices, open-ended lines, flanges, covers and closed vent systems not subject to § 60.5411a, thief hatches or other openings on a controlled storage vessel not subject to § 60.5395a, compressors, instruments, and meters. Devices that vent as part of normal operations, such as natural gas-driven pneumatic controllers or natural gas-driven pumps, are not fugitive emissions components, insofar as the natural gas discharged from the device's vent is not considered a fugitive emission. Emissions originating from other than the vent, such as the thief hatch on a controlled storage vessel, would be considered fugitive emissions."

The proposed GP 5A includes standards for a variety of emission sources and events. The proposed GP 5A, Section K covers "Fugitive Emissions Component" which is defined as "any component that has the potential to emit fugitive emissions of methane, VOC, or HAP at an unconventional natural gas well site or remote pigging station including, but not limited to, valves, connectors, pressure relief devices, open-ended lines, flanges, compressors, instruments, meters, covers, and closed vent systems." The proposed GP 5A therefore covers significantly more components than the GHGRP and therefore it mandates a record of all components that meet the definition under the proposed rule which is quite different from what is required under the GHGRP. This mis-match of the GP 5A proposed regulations with the GHGRP will result in significant compliance confusion and potentially reporting of two separate values from the same source. We recommend aligning GP 5A with the GHGRP where operators can estimate the component counts using GHGRP component counts for major equipment types. Once EPA completes its reconsideration of the NSPS OOOOa, PADEP will have the opportunity to update or revise the definitions.

GHGRP and ONE Future Company Data

The skewed distribution of fugitive emissions emphasizes that one-size-fits-all LDAR is not appropriate. Most regulatory LDAR requirements, which specify a fixed frequency and specific, limited detection methods, apply one-size-fits-all requirements that do not target the skewed emissions distribution. For example, data from EPA's mandatory greenhouse gas reporting program (GHGRP) show that up to 65% of compressors surveyed have no emissions, yet Subpart W requires that all compressors in the processing, transmission, storage, and LNG segments are surveyed annually. This illustrates the inefficient allocation of capital and resources and unnecessary regulatory burden on operators.

Based on the PADEP's independent analysis, quarterly LDAR is determined to be technically and economically feasible for the control of methane emissions if over 2% of components are found to be

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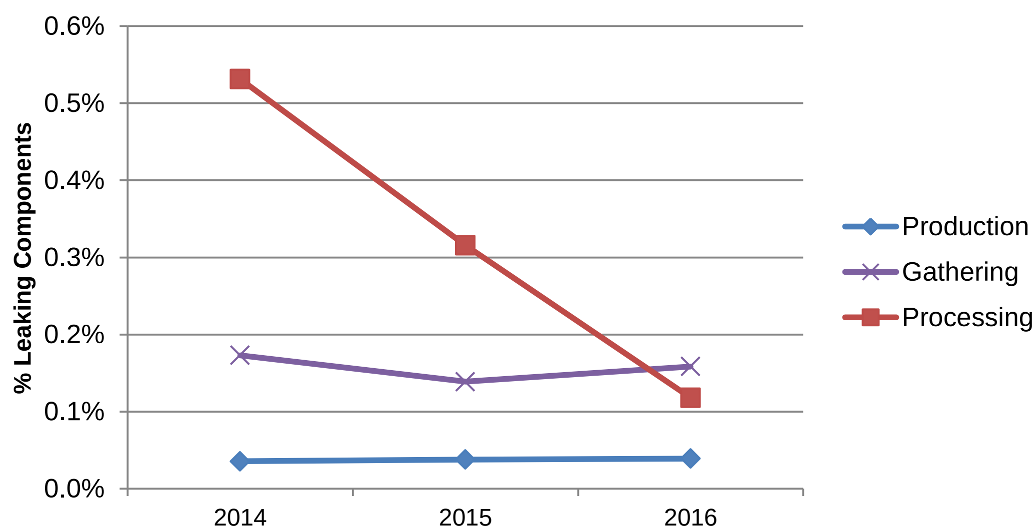
[20] Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources; Final Rule, June 3, 2016. On June 5, 2017, the EPA issued a notice of reconsideration and partial stay of the fugitive emission requirements of the rule for 3 months pending reconsideration; FR Vol. 82, No. 106, pp 25730-25734.

leaking. The proposed General Operating Permit for Unconventional Natural Gas Well Site Operations (GP-5A) includes requirements to perform monthly audio, visual and olfactory inspections and quarterly leak detection and repair (LDAR) inspections. LDAR inspections can be performed using an optical gas imaging camera, a Method 21 gas analyzer or other approved methods. For LDAR programs at unconventional natural gas well sites and remote pigging stations, there is an option to track the number of leaking components and reduce the inspection frequency to the federally required semiannual increment if less than 2% of components are found to be leaking in two consecutive inspections. If 2% or more of components are found to be leaking at the reduced frequency, the LDAR returns to the quarterly schedule until annual leaks are again below 2%.

Based on ONE Future data, the fraction of leaking components is significantly lower than what PADEP assumed in the cost analysis and in determining the LDAR monitoring frequency. Several ONE Future participant companies conduct LDAR programs and track the total number of components surveyed. This information enables calculating the percentage of components surveyed that are found leaking. Figure 2 shows the percentage of leaking components in production, gathering, and processing operations to be extremely small (less than 0.55%). There is a significant decrease in the percentage of components found to be leaking each subsequent year for processing operations, while there is essentially no change in the number of components leaking over the three year period for production and gathering operations.

Figure 2. Percentage of Leaking Components Over Time (ONE Future Data)



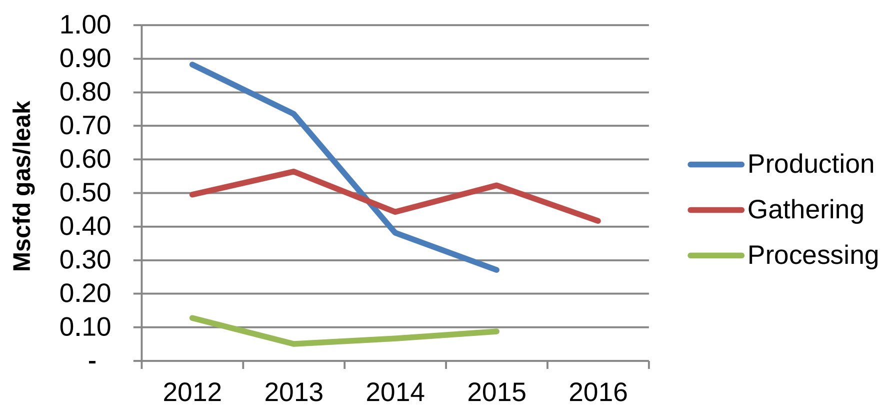
Another study, which surveyed and quantified thousands of leaks at production sites using both Method 21 and optical gas imaging (OGI)[21] showed that only 0.175% of components were found leaking using

[21] ERG and Sage Environmental Consulting, LP. City of Fort Worth Natural Gas Air Quality Study, Final Report. Prepared for the City of Fort Worth, Texas. July 13, 2011. http://fortworthtexas.gov/gaswells/default.aspx?id=87074

OGI, while 1.07% were found leaking with Method 21 (the additional leaks found by Method 21 are all much smaller than the leaks detected by OGI). PADEP needs to reconsider the cost effectiveness of the proposed rule for a more realistic and lower percentage of leaking components.

ONE Future data also shows that the size of the leaks found decreases over time, as shown in Figure 3.

Figure 3. Volume of Gas Released from Leaking Components (ONE Future Data)



Based on the scientific evidence and ONE Future operator experience, the initial requirement for quarterly frequency is not warranted. Recent studies have shown limited benefit in moving from annual to semi-annual and semi-annual to quarterly LDAR. Further, studies and policy recommendations that have pushed for quarterly LDAR based on unpredictable/stochastic nature of "super-emitters" fail to recognize that their observations (which are mostly outside the facility fence line and employ indirect measurement techniques) do not delineate the emissions between episodic known events, chronic (design or uncombusted methane emissions) or "real fugitive" emissions. The reliance of certain studies in Table 27 of the TSD to justify the cost-effectiveness of quarterly LDAR, without further classification of these high emitting facilities, warrants a revision to the LDAR cost-effectiveness analysis.

Data from the ONE Future members' annual leak surveys, as shown in Figures 2 and 3, demonstrate that the leak frequency is already well below 2%, and the volume of gas per leak is small and generally decreases over time. In addition, the complex process for determining the percentage of leaking components introduces a burdensome paperwork exercise with no emissions reduction benefit. Based on data from the ONE Future members and the recent Stanford study, we recommend monthly AVOs and annual inspection LDAR and moving toward a semi-annual basis if and only if the leaking components are over 2% of the estimated components[22], where component counts can be estimated using EPA Subpart

[22] It is not clear if the PADEP's cost analysis included costs to develop a component count for all affected facilities. The costs for as built component counts are not trivial. ONE Future recommends estimating the component counts using EPA component counts per major equipment type, as specified in Subpart W.

W component counts for major equipment types. This is also supported PADEP's permitting and regulatory actions under 25 Pa. Code §127.512, which states:

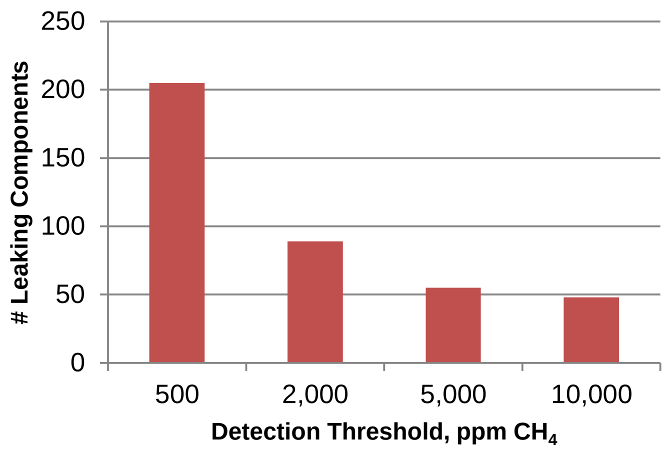
> *"Within 180 days after the start-up of the Source ID 036 turbine , and annually thereafter, the permittee shall develop and perform a leak detection and repair (LDAR) program and related inspection that include the use of an optical gas imaging camera such as a forward looking infrared (FLIR) camera or a gas leak detector capable of reading methane concentrations in air of 0% to 5% with an accuracy of ± 0.2%."*

RECOMMENDATION 3: GP5A SHOULD BE FINALIZED TO ENSURE ADOPTION OF NEW LEAK DETECTION PROGRAMS AND PADEP SHOULD WORK WITH OPERATORS TO INVESTIGATE AND DEVELOP NOVEL LDAR PROGRAMS

In recent years methane leak detection technology has been evolving quickly because of the national focus on reducing these emissions. These new or improved technologies may soon make possible less costly, more efficient LDAR programs that achieve equal or greater methane emission reductions. Therefore states should retain flexibility in any regulations that are passed to accommodate these new (or even existing) technologies and programs. In detection technologies, there has been governmental investment in research and development and also private sector independent developments. Governmental investments include the Department of Energy's ARPA-E MONITOR program. Private sector development includes individual technology offerings from detection companies, as well as efforts like the Environmental Defense Fund's Methane Detectors Challenge. The changes have been rapid enough that the Interstate Technology & Regulatory Council (ITRC), of which the Commonwealth of Pennsylvania is a participant, recognized the need for better understanding and flexibility on methane detection. The ITRC has commissioned a Methane committee titled "Evaluation of Innovative Methane Detection Technologies". The committee is charged to compose a document that outlines the current detection technologies, and also establishes guidance on how to evaluate newly developed technologies. A report is due in late 2017. Pennsylvania's representative on this committee is Lisa Dorman. We believe that ITRC's efforts, including Pennsylvania's participation in this effort, show the need to remain flexible to future regulatory approaches.

An example where an existing commercial technology that can be incorporated into the LDAR program involves the Heath Remote Methane Leak Detector (RMLD). A ONE Future partner has used the RMLD which has enabled them to identify smaller leaks than are detected using OGI. This is illustrated in Figure 4, which shows the change in the number of leaks detected for different CH_4 detection limits.

Figure 4. Leaks Detected Relative to Detection Limit



The importance of flexibility and potential promise of emerging techniques is highlighted by Ravikumar et al. (2017):

> *"Policies should acknowledge future availability of newer and potentially cheaper technologies for leak detection and design regulations that allow for technological flexibility."*

The ARPA-E MONITOR program may hold promise for new continuous methane emissions detection technologies and provided it is cost-effective, we encourage PADEP policies to be flexible to enable regulated entities to test and if possible adopt these novel technologies in lieu of the proposed technologies.

Kemp et al.[23] from Stanford employed the FEAST model to simulate four LDAR "programs[24]" over a 10 year period and assessed the Net Present Value (NPV) of these programs. The authors found that aerial infra-red detection programs (with their assumptions) provided the most positive NPV. The authors in this paper illustrate the difference between "low-cost LDAR technologies ("cheap detectors") and low-cost LDAR programs ("cheap detection")" and appear to advocate that "low-cost leak detection programs can rely on high-cost technology, as long as it is applied in a way that allows for rapid detection of large leaks". ONE Future is aware of several commercial and scientific vendors of these technologies and recommends the PADEP work with oil and gas operators, to devise a low cost, rapid LDAR detection program employing emerging and novel technologies and techniques. Such programs, if designed carefully with private-government partnership, can mutually benefit all stakeholders without adding undue burdens and costs to operators. Further, such potential advanced programs can provide the "blue

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[23] Comparing Natural Gas Leakage Detection Technologies Using an Open-Source "Virtual Gas Field" Simulator, Chandler E. Kemp, Arvind P. Ravikumar, and Adam R. Brandt, DOI: 10.1021/acs.est.5b06068, Environ. Sci. Technol. 2016, 50, 4546−4553, March 2016

[24] Method 21/Flame Ionization Detectors, distributed network of methane sensors, Optical Gas Imaging techniques and Infra-red equipped aircrafts. See Kemp et al. for further details.

print" in LDAR and Directed Inspection and Maintenance (DI&M) that can be exported to other states and countries.

RECOMMENDATION 4: GP5A SHOULD ALSO PROVIDE FOR ALTERNATIVE COMPLIANCE DEMONSTRATION THROUGH PERFORMANCE-BASED PROGRAMS SUCH AS ONE FUTURE METHANE EMISSION INTENSITY FRAMEWORK

The draft GP5A proposal aims at regulating certain key emission sources at oil and gas facilities employing traditional technology-based standards. ONE Future's flexible, performance-based system focuses on identifying the most cost-efficient and cost-effective abatement opportunities first, in order to yield the greatest emission reductions in the shortest amount of time and at the lowest cost. A natural corollary to this is to eschew wasteful expenditures of capital and manpower whenever possible.

As noted earlier, numerous peer-reviewed methane measurement studies[25,26,27,28 29,30,31] have consistently demonstrated that a majority of the emissions within a set population of facilities or emission components originate from a small minority of the potential emissions sources within that population. Similarly, a set of facilities will exhibit a heavy-tailed skewed distribution of emission sources, in every segment of the natural gas value chain, which creates an opportunity to focus on the highest emitting sources in order to capture maximum emissions reductions at lowest cost. In addition there is significant regional variation in methane emissions[32,33,34,35.] However, the proposed GP 5A regulations have followed the typical "technology-based regulatory framework". Because the science clearly shows that a majority of the

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[25] Frankenberg, C.; Thorpe, A. K.; Thompson, D. R.; Hulley, G.; Kort, E. A.; Vance, N.; Borchardt, J.; Krings, T.; Gerilowski, K.; Sweeney, C.; et al. Airborne methane remote measurements reveal heavy-tail flux distribution in Four Corners region. *Proc. Natl. Acad. Sci. U. S. A.* **2016,** *113* (35), 9734-9739; DOI 10.1073/pnas.1605617113.
[26] Brandt AR, et al. (2014) Methane leaks from North American natural gas systems. Science 343(6172):733–735.
[27]Zavala-Araiza D, et al. (2015) Reconciling divergent estimates of oil and gas methane emissions. Proc Natl Acad Sci USA 112(51):15597–15602.
[28] Allen, D. T., V. M. Torres, J. Thomas, D. W. Sullivan, M. Harrison, A. Hendler, S. C. Herndon, C. E. Kolb, M. P. Fraser, A. D. Hill, B. K. Lamb, J. Miskimins, R. F.Sawyer, and J. H. Seinfeld. 2013. "Measurements of Methane Emissions at Natural Gas Production Sites in the United States." *Proceedings of the National Academy of Sciences* 110 (44):17768–17773. doi: 10.1073/pnas.1304880110.
[29] Mitchell, A.L.; Tkacik, D.S.; Roscioli, J.R.; Herndon, S.C.; Yacovitch, T.I.; Martinez, D.M.; Vaughn, T.L.; Williams, L.L.; Sullivan, M.R.; Floerchinger, C.; Omara, M.; Subramanian, R.; Zimmerle, D.; Marchese, A.J.;Robinson, A.L. Measurements of Methane Emissions from Natural Gas Gathering Facilities and Processing Plants: Measurement Results. *Environ. Sci. Technol*. **49**, 3219-3237
[30] Zimmerle, D.J.; Williams, L.L.; Vaughn, T.L.; Quinn, C.; Subramanian, R.; Duggan, G.P.; Willson, B.; Opsomer, J.D.; Marchese, A.J.; Martinez, D.M.; Robinson, A.L.; Methane Emissions from the Natural Gas Transmission and Storage System in the United States. *Environ. Sci. Technol*. **49**, 9374
[31] Lamb, B. K. et al. Direct measurements show decreasing methane emissions from natural gas local distribution systems in the United States. Environ. Sci. Technol. 49, 5161–5169 (2015).
[32] Peischl J et al 2016 Quantifying atmospheric methane emissions from oil and natural gas production in the Bakken shale region of North Dakota J. Geophys. Res. Atmos. 121 6101–11
[33] Allen, D. T. et al. Methane emissions from process equipment at natural gas production sites in the United States: pneumatic controllers. Environ. Sci. Technol. 49, 633–640 (2015).
[34] Allen, D. T. et al. Methane emissions from process equipment at natural gas production sites in the United States: liquid unloadings. Environ. Sci. Technol.49, 641–648 (2015).
[35] Marchese A J et al 2015 Methane emissions from United States natural gas gathering and processing Environ. Sci. Technol. 49 10718–27

emissions are from a minority of facilities (or, emissions points), ONE Future believes that methane reduction policies should be based on a performance-based model framework. And this fact is now reinforced by scientists in peer reviewed literature. In a very recent paper[36], scientists from Stanford University convey:

> "**Combining empirical evidence with model result**s, we propose four policy options for effective methane mitigation: **performance oriented targets** for accelerated emission reductions, **flexible policy mechanisms to account for regional variation**, **technology-agnostic** regulations to encourage adoption of the most cost effective measures, and **coordination with other greenhouse gas mitigation policies** to reduce unintended spillover effects"

ONE Future does not take a position on the merits of regulating existing oil and gas facilities under GP 5A, but we believe strongly that the flexible, performance-based approach we have proposed will accomplish deeper emission reductions among participants more quickly, and at a lower cost, than a one-size-fits-all mandatory program. The ONE Future's flexible and performance-based approach to the management of methane emissions is an approved option[37] under the EPA's Methane Challenge program. We believe that orienting our activities toward this specific and measurable outcome ensures a sustained focus on identifying the opportunities for emissions abatement that yield the greatest benefit for the least cost. It grants individual companies the flexibility to choose precisely how they can most cost-effectively and efficiently achieve their goal – whether that be by deploying an innovative technology, modifying a work practice, or in some cases, replacing a high-emitting asset with a low-emitting asset. The EPA has worked to develop a rigorous and transparent emissions accounting protocol that defines the supplemental technical information that is required by ONE Future Methane Challenge participants. Therefore, we strongly encourage that PADEP consider performance-based compliance alternatives in managing methane emissions along with appropriate monitoring, recordkeeping and reporting requirements. We look forward to further discussions on specific recommendations

[36] Ravikumar, A.P. and A. Brandt, Designing better methane mitigation policies: the challenge of distributed small sources in the natural gas sector, April 19, 2017, https://doi.org/10.1088/1748-9326/aa6791
[37] https://www.epa.gov/natural-gas-star-program/natural-gas-star-methane-challenge-program