Methane Fugitive Emissions and Flaring in Oil and Gas Operations
A proposed POPA study and statement

W. D. Collins, M. P. Marder, and R. L. Orbach

Preamble

A recent poll of the American Physical Society membership finds that the foremost priority of concern is global warming, replacing science funding. This imperative suggests the Society should, to the extent possible, utilize its scientific strengths to address this issue. To this end, APS previously conducted its own greenhouse gas inventory (an internal-facing activity). Additionally, the Society recently submitted a public comment opposing the Administration's proposed policy amendments to curtail regulation of greenhouse gas emissions and instead urged the EPA to conduct a rigorous assessment of methane emissions from the oil and gas industry. This proposed study is a natural next step in APS's climate change efforts.

One of the egregious contributors to warming is methane ("natural gas"). It is a more potent heat-trapping gas than CO_2, although it remains in the atmosphere only about 12 years before being oxidized to produce CO_2. Most methane production arises from wells, either "dry" or "wet," the latter producing oil and its volatile compounds along with methane. Ideally, the gaseous components are carried away from the drilling site via pipelines or trucks to centers for treatment for commercial uses. In the absence of sufficient transport, the volatile gases are burned ("flared"), resulting in large amounts of direct CO_2 emission, and gaseous emissions associated with incomplete combustion. The World Bank has estimated that global natural gas flaring has increased to 145 billion cubic meters of methane in 2018. Of that total, the U.S. is estimated to have produced 9.5 billion cubic meters or about 7% the total.

The release of volatile compounds associated with oil drilling is episodic, and the above numbers are rough estimates. Self-reporting is known to severely underestimate actual emissions. There are systematic studies already under way that are measuring not only methane release, but also capable of determining the other volatile gases that may be emitted during the drilling process. A specific example is the work of Professor David Allen at the University of Texas who is establishing a more-or-less permanent observing platform in the Permian Basin in West Texas, one of the most prolific sites for oil and gas production in the world. We are proposing a series of actions based on his (or others, as they may develop) observations and reports.

Objective

Apart from a few local studies, most methane flaring sites "self-report" their amounts to regulatory authorities. These reports are notoriously under estimates, and do not include an inventory of other gases emitted into the atmosphere along with the product of methane combustion, CO_2. Flaring is episodic, usually peaking during the early production period of oil drilling and recovery. Some independent estimates can be obtained from satellites that capture light emitted from flares at night. However, there is no continuous area-wide independent measurement of the totality of flaring emissions available to the regulatory bodies nor public. In the absence of reliable information, it is difficult if not impossible to assess the full impact of flaring and the associated gaseous emissions on heat trapping and health.

The egregious release of methane is not limited to small producers (or "wild-catters"). Some large corporations will not drill until they have pipelines or other means for capturing volatiles that may be produced. But other large producers do not. Size of operation is not a useful metric for assessing methane release.

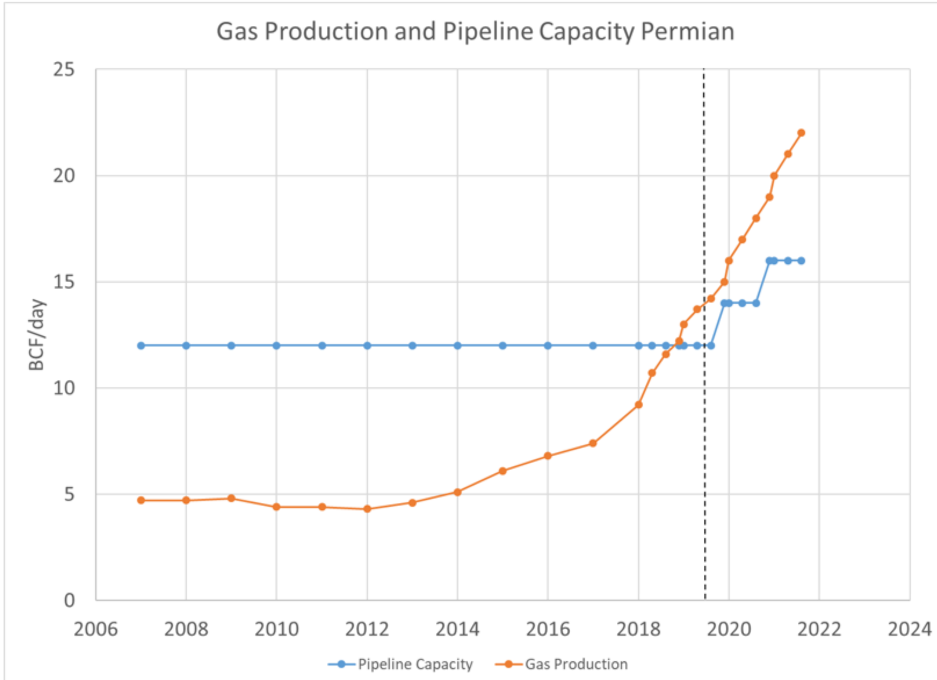
Worse, emissions for most oil and gas extraction sites are controlled by state agencies. In Texas, it is the Railroad Commission (RRC) that is responsible for setting the limits on fugitive emissions from drilling sites. It is our understanding that they already have the authority to limit methane emissions both from flaring and other sources associated with oil and gas drilling production. But it is also our understanding that they have not pursued this initiative in an aggressive manner, even with the certain knowledge of under-reporting and environmental damage caused by methane release.

It is our objective to identify the challenges and relevant technologies and policy actions that are relevant to fugitive methane production (in this case, using the Permian Basin as a test case) to inform production sites and decision making worldwide. These steps are meant to develop a firm foundation for informing the public of the dangers associated with lack of regulations and enforcement, and to develop recommendations to reduce greenhouse gases based on reliable monitoring.

Motivation and Background

Flaring of natural gas from oil and gas production wells is a wasteful use of an important energy source. The greenhouse gas CO_2 is generated with no associated productive usage. Because of incomplete combustion, methane and other gases are released into the atmosphere: CH_4, CO, CO_2, NO, NO_2, SO_2, and H_2S. These compounds, in combination with their particulate matter derivatives, can lead to "acid rain" with deleterious effects on agriculture, human health, economic loss, and pollution. Current estimates of flaring in the United States are grossly under reported. For Texas, the Railroad Commission, on the basis of self-reporting, arrived at 268.2 Million cubic feet flared daily in 2017.[1] Published reports[2] have stated that the Permian Basin alone is flaring more than 660 Million cubic feet per day, reaching one Billion cubic feet per day in the coming months. In 2017, the state of Texas produced 13.7 Billion cubic feet of natural gas per day. It is estimated that will reach 15 Billion cubic feet this year, and close to 24 Billion cubic feet by 2022. This rough doubling of output will outstrip current projections of pipeline capacity in Texas by nearly 8 Billion cubic feet per year, leading to catastrophic projections of flared gases, with all their deleterious impact.

A recent study[3] has used available data to estimate the gap between gas production and pipeline capacity in one of the more prolific reservoirs for oil and gas:



The gap is already significant, and will only get worse. Additionally, methane fugitive emissions outside flaring present a large unknown with potential large impacts.

Opportunity

There is an opportunity to assess the actual amount of flaring and methane release through measurement platforms already on the ground, or soon to be completed. This information will provide real time 27/7 data for use in this study. A specific example is the Permian Basin in Texas, and the installation and observations of Professor David Allen.[4,5]

Tentative Outline

1. Executive summary (1 page)
2. Why monitoring methane fugitive emissions and flaring from oil and gas operations is important
    1. Significance as 2nd most important anthropogenic GHG
    2. Rapidly rising atmospheric concentrations
    3. Recent demonstrations of its forcing directly from observations
    4. Recent enhancements to its forcing from inclusion of near-IR solar absorption
    5. Decadal atmospheric lifetime implies target of mitigation efforts
    6. Global emissions of methane by natural/industrial/agricultural sector
    7. Social cost of methane = 10X that of carbon dioxide
    8. Characteristics of sources:
        (a) Natural sources are highly heterogeneous
        (b) Natural sources are subject to historically unprecedented warmer conditions, leading to higher emissions
        (c) Anthropogenic sources can be highly episodic (e.g., Aliso canyon blowout)
        (d) Limited authorization to study domestic industrially sensitive and many international sources
3. Current capabilities for measuring methane emissions:
    1. Ground based fixed networks, e.g., NOAA's, UT Austin's super-site, etc
    2. Airborne platforms
    3. Satellite-based monitoring
4. Difficulties in monitoring methane from oil and gas operations:
    1. Challenges in measuring:
        1. Need to measure "everywhere, all the time" to catch intermittent, highly localized "hotspots" that contribute substantially to methane emissions
        2. Space-time scale ranges sensed by each of the current measurement technologies
        3. Gaps between those ranges and "everywhere, all the time"
        4. Differences between current measurements of concentrations and the need to measure (or infer) emissions
    2. State of the art on the ground:
        1. For CONUS, EPA's estimates of ground-level methane from their inventories of point sources underestimate true emissions by likely factor of 3.
        2. Implications of this underestimation -- equivalency in terms of CO2
5. Options for improving physics and engineering underlying our measurements:
    1. Description of some possible technical pathways
    2. Value-added proposition of these pathways -- how would these help close measurement gaps identified in section 4.3.
6. Summary of findings and recommendations for next steps and policy initiatives (2-3pages)
7. Appendices

Approach/Plans

The following components of the study would make use of existing work and attempt to answer the following questions:

1. Is it possible to have continuous reliable monitoring of a) flaring, and b) methane emissions from oil and gas extraction sites using current technology?

2. If not, are there innovations in sensing technology that can be researched and developed by the physics community that would allow continuous reliable monitoring?

3. What would the cost be to implement a continuous reliable monitoring scenario, and to make the results public?

4. What would be the recommendations to reduce greenhouse gas emissions based on reliable monitoring?

Participants

This report will be generated by a panel of experts, led by Profs. Orbach and Collins, and assisted by a first-year graduate student at UT Austin working under Prof. Orbach and Prof. DiCarlo with relevant knowledge and expertise.
Current list of confirmed members of the panel of experts:

Ray Orbach	UT Austin		Academia
Bill Collins	LBL	Radiative forcing by CH4	Nat. Lab
Dave Schimel	JPL	Airborne Sensing (Remote and boundary-layer measurements)	Nat. Lab
Sebastien Biraud	LBL	In situ and airborne characterization of methane emissions	Nat. Lab
Ian Coddington	NIST	dual-comb spectroscopy for remote sensing of CH4	Nat. Lab
Jeff Peischl	NOAA	Ground-based and airborne measurement of CH4	Nat. Lab
Anuradha (Anu) Radhkrishnan	UT Austin	Graduate Student Assistant to the project, advisor: David DiCarlo, Ray Orbach	Academia
David DiCarlo	UT Austin	In situ measurements of methane emissions in oil and	Academia

		gas operation	
Michelle Bailey	NIST	Remote sensing, optics	Nat.Lab

Deliverables

A report summarizing the findings outlined above in Approach/Plans would be produced, and made available to the APS for action (especially Item #3), and to the public.

Tentative Timeline

Months	11/20	12/20	1/21	2/21	3/21	4/21	5/21	6/21	7/21	8/21	9/21	10/21
Nominate contributors for all sections of the outline	X											
Get confirmation of participation from contributors	X	X	X									
Identify an integration team			X									
Virtual meeting Kick-off					X							
Regular meetings						X	X	X	X	X	X	X
POPA meetings				X				X				X
Meetings with industry/Gov experts							X	X	X			
Integration of the document									X	X	X	
Bibliography and fact checking										X	X	
Final Touches and launch											X	g

References

1. Railroad Commission of Texas. March 2019. "Natural Gas Production and Well Counts." https://www.rrc.state.tx.us/oil-gas/research-and-statistics/production-data/historical-production-data/natural-gas-production-and-well-counts-since-1935/

2. Davis, Carolyn. March 2019. "Permian Natural Gas Flaring Said Likely to Hit 1 Bcfd Plus Until Pipeline Cavalry Arrives." Intelligence Press, Inc. https://www.naturalgasintel.com/articles/117831-permian-natural-gas-flaring-said-likely-to-hit-1-bcfd-plus-until-pipeline-cavalry-arrives
3. P. Yeric and D. DiCarlo, "Logistical Strategies for Immediately Reducing Natural Gas Flaring in Texas," The Hildebrand Department of Petroleum and Geosystems Engineering, The University of Texas at Austin, unpublished, 2019.
4. D.T. Allen and V.M. Torres, "TCEQ 2010 Flare Study Final Report," Texas Commission on Environmental Quality, PGA No. 582-8-862-45-FY09-04, Tracking No. 2008-81, August 1, 2011; W.B. Knighton, S.C. Herndon, J.F. Franklin, E.C. Wood, J. Wormhoudt, W. Brooks, E.C. Fortner, and D.T. Allen, "Direct measurement of volatile organic compound emissions from industrial flares using real-time online techniques: Proton Transfer Reaction Mass Spectrometry and Tunable Infrared Laser Differential Absorption Spectroscopy," Industrial and Engineering Chemistry Research **51**, 12674 (2012); D.T. Allen, D. Smith, V.M. Torres, and F.C. Saldaña, "Carbon dioxide, methane and black carbon emissions from upstream oil and gas flaring in the United States," Chemical Engineering **13**, 119 (2016).
5. https://www.engr.utexas.edu/news/archive/8952-sensor-network-could-change-how-methane-emissions-are-detected