DIALOGUE

LEAKING METHANE: NATURAL GAS, CLIMATE CHANGE, AND UNCERTAINTY

SUMMARY

Recent studies suggest natural gas is significantly more carbon-intensive than previously realized, with methane having at least 25 times the warming potential of carbon dioxide. If the United States is to meet greenhouse gas reduction goals, it must curtail methane leakage between 30% and 90%, and leakage is anticipated to cost producers $2 billion each year in lost product. Absent regulations from the federal government and many states, nongovernmental organizations and the private sector are developing innovative solutions. On April 8, 2020, the Environmental Law Institute hosted a panel that explored cutting-edge practices to monitor and mitigate leaking methane. Below, we present a transcript of the discussion, which has been edited for style, clarity, and space considerations.

Chandler Randol is Manager of Educational Programs for ELI.
Jean M. Mosites (moderator) is a Shareholder at Babst Calland.
Richard Hyde is the Executive Director of ONE Future.
John Jacus is a Partner at Davis, Graham & Stubbs.
Theresa Pugh is the President of Theresa Pugh Consulting, LLC.
Ben Ratner is the Senior Director, EDF+Business, at Environmental Defense Fund.

Chandler Randol: I would like to welcome today's moderator, Jean Mosites. Jean is a shareholder in the Environmental Energy and Natural Resources and the Public Sector groups at Babst Calland. Her practice includes client counseling on environmental compliance in the energy sector and resolving liabilities under federal and state remediation programs, as well as administrative appeals in environmental litigation in state and federal courts.

Jean M. Mosites: I'm going to give a brief overview of some of the topics of interest on this issue of methane leakage. Then, we have terrific speakers with a variety of perspectives who will delve into it in more detail.

Everybody in the audience and on the panel is aware that oil and gas activities have emissions from a variety of parts along the production through the processing to the transmission and then out to the customers (see Figure 1 on the next page). When we're talking about methane leakage—and we're going to talk about the studies, the statistics, and the trends where we see the leakage—we'll talk about the technologies and the solutions and whether they are voluntary or regulatory obligations and what we think is going to happen going forward.

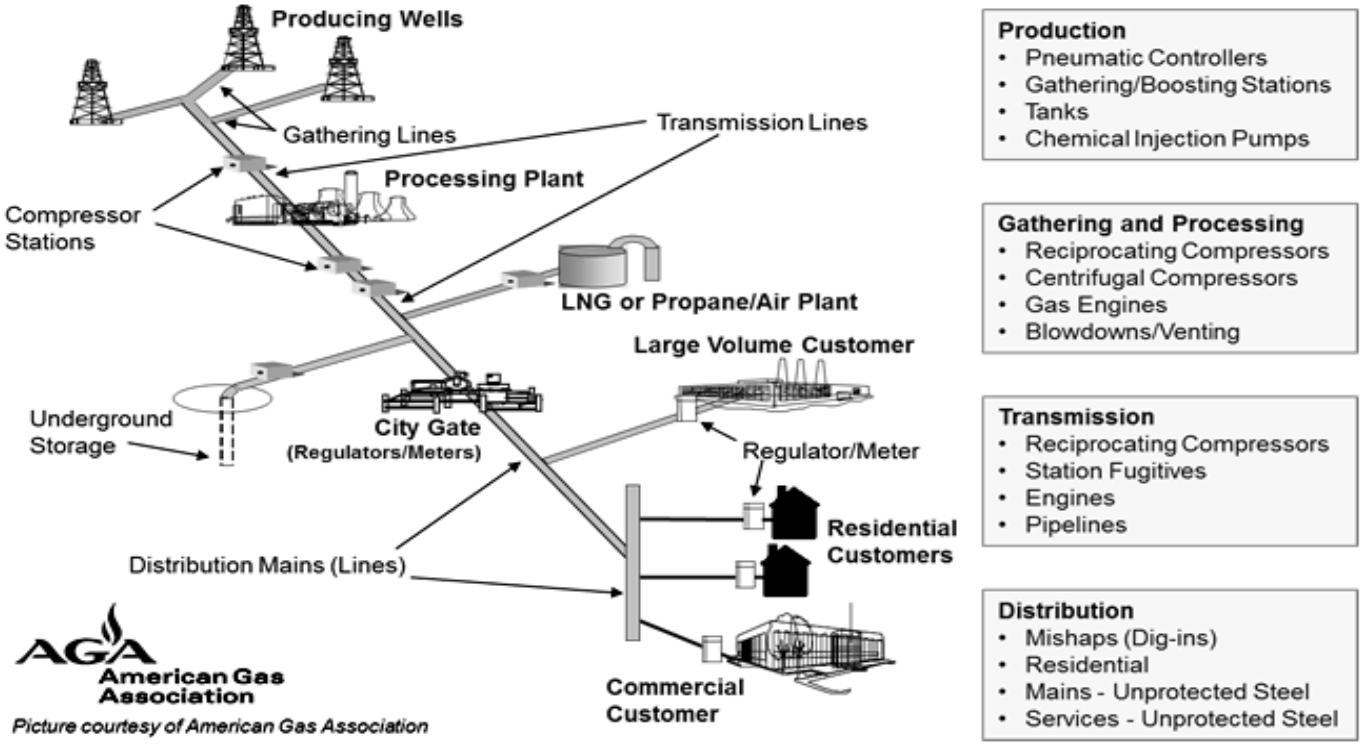
When talking about public and private research and statistics, one organization involved is the Environmental Defense Fund (EDF). Ben is probably going to talk about that when we get to his portion of the panel discussion. A 2018 study that assessed historic methane emissions in comparison to the EPA's inventory estimate and a subsequent study that came out a year later assessing historic methane emissions from NOAA's Global Greenhouse Gas Reference Network look at the kinds of evidence and statistics we find with respect to the increases, decreases, or trends in methane emissions over time.[1]

There are other studies as well. The Pipeline and Hazardous Materials Safety Administration (PHMSA) has a research portfolio with 13 leak detection projects that it is working on with industry.[2] It's also an interesting approach to look at the research that's being done on the various technologies.

If you look at Figure 2 (page 10697), which shows the sources of methane emissions in 2018, you can see that natural gas systems are the second highest source of U.S.

1. Ramón A. Alvarez et al., *Assessment of Methane Emissions From the U.S. Oil and Gas Supply Chain*, 361 Science 186 (2018), *available at* https://science.sciencemag.org/content/361/6398/186.full?ijkey=42lcrJ/vdyyZA&keytype=ref&siteid=sci; Xin Lan et al, *Long-Term Measurements Show Little Evidence for Large Increases in Total U.S. Methane Emissions Over the Past Decade*, 46 Geophysical Res. Letters 4991 (2019) *available at* https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018GL081731.
2. Buddy Secor, Engineering Operations Supervisor, PHMSA, PHMSA Research and Development: Leak Detection/Mitigation (June 7, 2018), *available at* https://www.epa.gov/sites/production/files/2018-06/documents/04_buddysecor_phmsa_presentation.pdf.

Figure 1. Emissions From Oil and Gas Activities



Source: U.S. EPA, *Overview of the Oil and Natural Gas Industry,* https://www.epa.gov/natural-gas-star-program/overview-oil-and-natural-gas-industry (last visited July 14, 2020).

methane emissions.[3] Thus, we will be talking about the progress or other things we are seeing with respect to this industry.

John is going to talk in more detail about federal regulation and state regulation. In Pennsylvania, where I am, the governor has a methane reduction strategy.[4] It has addressed methane in a variety of ways through permitting and proposed regulations that would control volatile organic compound (VOC) emissions and then incidentally control methane. If you look at some of EPA's statistics as well or its evaluation of states, you can see that there are other states doing a variety of things, and John will talk about Colorado in more detail.

One of the other things that we want to be sure to cover are the voluntary efforts, including industry-led or industry-supported initiatives. Richard is going to talk about the ONE Future coalition. There are also other climate initiatives, as well as environmental partnerships.

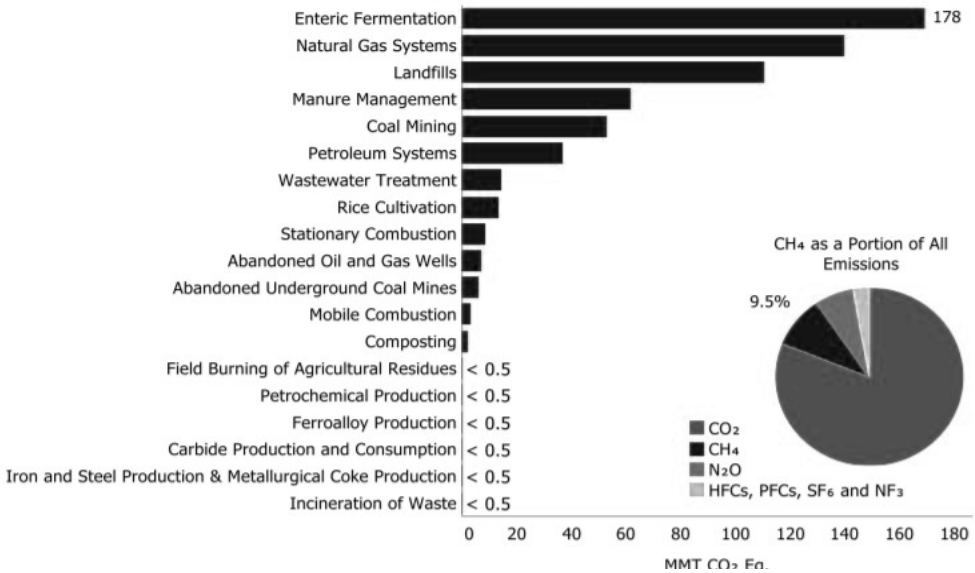
We know that there are global efforts. We also know that EPA's Natural Gas STAR Program has been around for quite a while. They are not only pledges, they also look at the technology. There are no simple answers here; the variety of input and views and possibilities really makes this a complicated topic. I think we will hear a lot of interesting ideas from our speakers with respect to those possibilities.

First, we will hear from John, a partner at Davis, Graham & Stubbs. He has more than 30 years of experience representing clients under all the major federal and state environmental laws in regulatory programs. His practice includes environmental regulatory counseling, administrative proceedings, litigation, and complex business transactions. He routinely handles rulemaking, adjudicatory proceedings, permitting and litigation for cost recovery, citizen suits, environmental insurance, judicial appeal of adverse agency actions, and more.

John Jacus: I'm going to provide a federal and state regulatory framework. This is obviously at a pretty high level given our time constraints and the complexity of the new source performance standards (NSPS) at the federal level, which I'll summarize briefly beginning with NSPS Subpart OOOO,[5] or "Quad O" as we like to refer to it in the air practice.

3. EPA, Draft Inventory of U.S. Greenhouse Gas Emissions & Sinks (2020), https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf.
4. Pennsylvania Department of Environmental Protection, *Methane Reduction Strategy*, https://www.dep.pa.gov/Business/Air/Pages/Methane-Reduction-Strategy.aspx#:~:text=The%20plan%20is%20designed%20to,waste%20of%20a%20valuable%20product (last visited July 13, 2020).
5. 40 C.F.R. Subpart OOOO (2019).

Figure 2. 2018 Sources of Methane Emissions



Source: U.S. EPA, Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks (2020), https://www.epa.gov/sites/production/files/2020-02/documents/us-ghg-inventory-2020-main-text.pdf.

With that caveat, I want to clarify that we're talking about NSPS under §111 of the Clean Air Act (CAA).[6] Those are technology-based standards that apply to specific categories of stationary sources, particularly and exclusively to new, modified, and reconstructed affected facilities in those specific source categories. As folks in the practice know, those are not only established from time to time, they're then periodically updated by EPA based on their study and research into what categories of sources are significantly contributing to air pollution.

To be clear, we are not talking about cap-and-trade regulation. This is solely federal and federal-state partnership regulation under the CAA and then state counterpart statutes that can be more stringent than the federal act. No disrespect to folks with cap-and-trade programs, but in the absence of federal comprehensive cap-and-trade legislation, we're having to deal with methane as an air pollutant and regulating it in the confines of §111 of the CAA and the NSPS in maximum achievable control technology (MACT) provisions—primarily MACT being the national emission standards for hazardous air pollutants program provisions under §112.

With that caveat, I want to touch on the uniqueness of methane as a pollutant, in particular as it relates to the §111 framework that I mentioned for NSPS. I talked about Quad O and its VOC focus, adopted in 2012. I will briefly touch on the development of the Climate Action Plan[7] and related Strategy to Reduce Methane Emissions[8] under the Barack Obama Administration in 2014. I will also discuss the subsequent iterations of reconsiderations of the Quad O NSPS by EPA, with a hiatus in the middle of that for some methane white papers that formed the elements of what became a new Subpart OOOOa of 40 C.F.R. Part 60—the NSPS referred to as Quad Oa—and its methane focus as opposed to a VOC focus.

I will also talk about companion rulemaking by the Bureau of Land Management (BLM)—the venting and flaring rule[9] as it's been referred to—as promulgated in 2016 and as a companion to the original proposed and then promulgated NSPS Quad Oa with its methane focus, and then as revised under the current Administration.[10] Then, we'll talk a bit about state legislation and regulation that has occurred in parallel with these federal developments under primarily the NSPS.

Methane is a unique air pollutant. It's colorless, odorless, naturally occurring, and ubiquitous in the environment. A global greenhouse gas, it is derived from biogenic sources and microbial activity in forests, swamps, and the like—natural processes obviously—and anthropogenic activity: landfills, coal mines that are active, agriculture, natural gas systems, of course, and energy production, among other sources.

It is not toxic. It is not a hazardous air pollutant. It is not a criteria air pollutant for which national ambient air quality standards (NAAQS) have been set by EPA under

6. 42 U.S.C. §§7401-7671q, ELR Stat. CAA §§101-618.
7. Executive Office of the President, The President's Climate Action Plan (2013), *available at* https://obamawhitehouse.archives.gov/sites/default/files/image/president27sclimateactionplan.pdf.
8. The White House, Climate Action Plan—Strategy to Reduce Methane Emissions (2014), *available at* https://obamawhitehouse.archives.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf.
9. BLM, Waste Prevention, Production Subject to Royalties, and Resource Conservation, 82 Fed. Reg. 83008 (Nov. 18, 2016).
10. BLM, Waste Prevention, Production Subject to Royalties, and Resource Conservation; Rescission or Revision of Certain Requirements, 83 Fed. Reg. 49184 (Sept. 28, 2018).

the CAA. And it is primarily not a significant ozone precursor. There have been some misconceptions about that. It's not terribly reactive. Our eight-hour ground-level ozone standard was set because ozone forms over the course of a day typically, primarily in summer months but also, as we know now, in winter months in certain unique areas with topography and snow cover and a lot of sun, that can create ozone in winter conditions. But because methane converts very slowly, it doesn't appreciably contribute to the eight-hour formation of ground-level ozone that we are concerned about for purposes of meeting and exceeding the ozone NAAQS, the ozone federal health-based standard. Because it's uniquely that way, it becomes a bit of a challenge to regulate within the confines of §111.

Quad O was passed in 2012, the first of the NSPS, for natural gas systems. It applies to each natural gas well that is hydraulically fractured. Hydraulically fractured gas wells were the more limited focus of Quad O as originally promulgated, including centrifugal compressors using wet seals, reciprocating compressors, continuous bleed pneumatic controllers, and storage vessels or tanks with a potential to emit equal to or greater than six tons per year of VOCs. Those were divided into Groups 1 and 2 depending on date of construction. It also applied to groups of equipment within a processing unit at onshore natural gas processing plants and sweetening units to remove hydrogen sulfide located at onshore natural gas facilities.

Again, that came along in 2012. Folks got with the program and began their compliance efforts. Then, of course, in March 2014, the Obama Climate Action Plan was released. This was a targeted strategy to cut methane emissions from key sources such as landfills, coal mines, agriculture, and oil and gas production. The Obama Climate Action Plan had lofty goals, but recognized that it had some hurdles to overcome as well. The goals were to reduce carbon pollution in the United States, prepare for climate change impacts, and lead internationally on the effort, but it acknowledged data gaps and unclear legal authority as hurdles to realizing the overall methane reductions targeted in the strategy. The methane reduction strategy and interagency methane task forces were developed to implement the plan.

The Quad Oa NSPS was then developed over the course of several years. I'm not talking at all about the litigation and administrative petitions for reconsideration that occurred on top of all of the substance of the NSPS. That was quite a lot of activity. It would consume an awful lot of time to go through that in any detail. I'm not trying to shortchange the judicial and administrative side of this, but we're really talking about the substance of the NSPS and how they were developed in light of those challenges. Those petitions for reconsideration are still pending in the U.S. Court of Appeals for the District of Columbia (D.C.) Circuit, but are held in abeyance given the current reconsiderations of various aspects of the proposed revised Subpart Quad Oa, and I'll get to that in a moment.

So, Quad Oa, following the adoption of the Climate Action Plan and Strategy to Reduce Methane Emissions and the development of white papers to address various source categories within the natural gas industry in particular, became effective in 2016, focusing on hydraulically fractured oil well completions. This is in addition to gas wells under Quad O, pneumatic pumps that are natural gas-driven, fugitive equipment leaks from well sites and compressor stations. These were for non-Quad Oa-regulated emissions sources. Then it created additional methane standards for previously Quad O-regulated sources, such as equipment leaks at natural gas processing plants, pneumatic controllers, reciprocating and centrifugal compressors, and storage tanks.

For well sites, leak detection and repair (LDAR) is a big deal. That's a large focus of methane emissions reductions at the state and federal levels and through voluntary efforts as well as other technologies. But certainly optical gas imaging (OGI), and the use of infrared cameras that are part of the OGI technology, has been the primary go-to technology under Quad Oa and also under state programs developed starting in 2014 in Colorado. I'll talk about that shortly.

Quad Oa required LDAR at well sites on a semiannual basis. "Fugitive emissions" were defined as any visible emission from a fugitive emission component observed during OGI. The best system of emissions reduction under Quad Oa is defined as OGI followed by repair. Fugitive emissions components include valves, connectors, pressure relief valves, open-ended lines and valves, thief hatches, and closed vent systems. Quad Oa also incorporated next-generation compliance tracking verification in a lot of its provisions.

At just about the same time, BLM came out with a venting and flaring rule, and then adopted the Climate Action Plan and methane strategy. Both noted that BLM was taking action to address flaring via the imposition of royalties under federal statute. This was done through an amended notice to lessees, notice NTL-4A.[11] Major points of similarity with Quad O were the control of emissions during well completions, production test and gas conservation plans, storage vessel and tank emissions controls, pneumatic device controls, and LDAR requirements. Then focus was placed on well liquids and loading and purging, as well as the emission of casing head and associated gases on federal leases, for which BLM of course has jurisdiction.

The question of BLM authority was raised early on in challenges to the venting and flaring rule. The argument is that it had no direct statutory authority to require air pollution controls, either technological such as NSPS or performance-based controls, and that BLM's air quality-related authority is quite limited. Authorized activities must comply with NAAQS. It has to coordinate with EPA on major source permitting. It addresses air quality through the National Environmental Policy Act (NEPA)[12] process primarily. And it has some transportation conformity analysis requirements in nonattainment areas that include lands within its jurisdiction. BLM was relying on the promulgation of and the defense of the venting and

11. *See supra* note 9.
12. 42 U.S.C. §§4321-4370h, ELR Stat. NEPA §§2-209.

flaring rule of the Mineral Leasing Act and Federal Land Policy and Management Act[13] authority.

The key of the original venting and flaring rule was that it established flaring limits. It defined avoidable versus unavoidable losses of emissions or of natural gas. It includes waste prevention, but primarily through air quality control requirements. It defined royalty-free uses, and it made adjustments to royalty rates.

The Quad Oa and venting and flaring rules—NSPS on the one hand and venting and flaring under the Mineral Leasing Act on the other—were the subject of Executive Orders issued in 2017 by President Donald Trump.[14] Revised NSPS Quad Oa was proposed in 2018, and supplemental comments were solicited in late 2019 on the proposed revision.

The revised venting and flaring rule was promulgated eliminating air quality controls per se, but keeping true waste prevention requirements, gas conservation plans and the like, and adjustments to royalty rates for leases on federal public land. The revised venting and flaring rule has been challenged on Administrative Procedure Act (APA) and NEPA grounds. It seems as though, based on a recent hearing in the Northern District of California, that reversal of that rule on APA and/or NEPA grounds may be likely.

Proposed Quad Oa revisions, more to the point under the CAA, are that it now has a VOC focus with methane co-benefits, the same as Quad O originally in 2012. It withdraws the regulation of transmission and storage segment sources that was effected through both Quad O and Quad Oa as originally promulgated in 2012 and 2016, on the basis that both of those rules were the result of an improper expansion of the source category to include transmission and storage. It proposes to reconcile compliance with existing state LDAR programs, such as the 2014 LDAR program adopted for the first time in regulating methane in Colorado and then copied in a number of other states in various degrees and also by Quad Oa itself.

It would not trigger existing source regulation as a legal matter under CAA §111, but does deliver the same emissions reductions for new and modified and reconstructed sources—just not the triggering of the control technique guidelines and existing source regulation that might otherwise occur under Quad Oa as originally promulgated. Those are the major high-level changes with proposed revised Quad Oa.

State regulation of methane, as I've mentioned, began with Colorado's 2014 methane rules and LDAR program, which was really a template in many respects for Quad Oa as originally promulgated in 2016. Jean knows well that Pennsylvania was an early adopter of LDAR requirements of wellheads as a function of permitting exceptions. More regulation has been recently proposed increasing the frequency of LDAR and methane emission reduction measures in Pennsylvania. I'll defer to Jean for some color on that. Ohio and Wyoming have regulations in place. All of these and others are basically state statutory programs, more stringent than federal programs, and again, as I mentioned at the beginning, not based on cap and trade.

Here, in Colorado, we've had quite a bit of activity. We see more activity coming our way both legislatively and administratively. Last year, the state legislature passed Senate Bill 19-181.[15] This did a number of things for oil and gas regulation in Colorado, including changing the nature of our oil and gas commission and removing the operational preemption impediment to local control of oil and gas regulation. It also required our Air Quality Control Commission to adopt rules to minimize emissions of methane and other hydrocarbons, VOCs, and oxides of nitrogen from oil and natural gas exploration and production facilities. The Commission was to consider adopting more stringent provisions for LDAR frequency, performing continuous methane emissions monitoring, require pneumatic devices that do not vent natural gas, and grant or clarify the authority to regulate air pollution from pre-production, drilling, and completion activities. Pre-production activities typically involve mobile and not stationary sources at a well site, as those of you who are familiar with the oil and gas industry understand.

The first of these rules was adopted December 19, 2019, and became effective on February 14, 2020. The revisions of this Regulation No. 7, as it's called, primarily take statewide tank controls down to those emitting two tons or more per year of VOCs, loadout controls for tanks with throughput of 5,000 barrels. LDAR frequency has increased, from once for the smallest facilities to at least semiannually and up to quarterly or monthly for the larger producing and emitting facilities, the tanks at those facilities.

There's also a new monthly proximity-based LDAR requirement near occupied areas, which is not well understood or defined and is being clarified through guidance and perhaps some supplemental rulemaking later this year. There are emission inventory requirements and permitting changes that were passed as well that aren't as germane to this topic.

There's some companion legislation. Greenhouse gas emissions data collection and reporting requirements were established and went to rulemaking in May. In June, the air commission here adopted rules requiring greenhouse gas-emitting entities to monitor and publicly report their emissions. The climate action legislation was also passed last year with ambitious goals: to timely adopt the plan, rules, and regulations, and to meet greenhouse gas pollution reduction goals with 2005 as the base year. That's 26% by 2025, 50% by 2030, and 90% by 2050. There are many more rules coming in 2020 and 2021, and probably more legislation. There is no rest for the weary here in Colorado when it comes to methane emissions reduction and air pollution control affecting oil and gas operations.

Jean M. Mosites: Thanks, John. Our next speaker is Richard Hyde, executive director of ONE Future. He most recently served as the director of external affairs for Southern Company Gas, where he was responsible for leg-

13. 43 U.S.C. §§1701-1785, ELR Stat. FLPMA §§102-603.
14. *See, e.g.*, Exec. Order No. 13783, 82 Fed. Reg. 16093 (Mar. 31, 2017).
15. S.B. 19-181, 71st Gen. Assemb., Reg. Sess. (Colo. 2019).

islative and regulatory functions for the commercial businesses, including fuels and storage, pipeline investment, and energy marketing. Richard has been in the natural gas industry for more than 30 years, working for Panhandle Eastern and Trunkline Gas, Duke Energy, AGL Resources, and Southern Company Gas.

Richard Hyde: ONE Future is a coalition of now 24 natural gas companies. When the coalition was formed back in 2014, there were seven. The original seven companies went to EPA and said, you know, we would like to work with you to create a voluntary performance-based program that will reduce methane emissions in the natural gas industry. One of the key things that's different in the ONE Future coalition than a lot of the other programs out there that Jean talked about is that we go from the wellhead to the burner tip.

We have members in every segment of the natural gas value chain. We truly believe it's an industry issue. It's not necessarily one particular sector's issue. We look at this as working as a team to achieve this goal.

We got approval from EPA to create our program back in 2016. So, we really began our true efforts at that point in time. We set a goal that we think is somewhat unique. It's not as unique as it once was, but we set a goal of reducing methane intensity across the value chain down to 1% by 2025. The way we define "methane intensity" is simply emissions over throughput. We were using 2012 data at the time we set our target. The intensity for EPA from a national level was at 1.44%.

There were some studies that EDF and others have done, which John referenced, that go back to 2012. The studies said that in order for natural gas to be competitive as a fossil fuel in all aspects of usage, there needs to be a methane intensity of 1% or less. That was where we started from and then we went back and allocated that 1% back to each one of the sectors to create sector goals.

Each one of our members on an annual basis reports to our third-party consultant who then compiles the data up to a sector level. So, there are numbers for the production, distribution, processing, and so on. Then, we roll that up to our 1%.

We view our data as confidential, so it's not shared amongst ONE Future members. An individual company's data is not shared from a ONE Future perspective with anyone out in the community or in the public sector. Primarily, we view this again as an industry issue. Companies are free to report their results, but from a ONE Future perspective, you won't ever see us report other than from a sectoral level and then rolled up to a ONE Future level.

One of the key things that we believe in is that natural gas is a foundational fuel. It's not necessarily a bridge fuel. It will have a role in a low-carbon economy, but I preface that with *if* we take care of our methane emissions issue. If we don't, then we're going to be in a world of hurt. I think that's why you're seeing more and more companies get involved in this, because it is such a critical effort for us to handle that.

We also believe in efficiency for improvement. Again, we look at this as a value chain approach. We work collaboratively to make sure that it works. We need it to be science-based and transparent. We set meaningful targets, and I'd like to say we have done that with our 1%. We get smarter and smarter all the time. What we knew when we started is minuscule to what we know now. We will continue to get smarter as we go forward.

One of the key elements of our program is this performance-based approach. By that, I mean we work with EPA. We developed the protocol that listed out the sources of emissions that we would use and that we would report on, which is in addition to what we report to the inventory process. We include additional sources that we believe are important to capture and report on those.

We have told folks that the way we set the program up is that companies are allowed, within the toolbox that we have, to deploy the way that they do LDAR, the way that they mitigate leaks, the way they repair leaks, the way that makes the most sense for the particular company. We believe that each individual company knows its system better than anybody else. If we give them the tools and then we set a goal, we believe that we will show a much better and faster reduction than if we have a command-and-control and cookie-cutter approach, and it goes hand-in-hand with that. Flexibility is the key. If we allow the flexibility, we think at the end of the day we are going to be much better off and have much better results.

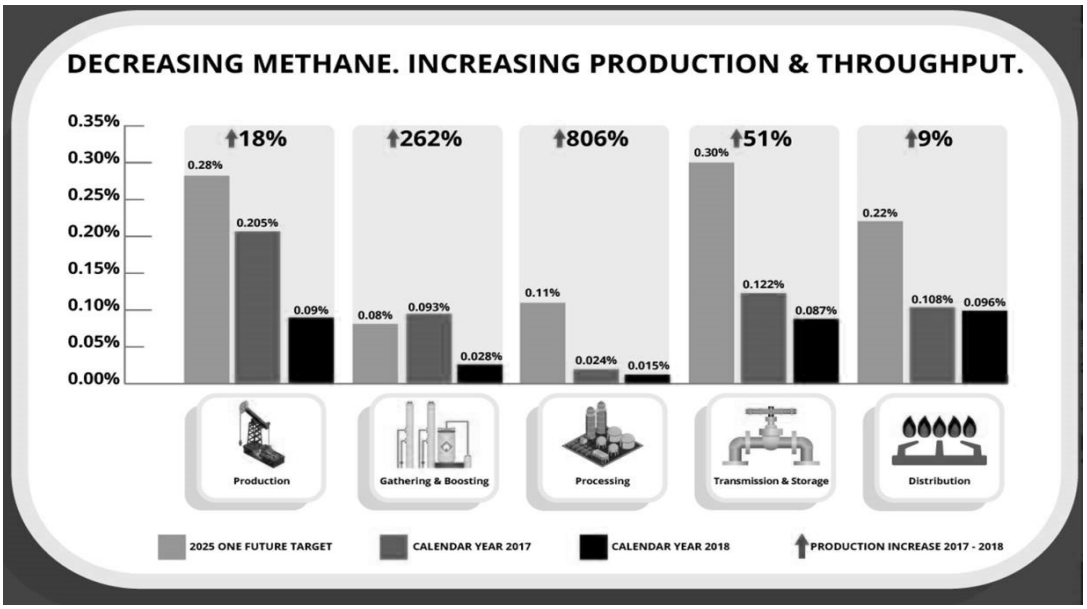
Our reporting has to be transparent. It needs to be consistent, and we're doing that. We've reported two years' worth of data so far. We continue to find ways to improve that as we move forward.

Obviously, safety is an issue. From the industry's standpoint, it is top priority. So, we think that that is one of the lenses that we need to look through as we go about doing this. We also have responsibility to our customers, our shareholders, and the investment community at large to ensure that we have a sustainable product as we move forward. And if we're going to continue to have the energy industry leadership and increase the U.S. energy dominance goals and continue to grow it, this is a must that we have to achieve to reduce our methane emissions.

For sustainability, again, we believe that natural gas has a role in a low-carbon economy, but we have to make sure that we are reducing our emissions so it remains a competitive fuel. I talked a little about this already. We set an ambitious target of 1%. We want to create the flexibility. We are obviously focused on cost-effectiveness. We think that that's when we get results faster.

Innovation, I think, is a key thing right now. The technologies that were out there when we started this back in 2012, 2014, even 2015, we're light-years ahead of that now. I know we're going to talk about things that EDF is doing, but there is a tremendous amount of new technologies that are available now and things that are in the works that we see are going to help us drive down emissions as we move forward. We think that is a hugely important factor to consider.

Figure 3. ONE Future 2025 Sector Targets and 2017 and 2018 Emission Intensity Results by Sector for Two Years of Reporting



Source: ONE Future, ONE Future 2018 Methane Emission Intensities (2018), http://onefuture.us/wp-content/uploads/2019/11/ONE-Future-2018-Final-Report-LN.pdf.

Looking at our results, the 1% is what we use as our target right now. Our first year was based on 2017 data, and the methane intensity level for 2017 data was 0.552. So, we're already half of our original goal. There were 14 companies that were included in that study or in those results. We've increased it. Like I said, now we're 24 companies. We reported late last year on our 2018 results.[16] We were down to 0.326. That's another 41% decrease from our 2017 through 2018 results, and we went from 14 companies reporting to 17 companies reporting. So, we continued to drive down emissions.

As we increase membership, will that hold? I don't know. If I knew that, I'd go to Vegas and bet big. I don't know that we can continue to drive down, but we're working on it. We're working very hard to make sure we're achieving that.

Figure 3 above provides a snapshot from year-on-year. The left bar in each category is the One Future goal. The middle bar is our 2017 results. Then, the right bar is our 2018 results. So, you can see we're driving down the emissions. The arrows that are pointing up are actual increases in throughput that each of the sectors had during that particular year. So, even having an increase in the throughput, we were able to drive down emissions.

We look at methane intensity as the measure of efficiency. So, how efficiently does a particular company and/or sector handle the methane as it is moving through its system? Obviously, we would love to drive that down to close to zero. Over the long term, I think we can do that. Again, new technologies are coming online. The new culture of companies focusing on that helps us to get there.

Jean M. Mosites: Our next panelist is Theresa Pugh. With more than 25 years' experience, Theresa Pugh Consulting offers business consulting regarding regulations pending before EPA, the U.S. Department of Labor's Occupational Safety and Health Administration, and the executive office within the Office of Management and Budget (OMB), as well as the Council on Environmental Quality. Theresa has previously worked for the Interstate Natural Gas Association of America, American Public Power Association, and American Petroleum Institute.

Theresa Pugh: The comments that I'm offering today are my own and not those of my former employers and not necessarily all of my current clients. But I'm certainly happy to offer some observations. I don't mean to sound arrogant, but maybe they are a little bit unique because I have worked in the oil and gas industry and their trade associations, and in the trade associations representing the electric utility industry. Now, I have clients in the industrial sector that are consumers of natural gas either as a fuel or to process that gas.

I want to make sure, though, that none of my comments or recommendations or critiques in any way suggest that I'm anti-natural gas. I'm not in the remotest sense anti-

16. ONE Future, ONE Future 2018 Methane Emission Intensities (2018), http://onefuture.us/wp-content/uploads/2019/11/ONE-Future-2018-Final-Report-LN.pdf.

natural gas, but I am in favor of increasing the manner in which and the speed with which we address *fugitive* leaks and other leaks that are unrelated to EPA regulation. And I'll explain why.

I had an industrial client that faced a pretty tough situation about 15 months ago, when Enbridge had a pipeline rupture up in the Northwest near the Sumas Pass in British Columbia, Canada. Even though the company did a fine job in repairing the rupture, for five months that pipeline did not operate at full capacity. The pipeline's capacity was reduced by 20%, which is a pretty common approach by the Canadian National Energy Board (NEB). NEB is kind of like a merger of PHMSA and the National Transportation Safety Board. We still don't know what the root cause was for that accident. The company did a fine job in repairing things in six days, but the practical result was, even though my client had a firm contract and had experience with firm contracts for 20 years, they still had a gas shortage of 20%. And 20% at a 200% cost increase is very significant.

This affected electric utilities and manufacturers in three U.S. states—Idaho, Oregon, and Washington—and one Canadian province. You might say, well, why the heck didn't they just pull gas up from southern California? For reasons that I've never completely understood, the natural gas system does not currently send gas up from, let's say, Houston to California and then allow also in urgent situations movement of gas up through northern California. So, the gas in northern California, Idaho, Oregon, and Washington comes from Canada almost always.

The 70% of the gas that was affected in these states and the Canadian province was reduced by 20%. This means that these manufacturing plants had to buy off the spot market for five months—not for six days, but for *five months*—until the original pressure was returned to 100%. If you're living in Houston, that's no big deal because there are so many pipes that you can reroute from. But in some parts of the country, there's not significant rerouting capacity. So, when you lose 20% of the pipeline or from a compressor station outage, that's a really big deal to a manufacturing plant and to an electric utility.

I'm going to give you a couple other examples. I want to show you what a $200 per one million British thermal units (MMBtu) price looks like to either a factory or a power plant. The Canadian utility did a great job in activating all of its demand side management. Actually, the utility is to be commended up in the Northwest.

I also want to mention that in the Northwest, when we had the Sumas Pass event, the Canadian agriculture industry was affected. It wasn't just manufacturers because in Canada in the winter they actually do their winter planting inside commercial "glass gardens" or commercial nurseries. They couldn't afford to pay the $200/MMBtu spot prices. Again, that went on for five months.

I'm going to skip the East Tennessee natural gas pipeline, but it provides examples of what happened to industrial customers. I do want to mention one in Michigan. In January 2019, we had a really rough winter. A lot of the situation in January 2019 was because of the extreme weather situation. Consumers Energy during this rough winter had a compressor station, the Reed City Compressor Station, catch fire. What is significant here is that there were 100 manufacturing plants, including 18 automobile plants or 18 auto suppliers, that were out of work for one week. As I understand it, the auto industry did go ahead and pay their employees. But not all of these 100 companies were able to pay their employees for one week.

I don't need to be too obvious here, but we're at a time right now where we know what's going on when companies are not able to make payroll due to extraordinary circumstances that nobody could have predicted. This could not have been predicted in January 2019. In their case, luckily it was only one week. But for the auto industry, many of those auto plants had already been out for one week because they traditionally give their employees a week off at Christmas. So, being out for two weeks is significant.

The utility is not my client, but the utility did a very good job on demand side management to try to make up for the loss. But there was an impact in Michigan. If this were to happen again in any other location, you might well see a sizeable impact on manufacturing plants or electric utilities as the consumers of natural gas.

I'm an unpaid advisor along with about 80 other people on the North American Electric Reliability Corporation (NERC) committee on natural gas and electricity, sort of the marriage of the two, if you will. They did a study in 2017 using U.S. Department of Energy (DOE) and Argonne National Laboratory materials and documents, and identified 12 U.S. underground storage facilities that they were concerned about from a reliability perspective for the electric utility industry.[17] This is at the bulk electric level, not your mom-and-pop small town utility with a small 150-megawatt generator. And we're not talking about factories. We're talking about that NERC identified this, was concerned that there could be problems at the bulk electric level, and there are 18 locations where power plants, hospitals, and factories that, as their customers, could be affected by voltage support. Those in the high-tech industry or in the medical instrumentation facilities or at a hospital don't want voltage issues.

When I say plants, I don't mean factories. I mean power plants that are identified by NERC as at-risk due to the natural gas infrastructure industry where once again there could be power outages due to a force majeure event, due to either a compressor station going out or the pipeline going out, due to being out of service, due to the question of whether it is a methane leak. Not all these leaks would be big enough to be identifiable or reportable to PHMSA, which is a part of the U.S. Department of Transportation. That's another thing that is baffling to me coming from the electric utility world.

In the electric utility world, you tell the regulatory agency when there's been a loss of, say, 30 minutes without the ability to be in operation. There's no comparable reporting at DOE or other agencies—not even EPA. So,

17. NERC, Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System (2017), https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SPOD_11142017_Final.pdf.

that would be something that I would recommend the U.S. Congress change.

My perspective is that the CAA OOOO(a) regulation for the gas industry for gas transmission and distribution and gathering should be covered. Should there be some surgical improvements? Yes, I think so.

I think there were some things EPA got wrong. There should be a loosening of what types of technologies can be used to actually identify the leak. It shouldn't just be an LDAR infrared camera. That might be very expensive to operate. There may be seasonal implications if you're trying to run that in extreme heat or extreme cold. You have to have a pretty high skill set of people.

There may be in the future different types of sensors and remote things that at first look kind of rickety, but they would be improved over time. That includes some type of fence line sensors or almost an iPhone-type thing.

My personal view is try to keep that as inexpensive as possible and practical and, hopefully, that the technology can differentiate between agricultural methane, landfill gas, and emissions from a wastewater treatment facility. You get the idea. I want it to be effective. I want it to be useful. And I want it to be affordable. That would be one of my recommendations. I thought EPA was a little too prescriptive in that area.

You might ask, why do you think all this should be handled under EPA and not PHMSA? Frankly, I wish it would be PHMSA. I think PHMSA would be a better agency to take a more comprehensive view about fugitive methane emissions, and about corrosion and other safety issues. But I can't see my way through to getting PHMSA to do that because Congress gave PHMSA a very odd cost-benefit analysis. Sort of a second step, if you will, that I don't find at OMB or regulatory agencies in terms of the level of difficulty in getting their regulation proposed and promulgated. I think PHMSA has had a tense time more than I would like to see.

Again, I'd be more inclined to be described as an industry person, but I still think that we need to improve the safety standards at PHMSA. If I have to use EPA as my method, so be it.

I think you can be neutral on the question of climate and want to see an improvement on fugitive emissions, reduction, and corrosion control and all that. I'm not saying that I am neutral. I'm not denying climate is an issue. I'm just saying one could be neutral or agnostic on the climate question and still find merit to improving a fugitive leak.

I do have a recommendation on upstream oil and gas. It's based upon family experience. I think the really small oil and gas producers should be given probably a year before they get sucked into the regulatory obligations. When I say small, I mean truly small. I'm talking mom-and-pop type operators. They may be using sophisticated technology. They may be on a multi-well pad or something like that. But we're not talking about the majors here. We're not talking about huge oil and gas companies.

These little guys, they can just get squeezed out so bad that my recommendation would be that EPA give them additional time to sort out whether or not that production is even viable and immediate. Look what the oil and gas prices have done in the past six weeks. You can imagine how many small companies there are right now that, God help them, I hope they're around in a month. That would be my recommendation.

I never bought into the argument that we can't regulate a pollutant or a product. In this case, methane is both a pollutant and a product. I don't buy the argument that it cannot be regulated under both §111 and §112, you know, midstream transmission. It's not a VOC in midstream. It's not neurotoxic in midstream transmission. And I do think that gathering lines of say 11 inches and more ought to be regulated. It's unfortunate that no one has watched the gathering lines as sufficiently as they should have. I'm in favor of regulating gathering lines. Yet I'm in favor of the gas industry.

I realize we're mostly talking about EPA here, but what's relevant is that it has been difficult for PHMSA to regulate in some areas because of the secondary cost-benefit analysis that Congress placed on them that's not in other statutes. I've never seen anything like it.

I also want to draw your attention to the Carnegie Mellon Electricity Industry Center. Gerad Freeman and Jay Apt have looked at all the fugitive leaks and non-fugitive leaks that aren't even reported to anyone and also the equivalent. As I mentioned, an electric utility has to report to its regulatory body if it has a 2% or more derating for 30 minutes, which is the equivalent of 600 cubic feet of gas. Whereas, if PHMSA is to report, there are a number of requirements to submit, but it's 5,000 times higher. I think we need to improve things. If it means fixing it both at PHMSA and EPA, I'm for it within reason.

Jean M. Mosites: Thanks, Theresa. Our next panelist is Ben Ratner. Ben is the senior director of the EDF+Business Energy Transition Team, a dynamic group of business experts working in key areas of the global energy industry to speed and scale greenhouse gas reductions worldwide. Ben blends business and public policy approaches to accelerate strategies for virtually eliminating oil and gas methane emissions, electrifying heavy-duty transport, and achieving prices and limits on carbon pollution.

Ben Ratner: I couldn't agree more with Theresa that there are all kinds of reasons to care about this methane issue: whether it's climate change; whether it's air quality—as methane is often associated with other pollutants particularly in the upstream; whether it's license to operate for perhaps some of the clients that you serve or will serve in industry; whether it's operational efficiency as Rich alluded to, and more. There's a lot at risk frankly, but there's also a lot of opportunity in the methane space.

Why oil and gas methane? I think this has been well covered, but let me put a bit of an advocacy gloss on it. Methane is an incredibly powerful greenhouse gas. It is like a greenhouse gas on steroids because it's over 80 times more potent than carbon dioxide over a 20-year time frame. Methane accounts for about 25% of the man-made warming that we're experiencing today. Think about that: 25%.

Now, to be fair, oil and gas is not the only source. But as we've been discussing, of course, it's a top source. By our estimate, it accounts for about one-third of total man-made methane emissions. The key point here, which has been alluded to, is that solutions exist. They're cost effective. As Rich pointed out, in the innovation space, technology is getting better every day. We're working in collaboration with some of our colleagues in industry on innovative approaches to detect, monitor, and measure better, faster, and cheaper.

An example of that is the Methane Detectors Challenge, which is focused on fixed, stationary, continuous monitors—almost like a smoke detector but for methane.[18] We worked on that project with Shell, Equinor, Southwestern Energy, ExxonMobil, and others.

More recently, we've worked with Stanford University, ExxonMobil, and some other companies on what we call the Mobile Monitoring Challenge.[19] A peer-reviewed paper was published last year.[20] We evaluated about a dozen emerging technologies including drone, aerial, and truck-based approaches, to bring more speed and more agility to monitoring and locating emissions, and to really support the most rapid mitigation and learning on the continuous improvement journey.

I think it's important for everyone to appreciate that the world is really changing. We're entering a new era, and that's an era of democratization of data around the actual levels of methane emissions coming from oil and gas. One of the examples of that is methane satellites. So we're going from the historical status quo that your clients are used to, in which they would file some very nice self-reported figures based on desktop estimates and have those be largely unchallenged, to a world in which civil society increasingly has the means and the opportunity to work with some of the best scientists in the world to monitor, to measure, and to publicize real empirical data about the actual methane emissions coming from companies, facilities, value chains, and geographies.

I want to pause there because that is a profound shift. I think it's so important for you and your clients to understand—to appreciate—the magnitude of what's happening, to manage risk, and to position yourself for this new era. I don't think that overstates it at all.

In April, we learned that the TROPOMI instrument—a European satellite that measures methane emissions—found that oil and gas operations in America's sprawling Permian Basin are releasing methane at twice the average rate found in previous studies of 11 other major U.S. oil and gas regions.[21]

In 2022, through our affiliate MethaneSAT LLC, we will launch a methane satellite that will provide dedicated coverage of global oil and gas operations—their methane emissions specifically.[22] It's a purpose-built satellite. We're going to provide public and transparent emissions data updated in near real time, not just in America, but around the world, with pixels down to a pretty fine-grain level of resolution, about 400 meters by 100 meters.

EDF is working with Harvard University on this project. We're working with the California Institute of Technology. We're working with Ball Aerospace. We're working with the Smithsonian Astrophysical Observatory. I'm really looking forward to making this data public. We want it to be a constructive tool. We want it to be a collaborative effort to help governments take action on policies and regulatory measures that will really crack down on these potent sub-emissions to help investors understand if companies with whom they have a relationship are leading or lagging on this key environmental, social, and governance (ESG) issue.

We could have more and more from investors, right? Methane is a key ESG issue. They care more and more about ESG. And, of course, to support companies in their efforts, not that this is a substitute for ground-based, aerial, or other programs run by companies, but I think it's an important complement. I can say that we've gotten a lot of interest from many of our colleagues in industry on this project. It will be a new era.

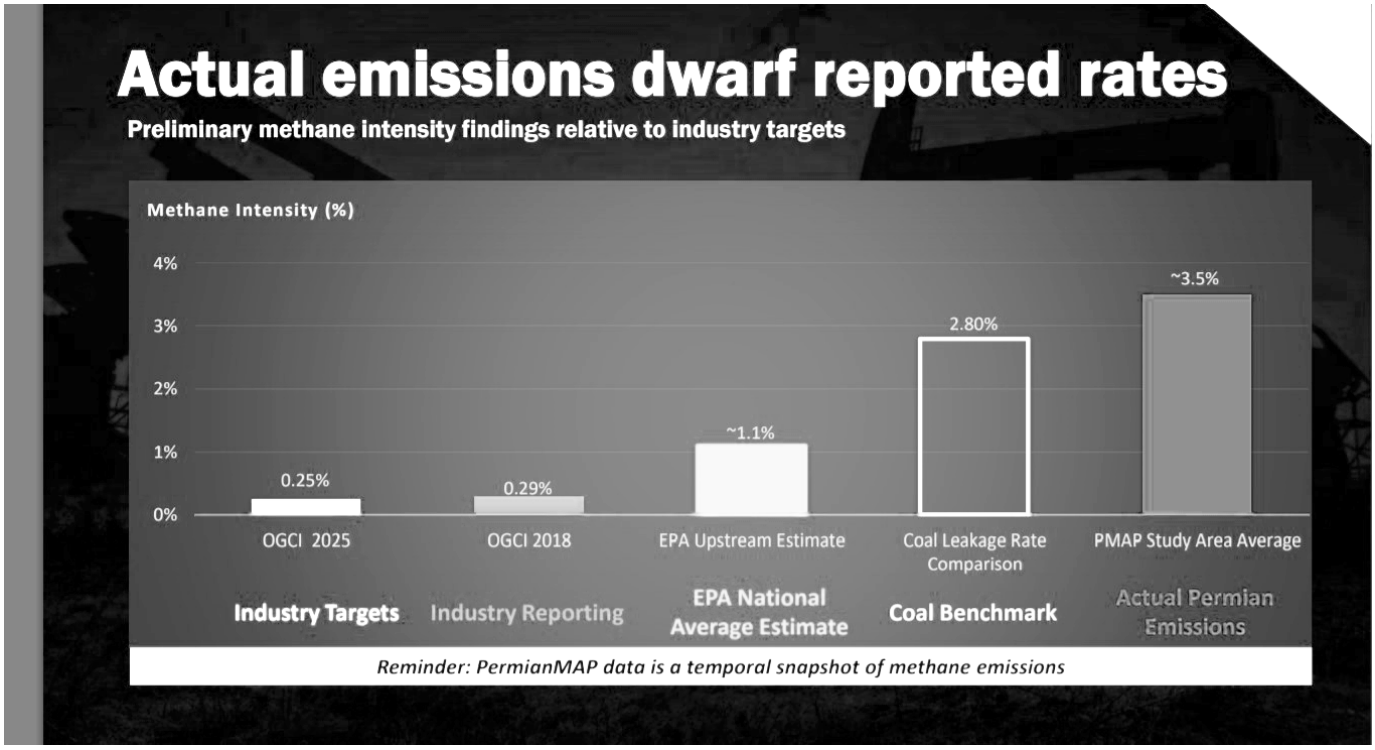
We couldn't be getting together on a better day than today. That's because EDF just released new data from our methane analysis project, PermianMAP, that finds methane escaping from oil and gas operations in the most productive part of the basin at nearly three times the rate reported in EPA's national inventory.[23]

What we are doing in the Permian Basin with collaborators is to estimate methane emissions, not from the entire basin, but from a very significant geographic portion of it that's highly productive with wells; to identify areas and companies with high emissions and develop a company performance measure; and to understand flare performance.

The 3.5% loss rate estimated in the study area is roughly 15 times higher than reduction targets set by leading producers, and much higher than many companies have reported.[24] It represents 1.4 million metric tons of wasted

18. EDF, *Methane Detectors Challenge*, https://www.edf.org/methane-detectors-challenge (last updated Mar. 1, 2019).
19. Isabel Mogstad, *Buckle Up: Methane Monitoring Is Going Mobile*, EDF+Business, Sept. 10, 2019, https://business.edf.org/insights/buckle-up-methane-monitoring-is-going-mobile/.
20. Arvind P. Ravikumar et al., *Single-Blind Inter-Comparison of Methane Detection Technologies—Results From the Stanford/EDF Mobile Monitoring Challenge*, 7 Elementa Sci. Anthropocene 37 (2019), *available at* https://www.elementascience.org/article/10.1525/elementa.373/.
21. Press Release, EDF, Satellite Data Reveals Extreme Methane Emissions From Permian Oil & Gas Operations; Shows Highest Emissions Ever Measured From a Major U.S. Oil and Gas Basin (Apr. 22, 2020), https://www.edf.org/media/satellite-data-reveals-extreme-methane-emissions-permian-oil-gas-operations-shows-highest; Yuzhong Zhang et al., *Quantifying Methane Emissions From the Largest Oil-Producing Basin in the United States From Space*, 6 Sci. Advances eaaz5120 (2020), *available at* https://advances.sciencemag.org/content/6/17/eaaz5120.
22. MethaneSAT, *Home Page*, https://www.methanesat.org/ (last visited Aug. 3, 2020).
23. Press Release, EDF, New Data: Permian Oil & Gas Producers Releasing Methane at Three Times National Rate (Apr. 7, 2020), https://www.edf.org/media/new-data-permian-oil-gas-producers-releasing-methane-three-times-national-rate; PermianMAP, *Home Page*, https://permianmap.org/ (last visited Aug. 3, 2020); U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks (last updated Apr. 13, 2020).
24. Press Release, Oil and Gas Climate Initiative, Oil and Gas Climate Initiative Sets First Collective Methane Target for Member Companies (Sept. 24, 2018), https://oilandgasclimateinitiative.com/oil-and-gas-climate-initiative-sets-first-collective-methane-target-for-member-companies/; ONE Future, ONE Future 2018 Methane Emission Intensities (2018),

Figure 4. Preliminary Methane Intensity Findings Relative to Industry Targets



Source: Environmental Defense Fund, *PermianMAP,* https://www.permianmap.org (last visited July 14, 2020).

gas each year, enough to meet the annual natural gas needs of every home in Dallas and Houston combined. Some wells were found to be releasing methane through leaks, venting, and malfunctioning flares at more than 100 times the national average rate.

But again, by making data publicly available, in some ways, this is almost "pre-MethaneSAT." It's almost a teaser. This is more focused geographically and it's coming two or three years before the methane satellite project, but I think it gives all of us a flavor of what may come.

Our approach is to partner with leading methane researchers using multiple direct measurement methods that estimate the emissions and to make the data publicly available. That's just the cornerstone that you've heard a couple of times from us and we'll continue to see more of that.

We heard earlier from Richard about some targets and some reported levels of methane intensity from the ONE Future coalition. Richard and I had some good conversations and I hope we'll intensify those. The Oil and Gas Climate Initiative (OGCI) includes about 13 of the leading energy companies around the world. They have set a voluntary target of 0.25% methane intensity, which I think is similar to what Richard mentioned for the upstream segment of his ONE Future coalition. They're currently reporting that they are emitting, as a group of 13, a consortium of about 0.29%. That sounds good, right? That sounds like ambitious targets. It sounds like OGCI is almost meeting that target, right? They're targeting 0.25%. They're at 0.29%. It sounds like a pretty stringent level of methane control.

Well, let's keep the story going. You look at EPA. The EPA national average estimate for the upstream is about 1.1%. So, EPA is saying that their best estimate, the national average not attributed to any one individual company, is about 1.1%.

Now, let's take a step back and remind ourselves that in the pathway to solving the climate crisis we need to achieve a net-zero world by mid-century—like by 2050 in the areas of the developed world like the United States. More and more of your clients in different sectors are endorsing a net-zero goal. Hundreds of corporations are now behind that as well as more and more government actors. That's the real goal. Gas must show a pathway to be part of the net-zero future.

But let's also think about a benchmark relative to coal, because we are so accustomed to hearing that natural gas is so much cleaner and better than coal. The benchmark that we would put out there from the published scientific work from my colleagues at EDF is that the coal leakage rate comparison is about 2.8%. What do I mean by that? For natural gas to deliver immediate climate benefits relative to coal in the electric power sector, the supply chain leakage rate must be limited to 2.8% or tighter.

The findings that we just released (see Figure 4), based on preliminary data from a portion of the Permian Basin, included an average leak rate of 3.5%. I came to EDF from a background in McKinsey & Company and Latham &

http://onefuture.us/wp-content/uploads/2019/11/ONE-Future-2018-Final-Report-LN.pdf.

Watkins. I've served in the corporate sector. I like working with my industry colleagues. We try to be very fact-based and not sensationalized, but these findings are jaw-dropping. This is a stunning, egregious, and completely unacceptable level of methane emissions that is orders of magnitude higher than industry is targeting. It is an order of magnitude higher than most in industry are reporting. It is three times higher than EPA estimates. It is not even in the ballpark yet on a pathway to net zero. In terms of near-term impacts on the climate, this is even worse than coal. So, this is a very important issue for your clients to take action on.

We are working with our team to attribute emissions rates to individual operators in the Permian Basin. and we think it's likely that there will be a real spread where we see some companies doing a much tighter job and some having an awful lot more work to do to be charitable on their methane emissions performance.

We released the PermianMAP dashboard, which I encourage you to check out.[25] This is all for the public good, not just for the social and environmental good. We'll be updating this regularly with aerial data.

We've also added more flaring data, which shows over 10% of the flares in the study area are malfunctioning or unlit.[26] You can see some regional emission rates and over time some operator-specific affiliated emissions.

I want to be clear on that nuance for those of you who are going to go look for and think about clients or future clients or any of our colleagues who are from industry. In some cases, there are emission data points that are attributable directly to a single operator—a reading of such and such kilogram per hour. We know that's Operator X based on where we found the reading, and it's only Operator X who has facilities there.

In other cases, there might be a methane-emissions reading of such and such rate. Well, we know it's in an area where Operators 1, 2, 3, and 4 are operating. We know how many wells each operator has in a certain area, but we can't yet attribute the emissions breakdown to a particular operator. So, we're still going to be a fact-based group. We're still going to be a science-based group. We will present the data. No less than that, but no more than that. So, in some cases, it's really going to be up to the companies to take the next step to identify: Okay, I've got a lot of methane emissions in some areas where I'm one of two operators, where I'm one of five operators, where I'm one of eight operators. How much, if any, of those are mine? What can I do about it? And is there any way that I can support my colleagues who are in the same area with me?

Chandler Randol: We've had a number of questions for you, Ben, asking if you could clarify what EDF uses to define methane intensity, as well as whether you can clarify what you're talking about when you say actual Permian emissions. They've noted that there might be some data that EPA and others aren't able to capture. They're wondering if you can clarify that for us.

Ben Ratner: The shift that we all collectively need to make—and Richard and I have talked about this—is going from desktop-based estimates to real-world methane emission measurements. That is the key paradigm shift. The world in which we still largely live but we're departing from pretty, pretty fast is one where frankly both companies and EPA—most regulators—are using these desktop-based methods where you literally take a calculator and you say, okay, how many flanges of a certain type do we have in this part of the state or in this part of our operations, and what do we think would be the average methane emissions rate for that kind of flange?[27]

You go by what are called emission factors and engineering calculations. You literally go through and you multiply and add, you multiply and add, you multiply and add, you multiply and add. Any one of us could do that exercise with a calculator and a computer. There's a problem with that because you're not in the field, you're not with an infrared camera, you're not with drones, you're not with aerial sensors, you're not with satellites taking actual empirical measurements of methane emissions.

What the science tells us study after study after study is that so often the estimated emissions from that desktop-based approach are inaccurate. Not always—but often they underestimate, in some cases significantly underestimate, the actual methane emissions in the atmosphere because those estimates are usually based on the assumption that things are probably working about the way they ought to. The whole problem with methane emissions is when things are not working the way they ought to. It's when a flare is malfunctioning and leaking or venting methane into the atmosphere. It's when there is an operator error and a thief hatch is left open. It's when a tank is not correctly sized, and so you have very significant methane emissions from a tank or any number of other reasons.

That's a shift that we really want to make. We put out a very timely report in March called "Hitting the Mark."[28] Legal & General Investment Management, who have about $1.6 trillion assets under management, wrote the foreword for this paper. The paper has some very practical recommendations that your clients can begin to implement, to start hitting the mark in how they determine and report their methane emissions in a way that is science-based.

I think the other question was how we calculate methane intensity. We put out materials from the Permian work that provides some more information about how that's calculated.[29] But the basic concept is that measured actual

25. PermianMAP, *Home Page*, https://permianmap.org/ (last visited Aug. 3, 2020).
26. PermianMAP, *Flaring Aerial Survey Results*, https://www.permianmap.org/flaring-emissions/ (last visited Aug. 3, 2020).
27. David Lyon, *Big Step Back: Changes in New EPA Greenhouse Gas Inventory Mask Methane Emissions*, EDF, Apr. 28, 2020, http://blogs.edf.org/energyexchange/2020/04/28/big-step-back-changes-in-new-epa-greenhouse-gas-inventory-mask-methane-emissions/.
28. EDF, Hitting the Mark: Improving the Credibility of Industry Methane Data (2020), https://business.edf.org/insights/hitting-the-mark-improving-the-credibility-of-industry-methane-data/.
29. EDF, Methodology: Permian Methane Analysis Project (PermianMAP) (2020), https://www.edf.org/sites/default/files/documents/PermianMapMethodology_1.pdf.

methane emissions are the numerator, and the denominator is natural gas production. In this case, we did not use oil or some sort of a blended number—just methane emitted over natural gas produced.

Theresa Pugh: My question is, how do you differentiate other methane from agricultural sources? I mean God bless the Permian Basin. There's one industry that really counts, but the other is agriculture. How do you know you're not inadvertently pulling in methane emissions from agricultural sources and double-counting? How do you differentiate? Do you have a marker?

Ben Ratner: That's a great question, Theresa. I don't want to go over my expertise on scientific and technical questions. My colleagues like Steve Hamburg, our chief scientist, or David Lyon, who runs the science piece of the Permian campaign, I'm sure would be delighted to write you an encyclopedia or speak with you and answer that question directly. I know we take that seriously. Source attribution is a critical question and we want to make sure that we get that right.

I'm not quite sure which techniques were deployed in the Permian campaign—there are a number of different scientifically accepted, and also just practical in some cases, methods for doing that source attribution. It could be isotopic analysis. It could be layering in geographic information from Google Maps or other information sources to know where you have feedlots, where you have landfills, and where you have oil and natural gas operations, then doing attribution in that manner. There are probably other methods besides that our more scientific folks would be able to speak to.

John Jacus: If I may, I want to also respond to Ben's announcements in his presentation. I commend EDF for being data-driven and for developing good data with industry in partnership with academia and other institutions, governmental and nongovernmental. I'm also mindful that technology needs to continue to evolve. We want this industry in particular to innovate, as I think Richard first mentioned among our speakers.

OGI, as required under Quad Oa and other rules, is limited. It does not estimate the mass of emissions. It simply gives you a visual representation, especially in single wave length. I know operators are exploring uses of and test piloting various monitors and technologies. I think a lot of change is coming soon in that regard that will make it cheaper and easier to be more certain about the emissions, so I take your announcement and study both very seriously. You obviously have invested a lot in it, but also with a grain of salt.

It's another study. It's probably a better study using better technology. I think everybody needs to do their homework and respond accordingly to what you just announced and to look at what you're doing in the Permian Basin. It's very important work and I'm sure it would be taken seriously by operators, the public, and regulators.

Richard Hyde: If I could go back to one thing that Ben was talking about when he talked about the emissions factors. That's also a significant issue for ONE Future member companies. Sometimes, it works both ways; you can overstate and you can understate your emissions. I think, as we look at the factors in today's world, there are many sources that probably should be direct-measured as opposed to an emissions factor. This is one of the areas where we've had some discussions and we're certainly in agreement with that. We're also very science-based. We want to go where the science leads us.

Having better data, we would all agree with that. Having better data is exactly what we want to do. Again, I also commend Ben and EDF for the work that they have done to hone in on this. We don't necessarily always agree with some of the ways, like a top-down versus a bottom-up approach. We won't necessarily always go down that road. But at the end of the day, we do agree that better data makes opportunities for better decisions and innovations. New technologies have come out that have been talked about. So yeah, the factors are an area where I think work can be done. It can be improved. We can get better data and then follow that data wherever it goes.

Chandler Randol: Another question is, in any uncertainty of a financial recession following COVID-19, how can we ensure that the issue of orphan wells and methane leakage is reduced to a minimum when facing potential bankrupting or dissolution of oil and gas companies? How can we ensure liability?

Jean M. Mosites: You can't. That is an unfortunate answer, right? In the state programs, when they issue permits and they have bonds that are required, there are circumstances that are not going to be addressed through that issue. Also, there are a lot of abandoned and orphaned wells in Pennsylvania that are from 100 years ago for which there is no bond. There is no permit. There is no one. So, that issue is not something for which you can easily assign responsibility and liability, whether you're in the middle of a pandemic or otherwise.

John Jacus: I would add that financial assurance is important. Orphan well programs exist and are funded. The industry needs to help take care of that, obviously, going forward through financial assurance for new wells. As well as to support orphan well programs and to address any potential for emissions leakage or other hazards posed by orphan wells.