United States House of Representatives
Select Committee on the Climate Crisis

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"Cutting Methane Pollution:
Safeguarding Health, Creating Jobs, and Protecting Our Climate"

Questions for the Record

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The Honorable Kathy Castor

1. **Dr. Kleinberg, in your testimony, you mentioned that reducing harmful methane pollution is cost effective and you described the suite of new technologies that are available. Could you please elaborate on how new technologies enable cost-effective reduction of methane pollution?**

   Achieving net zero carbon dioxide emissions will require a multi-decadal, multi-trillion dollar reorganization of the ways we use energy, which will have profound economic and social consequences [IEA, 2021]. In contrast, while anthropogenic methane emissions from the oil and gas industry are responsible for a substantial part of our climate change problem, reducing that part of the greenhouse gas inventory is relatively simple and surprisingly inexpensive. In the context of the oil and gas industry, methane emission reduction consists of two distinct phases. First, emitters must be detected and quantified. Second, they must be remediated.

   (a) Detection and Quantification

   Detection of gas leaks from petroleum and natural gas systems is not trivial. Intermittent super-emitters are responsible for a large fraction of methane losses to the atmosphere [House Committee on Science, Space and Technology, 2022]. Repeated rounds of measurements and repairs will eventually reduce emissions, but persistence is required [Kemp, 2021].

   Quantification is important because emission rates from individual sources span the range from less than 30 grams per hour to more than 100 tons per hour, more than three million times larger. It is a poor use of resources to focus attention on tiny leaks when vents thousands of times larger are allowed to persist. Yet, this is the situation today [Kleinberg, 2021].

Due to technological advances in aerial surveillance, mostly pioneered by U.S. researchers and companies, overflights of oil- and gas-productive basins are effective and inexpensive ways to detect and quantify methane emitters [Kleinberg 2022a, Section 3.1.1]. As pointed out in my written testimony to the Select Committee, a survey of 45,000 Permian Basin wells, during which methane emissions were quantified and operators were identified, cost about the same as drilling and fracking a single well [Kleinberg, 2022b].

Continuous monitoring of oil and gas infrastructure combined with prompt repair dramatically reduces the amount of methane entering the atmosphere [LongPath, 2022]. While aerial surveillance, with its considerable economies of scale, is usefully employed over all oil and gas infrastructure, continuous monitoring is best suited for sites with emission-prone equipment. These include gas processing plants, refineries, biogas and biomethane production facilities, liquefied natural gas terminals, and well sites or other facilities with storage vessels. Simple wells with minimal ancillary hardware, which constitute the majority of upstream sites, are unlikely to need this service. Therefore, continuous monitoring services can be deployed selectively, where they are most likely to be useful.

(b) Remediation

The most current and authoritative estimates of the cost of remediating methane emissions are provided by the International Energy Agency [IEA, 2022a]. These estimates are more reliable for the United States than for other nations [IEA, 2022b]. According to the IEA, 13,824 kilotons (kt) of methane was lost from U.S. oil and gas operations in 2021, of which the estimated technical abatement potential is 9,648 kt, 70% of the total. The share of emissions that could be avoided at no net cost is about 2,500 kt or 18% [IEA, 2022a].

The IEA marginal abatement cost curve is shown in Figure 1. Unlike nations such as China or Russia, most abatement measures that have not already been implemented in the U.S. impose a net cost on the industry. This is consistent with the widely held belief within the U.S. oil and gas industry that “we don’t leave money on the table”. According to IEA estimates, the net cost of eliminating 9,648 kt of methane would be approximately $1.7 billion, or $176/ton of methane. This is far less than the most recent estimate of the social cost of methane, $1500/ton of methane [IWG, 2021]. It is also far smaller than the LDAR-focused regulation 40 CFR 60 OOOOa of 2016, which proposed to reduce U.S. oil and gas methane emissions from regulated segments by 2% at a cost of $1340/ton of methane [Kleinberg, 2021].

At a cost of $1.7 billion, eliminating 70% of our oil and gas methane emissions would not have a material impact on our oil and gas industry, or on energy prices. U.S. oil and gas revenue in the United States averaged $157 billion per year between 2010 and 2020 [Statista, 2021] and capital expenditures are expected to exceed $100 billion in 2022 and each of the years thereafter [AOGR, 2021].

(c) Summary

The U.S. oil and gas industry has already remediated almost all the methane emitters that reduce operating efficiency and profitability. Additional incentives or regulatory measures are required to reduce emissions further. Improved methods for finding and quantifying methane emissions sources will enable operators and service providers to find emitters more efficiently, and to prioritize repairs so that the largest emitters are fixed first. Quick detection and prioritized repairs will result in less methane entering the atmosphere.

2. How could U.S. leadership on cutting methane pollution influence other countries to adopt similar technologies and strategies?

(a) American Petroleum Engineering Practice is Considered Standard Around the World.

There are a number of reasons why American engineering practice is followed widely around the world:

- The United States is the world's leading producer of both crude oil and natural gas [EIA, 2021].
- From my personal experience of forty years in the international oil and gas industry, I have found the leading schools of petroleum engineering, educating petroleum engineers from all over the world, are largely in the United States. These include Louisiana State University, the University of Texas at Austin, Texas A&M, and the University of Tulsa, among many others.
- The professional societies which set engineering standards and disseminate technical information are mostly based in the United States. These include the Society of Petroleum Engineers, the American Association of Petroleum Geologists, and the American Petroleum Institute.

This does not imply that American practice is automatically adopted everywhere, but it is the baseline against which local practices are compared. This is particularly true in the health, safety, and environment (HSE) arena. Over the course of my career, HSE standards have been globally upgraded, largely led by U.S.- and European-based international oil companies (IOCs) such as ExxonMobil, Chevron, and Shell.

(b) The United States has been the Global Leader in the Detection and Characterization of Methane Emissions in the Oil and Gas Industry.

In 1996 the U.S. Environmental Protection Agency published the monumental fifteen volume *Methane Emissions from the Natural Gas Industry* [EPA, 1996]. These documents are the foundation of the emission factor inventories universally used to report national methane emissions to the Secretariat of the United Nations Framework Convention on Climate Change [UNFCCC, 2022].

Not every nation matches the meticulous record keeping of the United States. The reports of the Russian Federation are particularly egregious examples of the inconsistent application of the emission factor method [Kleinberg, 2022a]. The advantage of a measurement-based reporting system is that nations will not be able to report superior performance by merely changing a multiplier on a spreadsheet, as permitted by the present reporting system.

(c) The United States Continues to be the Global Leader in the Detection and Characterization of Methane Emissions in the Oil and Gas Industry.

Remarkably, in the absence of government regulation or an established market, a methane emission characterization industry has sprung up, which is dominated by U.S. technology and service providers. This is detailed in my written testimony to the Select Committee [Kleinberg, 2022b].

Diffusion of these technologies to other nations is in its early stages. Measurement campaigns aligned with American principles have already been undertaken in Canada [MacKay, 2021], Mexico [Zavala-Araiza, 2021], and China [Zhang, 2021]. Technology diffusion will accelerate if markets for the new methods are encouraged to grow. Emission reduction incentives and smart regulation encourage the dissemination of new technology, with associated start-up business formation, small business vitality, and economies of scale. As technology improves and costs decline, methane reduction methods will spread to other countries. This story is common in the petroleum industry. My own oilfield innovations have benefited from this dynamic.

The adoption of a Carbon Border Adjustment Mechanism by the European Union, if extended to fossil fuels, would also provide powerful encouragement to oil, gas, and coal exporting nations to extend and routinize the use of these technologies.

(d) Summary

There is no guarantee that other nations will follow our example should the United States adopt new technologies and strategies for finding and reducing methane emissions. However, logic and experience provide evidence that the United States can set a standard for responsible practices in the oil and gas industry. Based on my long experience in this industry, I am fairly certain that if the United States does not set a good example, most other nations will see no need to do any better.

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Figure 1. International Energy Agency (IEA) methane abatement cost curve for the U.S. oil and gas industry. The horizontal axis is the cumulative quantity of methane that can be prevented from escaping to the atmosphere in kilotons per year, if specific remediation measures are undertaken (colored blocks). The measures are ordered by the net cost of remediation in U.S. dollars per million British Thermal Units (MBtu) of avoided emissions, plotted on the vertical axis [IEA, 2022a]. The annualized net cost of emission reductions is based on the capital and operating costs of the emission reduction technologies and the value of recovered gas [ICF, 2016, Section 2.1]. Costs associated with the light pink (Downstream LDAR) and gray (Other) blocks at the right end of the chart exceed 10 USD/MBtu. For methane, 1 MBtu = 990 cubic feet = 27.91 cubic meters = 19 kilograms [EPA, 2022].