Capturing Value

Science and Strategies to Curb Methane Emissions from the Oil and Natural Gas Sector

Institute *for* Policy Integrity
new york university school of law

Jayni Foley Hein
Policy Brief No. 15
December 2014

Introduction: Why Methane Matters

Reducing the risk of catastrophic climate change will require substantial, near-term reductions in greenhouse gas emissions. A major source of such emissions in the United States is domestic oil and natural gas production, which has dramatically expanded over the past decade, transforming the national energy landscape. The oil and natural gas sector is the nation's largest industrial emitter of methane: this primary component of natural gas is a potent climate pollutant up to 86 times more powerful than carbon dioxide on a 20-year timeframe.[1]

Currently the United States loses at least 1 to 3 percent of its total natural gas production each year when methane is leaked or vented to the atmosphere during the production, processing, transmission, storage, and distribution of natural gas and oil.[2] This is a waste of a valuable resource, as well as a source of greenhouse gas pollution. Curbing methane pollution is critical to meeting the nation's climate protection targets, as well as the Administration's new agreement with China, which commits the United States to reducing its total greenhouse gas emissions 26 to 28 percent below 2005 levels by 2025.[3]

Methane by the Numbers

Methane accounts for roughly **9 percent** of total U.S. greenhouse gas emissions

The oil and natural gas sector releases **7.7 million metric tons** of unburned methane each year—enough to heat 6.5 million U.S. homes

1 to 3 percent of total U.S. natural gas production is lost through methane leaks and venting

Methane is **86 times** more damaging to the climate than carbon dioxide on a 20-year timeframe, and 34 times more powerful on a 100-year timeframe

The atmospheric concentration of methane has increased by **151 percent** over the last 250 years

Nearly **90 percent** of projected 2018 oil and gas sector methane emissions will come from infrastructure that existed in 2011—sources not regulated by EPA's 2012 volatile organic compounds regulations

Available technologies can reduce methane pollution from oil and natural gas operations by **3.2 to 3.7 million metric tons per year** (42 to 48 percent of the sector's total methane emissions), at little or no net cost

The U.S. Environmental Protection Agency's (EPA) proposed Clean Power Plan is expected to result in increased use of natural gas, as combined cycle gas power plants will likely replace coal-fired power plants in some states. Reducing methane emissions from the oil and natural gas sector would further increase the climate benefits of switching from coal to natural gas.

Recent studies show that EPA can reduce methane pollution from the oil and gas industry by nearly 50 percent, using available, low-cost measures. Because of the commercial value of the natural gas that can be conserved, many of these measures pay for themselves by redirecting natural gas back to productive use as a fuel source for electricity and heating. And even without the resale value of natural gas, these measures can still be cost-benefit justified due to the social cost of methane emissions,[4] as well as the health benefits of reduced smog and hazardous air pollutants, which are co-emitted with methane during oil and natural gas production.

This policy brief provides an overview of the science of methane, oil and gas sector methane emissions, the history of federal action, available methane emission reduction opportunities, and potential regulatory pathways to secure methane reductions under the Clean Air Act. Because methane is so potent in the near-term, federal regulation to curb its release can reduce imminent climate effects and lower the overall cost of climate mitigation.

The Science of Methane

Methane is the main component of natural gas.[5] The energy released by the combustion of methane, as natural gas, is used to generate electric power, to heat homes and commercial buildings, and to power vehicles. Natural gas has been explored as a potential "bridge fuel" during the transition to a decarbonized energy system because it emits half as much carbon dioxide during combustion as coal.[6]

However, when methane escapes into the atmosphere *unburned* during the oil and natural gas production and distribution process, it is extremely efficient at trapping heat: its global warming potential is up to 86 times greater than carbon dioxide in the first 20 years after release, and 34 times more powerful on a 100 year timeframe.[7] Global warming potential (GWP) is an estimate of how much a greenhouse gas affects climate change over a period of time relative to carbon dioxide, which has a GWP value of 1.[8]

Due to its potency, and because methane survives in the atmosphere for only 8-12 years (compared to more than a century for carbon dioxide), it is known as a "short-lived climate forcing pollutant."[9] Climate scientists have concluded that cutting methane emissions in the near term could slow the rate of global temperature rise over the next several decades, especially when combined with rigorous carbon dioxide mitigation.[10] Sharp methane reductions could also delay imminent climate effects in the earth's most vulnerable regions, such as the Arctic.[11]

Over the last 250 years, the concentration of methane in the atmosphere increased by 151 percent.[12] Methane currently accounts for about 9 percent of total U.S. greenhouse gas emissions.[13] Methane also contributes directly to the formation of ozone—another source of global warming and impaired air quality.[14]

Methane Emissions from the Oil and Natural Gas Sector

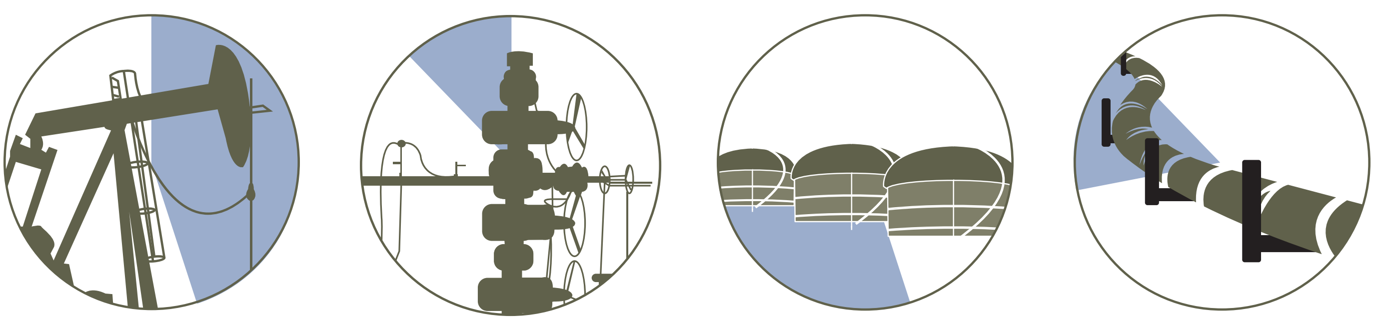
The oil and natural gas sector is the largest industrial source of methane in the United States.[15] It releases approximately 7.7 million metric tons of unburned methane each year—enough natural gas to heat 6.5 million U.S. homes.[16]

Due to hydraulic fracturing technology, natural gas production in the United States has increased 33 percent since 2006, and crude oil production has increased nearly 50 percent since 2008.[17] In 2012, natural gas accounted for about 25 percent of electricity production in the United States.[18] This market share is projected to grow over the next decade as industry continues to exploit natural gas deposits through the use of hydraulic fracturing, and regulations such as EPA's Clean Power Plan support the replacement of some coal-fired power plants with natural gas-fired power plants.[19]

Methane escapes into the atmosphere as "fugitive emissions" during the oil and gas production process due to leaks, as well as venting and flaring.[20] These methane emissions occur at all stages of the oil and gas production process, including production, processing, transmission, storage, and distribution.

Methane is released during oil production because some geological formations of oil also contain methane, which escapes during drilling and extraction. Petroleum systems account for about 19 percent of total natural gas and oil sector methane emissions; the production segment, alone, accounts for 98 percent of oil sector methane emissions.[21] Methane emissions from natural gas systems account for 81 percent of total oil and gas sector emissions; these emissions are more broadly distributed throughout the natural gas production lifecycle.[22]

Sources of Fugitive and Vented Methane Emissions in the Oil and Natural Gas Sector[23]



Production **45%**

Processing **12%**

Transmission & Storage **27%**

Distribution **16%**

Studies show that between 1 and 3 percent of the nation's natural gas production ends up as methane emissions leaked or vented into the atmosphere. Reported methane emission rates vary due to different testing methods and variable and uncertain rates of gas and oil production, among other factors. According to its national inventory of greenhouse gas emissions, EPA estimates methane leakage from the natural gas sector to be about 1.5 percent.[24] Recent studies published in *Science* and *Proceedings of the National Academy of Sciences* show that natural gas sector methane emissions may exceed EPA's estimate.[25] Other studies are consistent with EPA's estimates.[26]

The range in fugitive methane emission estimates underscores the need for stronger methane standards while EPA continues to collect more accurate data. A number of studies calculate the climate benefits of switching from coal to natural gas combined cycle power plants at a range of methane leakage rates.[27] Additional studies justify the use of natural gas as a temporary bridge fuel as we shift towards more renewable energy and low-carbon energy sources.[28]

How Methane Emissions are Calculated

The Bottom-Up Approach

EPA calculates the total oil and natural gas sector methane emissions reported in its annual Greenhouse Gas Inventory using a "bottom-up" approach, which estimates the emissions for a piece of equipment or process as the product of:

(i) an agency-established emissions factor, developed from sample sources in the field; and
(ii) the number of times this activity is repeated each year.[29]

This is done for many different activities in the oil and natural gas sector, and the results are tallied to provide an estimate of national emissions.

The Top-Down Approach

"Top-down" studies involve measuring methane concentrations in the air above a defined region or basin and analyzing these in conjunction with wind patterns and other variables to estimate the leakage originating from the natural gas and oil system.[30]

Top-down studies typically find higher emission rates than bottom-up studies. For example, satellite observations of large oil and gas basins in East Texas and North Dakota found 9 to 10 percent methane leakage rates in those basins.[31] Another top-down study found that up to 4 percent of the methane produced at a field near Denver was escaping into the atmosphere.[32]

These basin-specific studies may not be representative of all regions or well sites in the United States. In addition, because they rely on air measurements, top-down studies may attribute some methane emissions to the oil and gas sector that actually come from other sources. Reconciling the differences between top-down and bottom-up methods will improve our understanding of methane emissions from the natural gas and oil supply chain.[33]

Federal Action on Oil and Gas Sector Methane Emissions, To-Date

In 2012, EPA finalized New Source Performance Standard (NSPS) for volatile organic compounds (VOCs) and National Emissions Standards for Hazardous Air Pollutants (NESHAPs) for the oil and natural gas sector.[34] Volatile organic compounds are chemicals that contribute to ground-level ozone and smog. Because VOCs and methane are often emitted together during natural gas and oil production, methane reduction is a co-benefit of the 2012 regulations.

The New Source Performance Standards for VOCs require operators of new or modified hydraulically fractured natural gas wells to use a procedure known as a "reduced emission completion," or "green completion," to capture the natural gas that initially escapes upon well completion. This gas contains VOCs, as well as methane. This rule applies only to new and re-stimulated natural gas wells, and not to oil wells. The 2012 rules also require new or modified processing plants, compressors, and pneumatic devices to reduce VOC emissions; however, they do not regulate existing equipment.[35] When fully implemented in 2015, these rules are expected to reduce 0.9 to 1.5 million metric tons of methane per year, as a co-benefit.[36]

Flaring, Venting, and Green Completions

When a natural gas or oil well is first developed (a stage known as "well completion") some amount of methane escapes to the surface, where it is either vented into the air, flared (burned off), or captured in a closed-loop process called green completion. Both flaring and venting release carbon dioxide, methane, and VOCs into the atmosphere. Methane is commonly vented or flared during oil well completions, especially in regions that lack natural gas gathering pipeline infrastructure.[37]

When safe, flaring is preferable to direct venting because it burns methane, emitting carbon dioxide as a byproduct of combustion, instead of more potent methane. Compared to venting, flaring also releases fewer VOCs and hazardous air pollutants.[38] However, no flare is 100 percent efficient: some unburned methane and VOCs still escape into the atmosphere, along with carbon dioxide, nitrogen oxides, and carbon monoxide.[39]

In a green completion, a closed-loop system captures and separates methane and VOCs from the gas and used hydraulic fracturing fluid ("flowback") that comes back up from the well. The gas is then routed to a tank for separation, enabling the sale or use of methane that would otherwise be released to the atmosphere.[40] Green completions can reduce methane and VOC emissions from oil and gas wells by up to 98 percent.[41] Green completions also present an opportunity for cost savings, as they process and bring natural gas to market.[42]

In its 2013 Climate Action Plan, the Obama Administration committed to developing an interagency strategy to limit methane emissions from the oil and gas sector.[43] Fulfilling this commitment, on March 28, 2014, the Administration issued its "Strategy for Reducing Methane Emissions," which outlined actions to help meet its goal of reducing U.S. greenhouse gas emissions by 17 percent below 2005 levels by 2020.[44]

On April 15, 2014, EPA released five technical white papers discussing major sources of methane emissions in the oil and gas sector, identifying techniques for mitigating those emissions, and soliciting expert review and comment.[45] If EPA decides to develop methane regulations for the oil and gas sector, it has indicated that it will complete those regulations by the end of 2016.[46]

On November 25, 2014, EPA signed two actions to increase the reliability and scope of oil and gas companies' annual methane emission disclosures to EPA's Greenhouse Gas Reporting Program.[47] In the first action, EPA finalized a rule eliminating certain monitoring methods for oil and gas sources which had allowed the use of unreliable reporting methods to calculate emissions. The second action proposed methane reporting requirements for additional emissions

Photo © Tim Evanson. Licensed under CC BY-SA 2.0 via Wikimedia Commons

sources in the oil and gas sector, including gathering and boosting equipment, completions at oil wells, and certain transmission sources.[48]

Through the Natural Gas STAR program, EPA will also continue to work with the industry to expand voluntary efforts to reduce methane emissions.[49] Natural Gas STAR partners currently share information on methane emission reduction technologies and practices through submission of annual progress reports.[50] In addition to EPA actions, the federal Bureau of Land Management is also expected to propose updated standards to reduce venting and flaring from oil and gas production on federal lands.[51]

Available Methane Reduction Opportunities

Available, low-cost technologies and practices can be deployed throughout the oil and natural gas lifecycle to capture methane currently lost due to leaks, venting, and flaring. Because methane is the primary component of natural gas, it can be sold for end use—capturing value while reducing climate-forcing pollution.

Recent studies show that substantial reductions in methane and volatile organic compounds (VOCs) are achievable at low or zero cost (assuming the captured gas is sold), using available technology:

- A 2014 report by ICF International found that a 40 percent reduction in fugitive methane releases and 44 percent reductions in VOCs and hazardous air pollutants could be attained at a cost of one cent per thousand cubic feet (mcf) of natural gas.[52] Ninety percent of the reductions achievable were described in EPA's five technical papers released this spring;

- A 2014 report issued by Clean Air Taskforce, Natural Resources Defense Council, and Sierra Club found that fugitive methane can be reduced by 42 to 48 percent using available methods at an annual cost equal to 1.5 percent of the industry's annual revenue;[53]
- A 2013 report by the World Resources Institute found that three methane capture and avoidance technologies (plunger lifts, low-bleed pneumatic devices, and leak detection and repair systems) could cut methane emissions across the natural gas system by 30 percent;[54] and
- A 2012 report by the Natural Resources Defense Council identified ten commercially available, low-cost ways for operators to capture methane that would otherwise be leaked or vented from oil and gas production, processing, and transportation systems.[55] Many of these technologies pay for themselves or turn a profit in one to two years, due to the resale value of the captured gas.

As the above reports describe in more detail, many control technologies and techniques to reduce methane leakage from the oil and gas industry have been amply demonstrated. The voluntary participants in EPA's Natural Gas STAR program have also shared information on methane emission reduction technologies and practices, and their revenue-generating potential at different natural gas prices and timelines.[56] Available control measures include:

Leak detection and repair ("LDAR")

- *Process:* Infrared cameras and other advanced equipment is used to detect and repair methane leaks from well-pads, processing plants, compressor stations, and distribution facilities.
- *Reduction capacity:* Approximately 1.70-1.80 million metric tons of methane per year.[57]
- *Economics:* Using a gas price of $4/mcf, these measures are usually profitable, due to the value of the gas conserved by finding and fixing leaks.[58]

Green completions for oil wells

- *Process:* Closed-loop systems capture liquids and gases coming out of the well during the initial "completion" stage of production, then route fluids and gases to a tank for separation to enable the sale or reuse of gas.
- *Reduction capacity:* Approximately 0.26-0.50 million metric tons of methane per year.[59]
- *Economics:* Green completions cost between $8,700 and $33,000 per well, and can generate between $28,000 and $90,000 per year, per well, in captured natural gas revenue.[60]

Minimizing well venting during liquids unloading

- *Process:* Water from underground formations can accumulate in oil and gas wells, slowing production. Instead of "blowing down" such wells by opening them to the atmosphere—a process that vents large amounts of methane—automated plunger lifts can efficiently lift liquids out of the well, reducing vented emissions during liquids unloading by up to 90 percent.[61]
- *Reduction capacity:* Approximately 0.12 million metric tons of methane per year.[62]
- *Economics:* Installing automated plunger systems costs between $7,000 and $15,000 per well, and can return up to three times that investment within the first year, when accounting for the resale value of the captured gas.[63]

Low-bleed/no-bleed pneumatic equipment

- *Process:* Gas-driven pneumatic equipment is used to operate pumps, regulate gas flow and pressure, and control valves throughout the natural gas production, processing, and distribution lifecycle. Replacing high-bleed pneumatic equipment, which is designed to continuously vent methane, with low-bleed or no-bleed devices, can sharply reduce methane emissions from pneumatic equipment.[64]
- *Reduction capacity:* Approximately 0.72-0.87 million metric tons of methane per year.[65]
- *Economics:* Based on projected gas capture and natural gas resale values, low-bleed devices, which cost about $3,000 per replacement, can generate a modest profit within one year, and no-bleed devices within two years.[66]

Dry seal systems and compressors

- *Process:* Fugitive emissions from new and existing reciprocal and centrifugal natural gas compressors, which are used to pressurize gas, are projected to reach over 1 million metric tons of methane in 2018 in the absence of additional regulation.[67] Better maintenance practices, as well as the use of dry-seal or wet-seal degassing systems, can be used to reduce emissions from compressors.[68]
- *Reduction capacity:* Replacing older compressors can reduce methane pollution by approximately 0.48 million metric tons of per year.[69]
- *Economics:* Dry-seal or wet-seal degassing systems can pay for themselves or generate a profit within one to three years, depending on the actual equipment cost and amount of gas captured.[70]

Why Companies Leak, Vent, and Flare Valuable Methane

Any amount of methane lost to the atmosphere is natural gas that is not sold for consumption, resulting in loss of revenue and waste of non-renewable fossil fuel.[71] While methane's commercial value should motivate companies to address some of these issues on their own, many operators will not achieve an ideal level of leak prevention in the absence of regulation, because fugitive methane is an externality.

There are more than 500,000 producing natural gas wells and 536,000 producing oil wells in the United States.[72] The start-up costs of buying and installing leak detection, repair, and prevention equipment can deter companies from addressing leaks at their wells.[73] In some cases, site-specific factors, such as low flow rates or low gas pressure make methane emission control more challenging or unprofitable. Moreover, there is some uncertainty with respect to the payback period and profit margin of these investments. Low natural gas prices can also reduce the incentive for operators to make the investments needed to capture marketable natural gas.[74]

In states like North Dakota, short-term lease agreements with landowners or mineral rights owners have also caused companies to drill and fracture oil wells before natural gas gathering lines are available. The U.S. Energy Information Administration estimated that about 30 percent of North Dakota's natural gas production in 2014 was vented or flared, due to insufficient natural gas pipeline capacity and processing facilities.[75]

Regulations can help change the economic incentives and infrastructure issues that lead to excess leakage, venting, and flaring. The optimal amount of methane control should ideally be calibrated to the social cost of methane—the cost that an additional unit of methane emissions is projected to impose on society.[76] While voluntary programs have achieved limited success in controlling methane emissions, federal regulation is necessary to secure greater industry-wide emission reductions.

Regulatory Pathways for Reducing Methane Emissions

EPA has authority under the Clean Air Act to develop methane regulations for the oil and gas sector. By setting methane emissions standards under Section 111 of the Clean Air Act, EPA could significantly reduce methane emissions through low-cost technology requirements. Other regulatory options include the issuance of Control Techniques Guidelines for ozone under Section 182 of the Act, which would indirectly curb some methane emissions, as well as the expanded use of voluntary measures.

In addition, the Bureau of Land Management has authority to issue methane standards for the oil and gas operations on federal lands, and is required to minimize waste pursuant to the Mineral Leasing Act.[77] The Bureau of Land Management has stated that it may propose new rules for methane and VOC emissions from oil and gas operations on federal lands, or adopt existing federal or state rules as industry best practices.[78]

Methane's interstate and international climate impacts make it particularly well suited to federal regulation. An individual state will experience only a small fraction of the harm associated with its methane emissions, creating an incentive to under-regulate methane-producing activities, such as hydraulic fracturing.

Because EPA has indicated that it is considering regulation pursuant to Clean Air Act Sections 111 or 182 in the near-term, we focus on these approaches below.

Regulating Methane Under Clean Air Act Section 111

Clean Air Act Section 111 authorizes EPA to establish pollution control regulations, known as "New Source Performance Standards," for new or modified stationary sources of air pollution.[79] EPA promulgates standards of performance for categories of sources that the Administrator believes "caus[e], or contribut[e] significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."[80] EPA has already made an endangerment finding for methane, and has identified the oil and gas industry as the "single largest contributor to United States anthropogenic methane emissions."[81]

The New Source Performance Standards must "reflect the degree of emission limitation achievable through the application of the best system of emission reduction which . . . the Administrator determines has been adequately demonstrated."[82] In making this determination, the Administrator "tak[es] into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements."[83] When EPA establishes New Source Performance Standards for certain pollutants from new or modified sources in a source category, EPA is also required, under Section 111(d)(1), to prescribe regulations for states to submit plans regulating existing sources in that source category.[84]

When EPA revised its New Source Performance Standards for the oil and gas sector in 2012 to control VOCs, it did not directly regulate methane, citing substantial methane reductions as a co-benefit of its VOC regulations, as well as the need to collect more data through its recently established Greenhouse Gas Reporting Program.[85] EPA now has three years of Greenhouse Gas Reporting Program data, five technical white papers, and numerous peer-reviewed studies detailing sources and control techniques for methane emissions from the oil and gas sector.

Regulatory Design—New and Modified Sources

EPA can achieve substantial methane reductions by setting technology-based emission standards under Sections 111(b) and (d) of the Clean Air Act. EPA would likely set a methane emissions performance standard based on reduction levels achievable through the use of the mitigation techniques addressed in the agency's white papers.

In line with the research described above, EPA's technology-based emission standards should cover all significant sources of emissions and all segments of the oil and natural gas supply chain: production, processing, storage, transportation, and distribution.

EPA's suite of technical papers, as well as recent peer-reviewed studies, describe a plethora of technologically-available, low-cost methane reduction opportunities for wells, compressors, storage tanks, and pneumatic devices, among other components. Performance standards should ideally be calibrated to the social cost of methane—the cost that an additional unit of methane emissions is projected to impose on society. This would ensure that the oil and natural gas sector performs all abatement that is cost-benefit justified.

EPA can also look to existing state regulations as models for direct methane regulation, and to show that cost-effective control techniques exist. For example, Colorado has rules covering existing methane and VOC emission sources including wells, pneumatic devices, and storage tanks.[86] Colorado requires the use of green completions and low-bleed pneumatic controllers for oil and natural gas wells statewide, as well as "best management practices" to

Photo © Walter Siegmund. Licensed under CC BY-SA 3.0 via Wikimedia Commons minimize emissions during liquids unloading.[87] Wyoming's VOC regulations require green completions for all new oil and gas wells, and the state recently issued draft regulations addressing other sources of VOCs from new and existing oil and natural gas wells in ozone nonattainment areas.[88] Other states, such as North Dakota and Texas, have less stringent regulations.

The Regulatory Process—Existing Sources

Once EPA sets New Source Performance Standards under Section 111(b), it would initiate the 111(d) regulatory process by issuing a set of "emission guidelines" containing its findings regarding: (1) the best system of emission reduction that has been adequately demonstrated, (2) the degree of reduction achievable under such a system, and (3) the time necessary to achieve that reduction.[89] States would then be required to design individual implementation plans that are consistent with EPA's guidance.[90]

A state need not adopt the particular system of reduction identified by EPA in its emission guidelines so long as the state's own approach will achieve an equivalent or superior level of abatement.[91] EPA's guidelines and the corresponding state implementing standards should cover methane emissions from all significant sources of emissions, from all segments of the natural gas supply chain. States may also be able to use market-based systems, including trading or carbon taxes, to regulate methane emissions from the oil and gas sector, pursuant to Section 111.[92]

EPA would review each state's implementation plan to ensure its compliance with the guidelines.[93] If a state fails to submit a "satisfactory" plan, EPA may design and enforce a federal plan for the subject sources in that jurisdiction.[94]

Benefits of Regulating Methane Under Section 111

There are numerous benefits to regulating methane directly pursuant to Clean Air Act Sections 111(b) and 111(d). First, this regulatory pathway would apply federal methane standards to existing sources, which account for the majority of emissions from the sector. Nearly 90 percent of projected 2018 emissions will come from oil and natural gas infrastructure that existed in 2011—sources not regulated by EPA's 2012 VOC regulations.[95]

Second, Clean Air Act Section 111 enables EPA to set methane emission limits for segments downstream from the production well, where 50 to 60 percent of emissions occur,[96] and imposes no geographic restrictions, unlike Section 182. This would enable EPA to control methane emissions from the processing, storage, and distribution segments by requiring, for example, the use of techniques or technology that can eliminate the need for methane venting during routine pipeline maintenance.[97] Because the VOC content of natural gas is low at the distribution stage, VOC-specific regulations would likely not address these emissions.[98]

Third, regulating pursuant to Section 111 would provide states with flexibility to use market-based approaches to reducing methane emissions, such as trading or carbon taxes, if they so choose.[99]

Finally, regulating methane directly will reduce substantially more methane emissions than regulating it indirectly, using Section 182. Mitigation measures using available technologies can reduce methane pollution from oil and natural gas operations by 3.2 to 3.7 million metric tons per year, or 42 percent to 48 percent of the sector's estimated total methane emissions.[100] Section 111 methane standards would reduce methane pollution from the oil and gas sector by up to 10 times as much as the alternative VOC pathway. Due to their broader scope, Section 111 standards would also reduce smog-forming VOC pollution three to four times more than VOC emission standards, alone.[101]

Regulating Methane Under Clean Air Act Section 182

The Obama Administration's Methane Strategy states that EPA will also consider issuing Control Techniques Guidelines pursuant to Clean Air Act Section 182 to reduce methane emissions. Whereas Section 111 would target methane directly, Section 182 would directly regulate volatile organic compounds (VOCs), reducing methane as a co-benefit.

Section 182(b)(2)(A) requires states with ozone nonattainment areas to revise their state implementation plans to require "reasonable available control technology" for volatile organic compound sources located in those nonattainment areas.[102] Ozone nonattainment areas are those parts of the country where air pollution levels exceed the Clean Air Act's national ambient air quality standards for ozone.[103]

Only about 15 percent of all oil and gas wells are located in ozone non-attainment areas, restricting the utility of Section 182 in reducing methane. For example, petroleum producers in Los Angeles would be regulated, but hydraulic fracturing operations in the Bakken Shale region of North Dakota and Montana would not be.[104] Further, while volatile organic compounds and methane are often emitted together, some components of the supply chain emit them in very different amounts, leaving significant sources of methane unregulated in a Section 182-only regime.[105] For these reasons, this pathway would reduce far less methane than regulating methane directly, through Sections 111(b) and 111(d).

Regulating Methane Using Voluntary Measures

Finally, EPA could also take additional actions to reduce methane emissions through Natural Gas STAR and other voluntary programs. For example, EPA could encourage voluntary action by maintaining a clearinghouse for technologies and practices that reduce all types of air emissions from the oil and natural gas sector, with more detailed information on the costs and benefits of these measures. However, given the continued growth projected for the natural gas and oil sector, differing state regulations, and disparate operator-level incentives, sharply reducing methane emissions will require federal regulation and robust enforcement.

Conclusion

Reducing methane emissions from the nation's growing oil and natural sector is critical to curbing global warming. Methane is up to 86 times more potent than carbon dioxide within the first two decades of its release. Without comprehensive federal regulation to reduce these emissions, the concentration of methane in the atmosphere will continue to rise, increasing the likelihood of catastrophic climate change.

Federal regulation under Clean Air Act Section 111 can reduce methane emissions by up to 50 percent, using available technologies and practices. Many of these measures can pay for themselves, by capturing and selling the methane that would otherwise be leaked into the atmosphere.

Endnotes

1 IPCC Working Group I, Fifth Assessment Report, Climate Change 2013: The Physical Science Basis, Chapter 8: Anthropogenic and Natural Radiative Forcing (2014) at 714 (Table 8.7), *available at* https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf. The Intergovernmental Panel on Climate Change (IPCC) uses standard 20-year and 100-year time horizons when calculating global warming potential. Methane initially has a large climate effect, but over longer time periods, its effect lessens, as the gas undergoes chemical reactions in the atmosphere.

2 *See* U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2012 (April 15, 2014), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf [hereinafter "EPA Greenhouse Gas Inventory 2014"]; *see also* Brandt, et al., *Methane Leaks from North American Natural Gas Systems*, Science, Vol. 343, No. 6172 (2014) (revised October 2, 2014), *available at* http://www.sciencemag.org/content/343/6172/733.full; Brandt, et al., *Supplementary Materials for Methane Leaks from North American Natural Gas Systems*, Science, Vol. 343, No. 6172 (2014) (revised October 2, 2014), *available at* http://www.sciencemag.org/content/suppl/2014/02/12/343.6172.733.DC1/1247045.Brandt.SM.revision2.pdf.

3 U.S. White House, U.S.-China Joint Announcement on Climate Change (November 12, 2014), *available at* http://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change.

4 The social cost of methane, like the social cost of carbon, is a metric that estimates the monetary value of impacts associated with marginal changes in methane emissions in a given year. It includes a range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that have an incremental impact on cumulative global greenhouse emissions).

5 Natural gas is composed of approximately 80 percent methane, and may also contain ethane, propane, butane, nitrogen, oxygen, carbon dioxide, sulfur, and water. The composition of natural gas extracted from producing wells depends on the type, depth, and location of the underground deposit and the geology of the area. Oil and natural gas are often found together in the same reservoir. *See, e.g.,* U.S. Energy Information Administration, Natural Gas Processing: The Crucial Link Between Natural Gas Production and Its Transportation to Market, *available at* http://www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2006/ngprocess/ngprocess.pdf.

6 Compared to the average air emissions from coal-fired generation, natural gas produces half as much carbon dioxide, less than a third as much nitrogen oxides, and one percent as much sulfur oxides at the power plant. The process of extraction, treatment, and transport of the natural gas to the power plant generates additional emissions. U.S. EPA, eGRID (2000); *see also* U.S. EPA, Natural Gas, *available at* http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html.

7 The IPCC uses standard 20-year and 100-year time horizons when calculating global warming potential, even though methane survives in the atmosphere for only 8 to 12 years. According to the IPCC, there is no scientific argument for selecting 20 years and 100 years, compared with other timeframes. Methane initially has a large climate effect, but over longer time periods, its effect lessens, as the gas under-

goes chemical reactions in the atmosphere. IPCC Working Group I, Fifth Assessment Report, Climate Change 2013: The Physical Science Basis, Chapter 8: Anthropogenic and Natural Radiative Forcing (2014) at 633, 711-712, 714 (Table 8.7), *available at* https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf. For the first time, the IPCC figures account for methane "climate-carbon feedback"; without climate-carbon feedback, the IPCC's updated 100-year GWP for methane is 28, and its 20-year GWP is 84. *Id*. at 713-714. Climate-carbon feedback refers to the interaction between temperature change, atmospheric greenhouse gas levels, and the carbon cycle. There are many climate feedback mechanisms that can either amplify or diminish the effects of climate change contributing factors. As an example of a positive feedback, an increase in concentration of greenhouse gases causes warming of earth's surface which in turn results in melting of glaciers. This melting exposes the darker ground surfaces that now can absorb more solar radiation. This increase in absorption causes a further rise in temperature which causes more melting and thus forms a cycle.

8 EPA's Greenhouse Gas Inventory currently uses a lower 100-year GWP of 21 for methane, based on the IPCC Second Assessment Report; it plans to use a higher 100-year GWP of 25, based on the IPCC Fourth Assessment Report, in its 2015 Greenhouse Gas Inventory. EPA Greenhouse Gas Inventory 2014, *supra* note 2, at ES-3.

9 United Nations Environment Program, Short-Lived Climate Pollutants, *available at* http://www.unep.org/ccac/Short-LivedClimatePollutants/Definitions/tabid/130285/Default.aspx.

10 IPCC, Fifth Assessment Synthesis Report (2014) at 95, *available at* http://ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf; National Research Council, Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia (2011), *available at* http://www.nap.edu/catalog/12877.html.

11 Quinn, P. K., et al., *Short-lived pollutants in the Arctic: their climate impact and possible mitigation strategies*, Atmos. Chem. Phys., Vol. 8 (2008), pp. 1723-1735; *see also* Drew Shindell, et al., *Simultaneously Mitigating Near-term Climate Change and Improving Human Health and Food Security*, 335 Science 183–89 (2012).

12 EPA Greenhouse Gas Inventory 2014, *supra* note 2, at ES-13.

13 Executive Office of the President, The President's Climate Action Plan (2013) at p. 10, *available at* http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

14 Prather, M., et al., Atmospheric chemistry and greenhouse gases, Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge Univ. Press, Cambridge and New York (2001).

15 U.S. EPA, Overview of Greenhouse Gases: Methane Emissions, *available at* http://epa.gov/climatechange/ghgemissions/gases/ch4.html.

16 EPA Greenhouse Gas Inventory 2014, *supra* note 2, at 3-2 (Table 3-1). In 2012, methane emissions from oil and natural gas systems (which include production, transportation, refining, storage, and distribution) totaled 161.6 teragrams (tg) of carbon dioxide equivalent. Using EPA's outdated GWP of 21, this is equal to 7.7 million metric tons (MMT) of methane. The 6.5 million homes figure is from: David McCabe, *Waste Not: Common Sense Ways to Reduce Methane Pollution from the Oil and Natural Gas Industry, Clean Air Task Force*, Natural Resources Defense Center, and Sierra Club, at 4 (December 2014), available at http://www.catf.us/resources/publications/files/WasteNot.pdf [hereinafter "Waste Not Report"]

17 U.S. Energy Information Administration, Crude Oil Production: 2008-2013, *available at* http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm; U.S. Energy Information

Administration, U.S. Natural Gas Marketed Production: 1900-2013, *available at* http://www.eia.gov/dnav/ng/hist/n9050us2a.htm.

18 U.S. Energy Information Administration, Annual Energy Outlook: Total Energy Supply, Disposition, and Price Summary Table (2012), *available at* http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2012&subject=8-AEO2012&table=1-AEO2012&region=0-0&cases=ref2012-d020112c.

19 U.S. Energy Information Administration, Market Trends: Natural Gas (May 2014), *available at* http://www.eia.gov/forecasts/aeo/section_markettrends.cfm; U.S. Energy Information Administration, Annual Energy Outlook 2014 Early Release Overview, *available at* http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf (projecting that "natural gas production grows steadily, with a 56% increase between 2012 and 2040").

20 Equipment such as compressors and pneumatic valves vent methane by design as they process and move natural gas. Older equipment usually vents more methane than newer equipment, which can be designed to vent less methane. Methane is also burned off in an intentional process called flaring. Flaring combusts methane, producing carbon dioxide. Flaring methane most often occurs when natural gas is produced as a byproduct of oil production. Flaring or venting is also used to reduce the risk of fire or explosion, when gas cannot be stored or used commercially. Most, if not all, states that regulate flaring in oil and natural gas operations allow flaring or venting when necessary to protect public health, safety and welfare. For example, Colorado prohibits flaring and requires operators to notify emergency personnel if they flare gas pursuant to its "safety and welfare" exception. *See* Colorado Oil and Gas Commission, Rule 12 (as of Sept. 2014), *available at* https://cogcc.state.co.us/RR_Docs_new/rules/900Series.pdf.

21 EPA Greenhouse Gas Inventory 2014, *supra* note 2, at 3-2. In 2012, petroleum systems contributed 31.7 teragrams of carbon dioxide equivalent, and natural gas systems contributed 129.9 teragrams of carbon dioxide equivalent. Production field operations account for 98.4 percent of total methane emissions from petroleum systems. *Id.* at 3-55. Oil well operators commonly vent or flare methane, especially in areas without natural gas gathering pipeline infrastructure.

22 *Id.* at 3-2, 3-62, and 3-63. Natural gas system methane emissions come from field production (32 percent), processing (14 percent), transmission and storage (34 percent), and distribution (20 percent).

23 U.S. EPA, Natural Gas STAR Program: Breakdown of Emissions by Sector, Chart: 2012 Oil and Gas Methane Emissions, *available at* http://www.epa.gov/methane/gasstar/basic-information/index.html; *see also* EPA Greenhouse Gas Inventory 2014, *supra* note 2, at 3-11 to 3-13, 3-56, 3-64, and 3-67.

24 U.S. EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2011 (April 12, 2013), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf; U.S. EPA Greenhouse Gas Inventory 2014, *supra* note 2, at 3-11 to 3-13, 3-56, 3-64, and 3-67; Brandt, et al., S*upplementary Materials*, *supra* note 2.

25 Brandt, et al., *Methane Leaks, supra* note 2, at pp. 733-735 ("After normalization, the largest (e.g., national-scale) atmospheric studies suggest typical measured emissions ~1.5 times those in the GHGI."); Miller, S., et al., *Anthropogenic emissions of methane in the United States*, Proceedings of the National Academy of Sciences, Vol. 110, No. 50 (2013), *available at* http://www.pnas.org/content/110/50/20018.full ("EPA recently [in the 2013 Greenhouse Gas Inventory] decreased its [methane] emission factors for fossil fuel extraction and processing by 25–30% (for 1990–2011), but we find that [methane] data from across North America instead indicate the need for a larger adjustment of the opposite sign."); *see also* Caulton, et al., *Toward a better understanding and quantification of methane emissions from shale gas development*, Proceedings of the National Academy of Sciences, Vol. 111, No. 17 (2014) at pp. 6237-6242, *available at* http://www.pnas.org/content/111/17/6237.full ("The identification presented here of emissions during the drilling stage 2 to 3 orders of magnitude larger than inventory estimates indicates the need to

examine all aspects of natural gas production activity to improve inventory estimates. . ."); Horwath, et. al., *Methane and the greenhouse-gas footprint of natural gas from shale formations*, CLIMATIC CHANGE, Vol. 106, Issue 4 (2011), *available at* http://link.springer.com/article/10.1007/s10584-011-0061-5 (finding that 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the life-time of a well).

26 *See, e.g.,* Allen, D., et al., *Measurements of methane emissions at natural gas production sites in the United States*, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, Vol. 110, No. 44 (2013), *available at* http://www.pnas.org/content/110/44/17768.full.

27 Burnham, A., et al., *Life-cycle greenhouse gas emissions of shale gas, natural gas, coal and petroleum*, ENVIRON. SCI. TECHNOL. (2012) Vol. 46: 619–627, *available at* http://www.pubfacts.com/detail/22107036/Life-cycle-greenhouse-gas-emissions-of-shale-gas-natural-gas-coal-and-petroleum ("When compared to a coal boiler under a 100-year time horizon, a SG [shale gas] boiler has 31% fewer emissions while a SG NGCC [shale gas, natural gas combined cycle] plant has 52% fewer emissions."); Heath, G., et al., *Harmonization of initial estimates of shale gas life cycle greenhouse gas emissions for electric power generation*, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (2014) Vol. 11, No. 31, available at http://www.pnas.org/content/111/31/E3167.full (finding that "after harmonization, we find that per unit electrical output, the central tendency of current estimates of GHG emissions from shale gas-generated electricity indicates life cycle emissions less than half those from coal and roughly equivalent to those from conventional natural gas."); Venkatesh A., et al., *Uncertainty in life-cycle greenhouse gas emissions from United States natural gas end-uses and its effect on policy*, ENVIRON. SCI. TECHNOL. (2011) Vol. 45, pp. 8181–8189, *available at* http://www.fraw.org.uk/files/extreme/venkatesh_2011.pdf (comparing "an average coal plant" to "an efficient natural gas (NGCC) plant" and finding that with an average methane leakage rate of 2.2%, "on average, life cycle GHG emissions from the NGCC plant were about 50% lower than from the coal plant"); *see also* Brandt, et al., *Methane Leaks, supra* note 2 at pp. 733-735 ("LCA studies generally agree that replacing coal with NG has climate benefits."); Alvarez, R., et al., *Greater focus needed on methane leakage from natural gas infrastructure*, PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES (2012) Vol. 109 (17) at pp. 6435–6440, *available at* http://www.pnas.org/content/109/17/6435.full (finding that new natural gas power plants produce net climate benefits relative to efficient, new coal plants using low-gassy coal on all time frames as long as leakage in the natural gas system is less than 3.2% from well through delivery at a power plant).

28 *See, e.g.,* Burnham, A., et al., *Life-cycle greenhouse gas emissions of shale gas, natural gas, coal and petroleum,* ENVIRON. SCI. TECHNOL. (2012) Vol. 46: 619–627, *available at* http://www.pubfacts.com/detail/22107036/Life-cycle-greenhouse-gas-emissions-of-shale-gas-natural-gas-coal-and-petroleum; see also Nathan Myhrvold and Ken Caldeira, *Greenhouse gases, climate change and the transition from coal to low-carbon electricity*, ENVIRONMENTAL RESEARCH LETTERS, Vol. 7, No. 1 (February 2012) at p. 014019, *available at* http://iopscience.iop.org/1748-9326/7/1/014019/article.

29 Eric D. Larson, *Natural Gas & Climate Change,* CLIMATE CENTRAL (May 2013), *available at* http://assets.climatecentral.org/pdfs/NaturalGas-and-ClimateChange.pdf.

30 *Id.* at 31.

31 Schneising, O., et al., *Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations*, EARTH'S FUTURE, Vol. 2: 548–558 (2014), *available at* http://onlinelibrary.wiley.com/doi/10.1002/2014EF000265/full.

32 Pétron, G., et al., *Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study*, J. GEOPHYS. RES., Vol. 117, Issue D4 (2012), *available at* http://onlinelibrary.wiley.com/doi/10.1029/2011JD016360/abstract.

33 David T. Allen, *Methane emissions from natural gas production and use: reconciling bottom-up and top-down measurements*, CURRENT OPINION IN CHEMICAL

Engineering, Volume 5 (August 2014), pp. 78–83, *available at* http://www.sciencedirect.com/science/article/pii/S2211339814000525.

34 U.S. EPA, Final Rule – Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants, 77 Fed. Reg. 49490 (Aug. 16, 2012).

35 *Id.*

36 U.S. EPA, Fact Sheet: Overview of Final Amendments to Air Regulations for the Oil and Natural Gas Industry (2012), *available at* http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf.

37 Environmental Defense Fund, Co-Producing Wells as a Major Source of Methane Emissions: A Review of Recent Analyses, at 9, *available at* http://blogs.edf.org/energyexchange/files/2014/03/EDF-Co-producing-Wells-Whitepaper.pdf.

38 U.S. EPA, Office of Air Quality Planning and Standards, Regulatory Impact Analysis: Final New Source Performance Standards and Amendments to the National Emission Standards for Hazardous Air Pollutants for the Oil and Natural Gas Industry (Apr 2012) at 3-21, *available at* http://www.epa.gov/ttn/ecas/regdata/RIAs/oil_natural_gas_final_neshap_nsps_ria.pdf.

39 ICF International, Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries B-6 (March 2014) at 2-3, *available at* https://www.edf.org/sites/default/files/methane_cost_curve_report.pdf [hereinafter "ICF Report"]; *see also* Network for Public Health Law, Environmental Health—Hydraulic Fracturing Fact Sheet (Oct. 2011), *available at* https://www.networkforphl.org/_asset/w74j2w/.

40 U.S. EPA, Oil and Natural Gas Sector Hydraulically Fractured Oil Well Completions and Associated Gas During Ongoing Production (April 2014) at 23-24, *available at* http://www.epa.gov/airquality/oilandgas/2014papers/20140415completions.pdf.

41 *Id.* at 25 ("Any amount of gas that cannot be recovered can be directed to a completion combustion device in order to achieve a minimum 95% reduction in emissions. Additionally, both wells that co-produced oil and gas and were controlled with a REC [green completion] in the UT Austin study achieved greater than 98% reduction in methane emissions."); *see also* Allen, D., et al., *Measurements of methane emissions at natural gas production sites in the United States*, Proceedings of the National Academy of Sciences, Vol. 110, No. 44 (2013), *available at* http://www.pnas.org/content/110/44/17768.abstract ("In this work, net or measured emissions for the total of all 27 [green] completions are 98% less than potential emissions.")

42 U.S. EPA, Reduced Emissions Completions for Hydraulically Fractured Natural Gas Wells (2011), *available at* http://www.epa.gov/gasstar/documents/reduced_emissions_completions.pdf; *see also* Francis O'Sullivan and Sergey Paltsev, *Shale gas production: potential versus actual greenhouse gas emissions*, Environ. Res. Lett. Vol. 7 (2012), *available at* http://m.iopscience.iop.org/1748-9326/7/4/044030/pdf/1748-9326_7_4_044030.pdf.

43 Executive Office of the President, The President's Climate Action Plan (2013), at 10-11, *available at* http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf [hereinafter "Climate Action Plan"].

44 U.S. White House, Climate Action Plan: Strategy to Reduce Methane Emissions (March 2014), *available at* http://www.whitehouse.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf [hereinafter "Methane Strategy"]

45 U.S. EPA, White Papers on Methane and VOC Emissions, *available at* http://www.epa.gov/airquality/oilandgas/whitepapers.html.

46 Methane Strategy, *supra* note 44, at 7-8.

47 U.S. EPA, Fact Sheet: Final Rule–Greenhouse Gas Reporting Rule:2014 Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems (Nov. 15, 2014), *available at* http://www.epa.gov/ghgreporting/documents/pdf/2014/documents/subpart_w_2014_revisions_factsheet.pdf.

[48] *Id.*

[49] Methane Strategy, *supra* note 44, at 7-8.

[50] U.S. EPA, Natural Gas STAR Program: Recommended Technologies and Practices, *available at* http://www.epa.gov/methane/gasstar/tools/recommended.html.

[51] *See* Bureau of Land Management, Venting & Flaring Public Outreach (May 15, 2014), *available at* http://www.blm.gov/live/pdfs/V&F_Outreach_04302014_public_FINAL.pdf.

[52] ICF Report, *supra* note 39, at 1-1.

[53] Waste Not Report, *supra* note 16, at 4.

[54] Bradbury, J. M., et al., *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*, Working Paper: World Resources Institute (2013) at p. 6, *available at* http://www.wri.org/publication/clearing-the-air.

[55] Susan Harvey, Vignesh Gowrishankar, and Thomas Singer, *Leaking Profits: The U.S. Oil And Gas Industry Can Reduce Pollution, Conserve Resources, And Make Money By Preventing Methane Waste*, Natural Resources Defense Council (2012) at pp. 18 - 19, *available at* http://www.nrdc.org/energy/files/Leaking-Profits-Report.pdf [hereinafter "Leaking Profits"].

[56] U.S. EPA, Natural Gas STAR Program, Recommended Technologies and Practices, *available at* http://www.epa.gov/gasstar/tools/recommended.html.

[57] Waste Not Report, *supra* note 16, at 7.

[58] *Id.* at 17. Because reserves are being developed so quickly, natural gas prices have fallen. ICF International and NRDC based their calculations on a gas price of $4/mcf (thousand cubic feet), based on average 2011 prices. The U.S. Energy Information Administration projects that gas prices will remain below $5/mcf through 2018. U.S. EIA, Annual Energy Outlook 2013, Early Release Overview (Dec. 5, 2012), *available at* http://www.eia.gov/forecasts/aeo/er/early_prices.cfm.

[59] Waste Not Report, *supra* note 16, at 7; *see also* U.S. EPA, Oil and Natural Gas Sector Hydraulically Fractured Oil Well Completions and Associated Gas During Ongoing Production (2014) at 23 – 27.

[60] *Leaking Profits*, *supra* note 55, at 18. These estimates were developed using a gas price of $4/mcf.

[61] U.S. EPA Office of Air Quality Planning and Standards, Oil and Natural Gas Sector Liquids Unloading (2014) at 10, 16, 20-23, *available at* http://www.epa.gov/airquality/oilandgas/pdfs/20140415liquids.pdf; ICF Report, *supra* note 39, at 3-17.

[62] Waste Not Report, *supra* note 16, at 7.

[63] U.S. EPA Office of Air Quality Planning and Standards, Oil and Natural Gas Sector Liquids Unloading (2014) at 14-16; *see also Leaking Profits, supra* note 55, at 18; ICF Report, *supra* note 39, at 3-17.

[64] *Leaking Profits*, *supra* note 55, at 6.

[65] Waste Not Report, *supra* note 16, at 7.

[66] ICF Report, *supra* note 39, at 3-16.

[67] ICF Report, *supra* note 39, at 2-5.

[68] *Leaking Profits*, *supra* note 55, at 6.

[69] Waste Not Report, *supra* note 16, at 7.

[70] *Leaking Profits*, *supra* note 55, at 18.

[71] For example, using a gas price of $4/mcf, based on average 2011 prices, every billion cubic feet of methane captured and sold, rather than vented into the atmosphere, could generate approximately $4 million in gross revenue.

[72] U.S. EPA, Office of Air Quality Planning and Standards, Oil and Natural Gas Sector Hydraulically Fractured Oil Well Completions and Associated Gas During Ongoing Production (April 2014) at p. 2, *available at* http://www.epa.gov/airquality/oilandgas/2014papers/20140415completions.pdf (citing U.S. Energy Information Administration, Total Energy Annual Energy Review (2012), Tables 6.4 and 5.2).

[73] The American Petroleum Institute explains that in order to maximize profit and provide shareholders with the highest possible return on investment, the industry operates with a strict ranking of capital projects for maximum yield. *Leaking Profits*, *supra* note 55, at 9 (citing American Petroleum Institute and the International Petroleum Industry Environmental Conservation Association, Oil and Natural Gas Industry Guidelines for Greenhouse Gas Reduction Projects (March 2007), prepared by URS Corporation).

[74] According to the U.S. Energy Information Administration, gas prices are projected to remain below $5/Mcf through 2018. U.S. Energy Information Administration, Annual Energy Outlook 2013, Early Release Overview (Dec. 5, 2012), *available at* http://www.eia.gov/forecasts/aeo/er/early_prices.cfm.

[75] U.S. Energy Information Administration, North Dakota aims to reduce natural gas flaring (Oct. 24, 2014), *available at* http://www.eia.gov/todayinenergy/detail.cfm?id=18451.

[76] The social cost of methane is a metric that estimates the monetary value of impacts associated with marginal changes in methane emissions in a given year. It includes a range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that have an incremental impact on cumulative global greenhouse emissions). EPA economists have calculated the estimated social cost of a ton of methane emitted in 2015 to be $970. Marten, A. L., and S.C. Newbold, *Estimating the social cost of non-CO2 GHG emissions: Methane and Nitrous oxide,* Energy Policy (2012), Vol. 51, 957. A December 2014 report issued by Clean Air Taskforce, Natural Resources Defense Council, and Sierra Club found that available measures could reduce methane emissions from the oil and gas sector by 42 to 48 percent, at an estimated cost of $290 to $660 per ton of methane. Waste Not Report, *supra* note 16, at 42.

[77] The Bureau of Land Management's current regulations allow companies to vent or flare associated gas that, in the agency's view, cannot be economically captured. This results in lost revenue to the public. United States Department of the Interior, Royalty or Compensation for Oil and Gas Loss: Notice to Lessees and Operators of Onshore Federal and Indian Oil and Gas Leases (NTL-4A), *available at* http://www.blm.gov/pgdata/etc/medialib/blm/ak/aktest/energy/og_forms.Par.32669.File.dat/ntl4a.pdf. The Government Accountability Office found in 2010 that between 4.2 and 5 percent of all natural gas produced onshore on federal lands was vented, flared, or lost in fugitive emissions. The report also estimated that oil and gas operators could economically capture about 40 percent of their flared or vented natural gas on federal lands by using existing technologies. U.S. Government Accountability Office, Opportunities Exist to Capture Vented and Flared Natural Gas, Which Would Increase Royalty Payments and Reduce Greenhouse Gases (Oct. 2010), *available at* http://www.gao.gov/assets/320/311826.pdf.

[78] Bureau of Land Management, Venting & Flaring Public Outreach (May 15, 2014), *available at* http://www.blm.gov/live/pdfs/V&F_Outreach_04302014_public_FINAL.pdf.

[79] 42 U.S.C. § 7411(b)(1)(B); *see also* id. §7411(a)(2).

[80] 42 U.S.C. § 7411(b)(1)(A).

[81] U.S. EPA, Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 76 Fed. Reg. 52738, 52792 (Aug. 23, 2011)(citing U.S. EPA, 2011 U.S. Greenhouse Gas Inventory Report Executive Summary (2011)).

[82] 42 U.S.C. § 7411(a)(1).

[83] *Id.*

[84] *Id.* § 7411(d).

[85] U.S. EPA, Final Rule – Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants, 77 Fed. Reg. 49490 (Aug. 16, 2012).

[86] COLORADO DEPARTMENT OF HEALTH AND ENVIRONMENT, REVISIONS TO COLORADO AIR QUALITY CONTROL COMMISSION'S REGULATION NUMBERS 3, 6, and 7: Fact Sheet (2014), *available at* https://www.colorado.gov/pacific/sites/default/files/AP_Regulation-3-6-7-FactSheet.pdf.

[87] *Id.*

[88] WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY, AIR QUALITY DIVISION, STANDARDS AND REGULATIONS, NONATTAINMENT AREA REGULATIONS (10/24/2014), *available at* http://deq.state.wy.us/aqd/Resources-Division/Proposed%20Rules%20and%20Regs/Chapter%208%20-%20NAA-Existing%20Source,%20IBR%20draft%2010-24-14_REDLINE.pdf

[89] 40 C.F.R. § 60.22(b)(5).

[90] *Id.* § 60.23.

[91] *Id.* § 60.24(c).

[92] Wannier, G., et al., *Prevailing Academic View on Compliance Flexibility under § 111(d) of the Clean Air Act* 4, INSTITUTE FOR POLICY INTEGRITY, Discussion Paper No. 2011/2, *available at* http://policyintegrity.org/files/publications/Prevailing_Academic_View_on_Compliance_Flexibility_under_Section_111.pdf (emphasis added) (hereinafter *"Prevailing Academic View"*).

[93] *Id.* § 60.27(b).

[94] *Id.* § 2411(d)(2)(A).

[95] ICF REPORT, *supra* note 39, at 1-1.

[96] U.S. EPA, NATURAL GAS STAR PROGRAM: BREAKDOWN OF EMISSIONS BY SECTOR, CHART: 2012 OIL AND GAS METHANE EMISSIONS, *available at* http://www.epa.gov/methane/gasstar/basic-information/index.html.

[97] *Leaking Profits*, *supra* note 55, at 38.

[98] Richard K. Lattanzio, CONGRESSIONAL RESEARCH SERVICE, AIR QUALITY ISSUES IN NATURAL GAS SYSTEMS (March 4, 2013) at CRS-55, *available at* http://www.civil.northwestern.edu/docs/Tight-Shale-Gas-2013/Air-Quality-Issues-Natural-Gas-Ratner-2013.pdf. In addition, the 2012 New Source Performance Standards exempt activities and pieces of equipment in the transmission, storage, and distribution sectors of the industry. *Id.*

[99] *Prevailing Academic View*, *supra* note 92, at 4 (finding that a majority of legal academics who have examined the issue have concluded that the language of Section 111 "is broad enough to enable both EPA and states to incorporate compliance flexibility: using their statutory discretion, those authorities can define many flexible approaches as the most efficient (and therefore the "best") systems for reducing emissions at the sector level.")

[100] WASTE NOT REPORT, *supra* note 16, at 4.

[101] *Id.* at 40.

[102] 42 U.S.C. § 7511a(b)(2).

[103] U.S. EPA, *Green Book: Classifications of 8-Hr Ozone (2008) Nonattainment Areas*, *available at* http://www.epa.gov/airquality/greenbook/hnc.html (last updated July 2, 2014).

[104] *Id.*; U.S. EPA, *Map: 8-Hour Ozone Nonattainment Areas* (2008 Standard), *available at* http://www.epa.gov/airquality/greenbook/map8hr_2008.html.

[105] For example, Section 182 standards would likely not apply to any sources downstream of natural gas processing plants, where the volatile organic compound content of the gas stream is relatively low.

Institute *for*
Policy Integrity
new york university school of law

Institute for Policy Integrity
New York University School of Law
Wilf Hall, 139 MacDougal Street, New York, New York 10012
www.policyintegrity.org