



CLIMATE ACTION PLAN STRATEGY TO REDUCE METHANE EMISSIONS

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EXECUTIVE SUMMARY

Reducing methane emissions is a powerful way to take action on climate change; and putting methane to use can support local economies with a source of clean energy that generates revenue, spurs investment, improves safety, and leads to cleaner air. That is why in his Climate Action Plan, President Obama directed the Administration to develop a comprehensive, interagency strategy to cut methane emissions.

This document lays out that strategy – summarizing the sources of methane and trends in emissions; setting forth a plan to reduce both domestic and international methane emissions through incentive-based programs and the Administration’s existing authorities; and, outlining the Administration’s efforts to improve measurement of these emissions. This strategy also highlights examples of technologies and industry-led best practices that are already helping to cut methane emissions.

Today, methane accounts for nearly 9 percent of domestic greenhouse gas emissions. And although U.S. methane emissions have decreased by 11 percent since 1990, they are projected to increase through 2030 if additional action is not taken. As a key element of the Climate Action Plan, this strategy outlines new actions to reduce methane emissions. These actions will improve public health and safety while providing more energy to power our communities, farms, factories, and power plants. These steps will also make an important contribution to meeting the Administration goal of reducing U.S. greenhouse gas emissions in the range of 17 percent below 2005 levels by 2020. While the elements of the strategy will be further fleshed out in the coming months, Administration estimates show that steps along these lines could deliver greenhouse gas emissions reductions up to 90 million metric tons in 2020.

Through partnerships with industry, both at home and abroad, we have already demonstrated the technology and best practices to deliver substantial reductions in methane emissions. These cost-effective steps can deliver multiple benefits:

- *Economic Benefits:* Methane is the primary component of natural gas, so the recovery of methane that would otherwise be emitted can be productively used for power generation, heating or manufacturing. In addition, projects to reduce methane emissions can put people to work and spur investment in local economies.
- *Climate Change Benefits:* Every ton of methane in the atmosphere has a global warming effect that is more than 20 times greater than a ton of carbon dioxide. Thus, methane reductions yield important climate benefits, particularly in the near term.
- *Public Health:* Actions to reduce methane also improve the quality of the air we breathe. Methane is a contributor to ground level ozone, so cutting methane emissions reduces smog, which is associated with higher rates of asthma attacks. Moreover, methane is often co-emitted with volatile organic compounds, some of which are hazardous air

pollutants, and many measures can cost-effectively reduce both pollutants.

- *Safety:* Improved safety and reduced methane emissions go hand-in-hand, as in our natural gas transmission and distributions systems and coal mining industries.

Reducing Methane Emissions

The Administration is pursuing a targeted strategy that builds on progress to date and takes steps to further cut methane emissions from a number of key sources:

- **Landfills:** In the summer of 2014, the Environmental Protection Agency (EPA) will propose updated standards to reduce methane from new landfills and take public comment on whether to update standards for existing landfills. Through the Landfill Methane Outreach Program, EPA will further reduce methane emissions through voluntary programs – partnering with industry, state, and local leaders, many of whom are putting the methane waste to use powering their communities.
- **Coal Mines:** In April of 2014, the Interior Department’s Bureau of Land Management (BLM) will release an Advanced Notice of Proposed Rulemaking (ANPRM) to gather public input on the development of a program for the capture and sale, or disposal, of waste mine methane on lands leased by the Federal government. In addition, EPA will continue to partner with industry through its voluntary program to reduce institutional, technical, regulatory, and financial barriers to beneficial methane recovery and use at coal mines.
- **Agriculture:** In June, in partnership with the dairy industry, the US Department of Agriculture (USDA), EPA and the Department of Energy (DOE) will jointly release a “Biogas Roadmap” outlining voluntary strategies to accelerate adoption of methane digesters and other cost-effective technologies to reduce U.S. dairy sector greenhouse gas emissions by 25 percent by 2020. USDA and EPA will also continue to support biodigester technology deployment by providing financial and technical assistance through voluntary programs.
- **Oil and Gas:** Building on the success of voluntary programs and targeted regulations in reducing methane emissions from the oil and gas sector, the Administration will take new actions to encourage additional cost-effective reductions. Key steps include:
 - In the spring of 2014, EPA will assess several potentially significant sources of methane and other emissions from the oil and gas sector. EPA will solicit input from independent experts through a series of technical white papers, and in the fall of 2014, EPA will determine how best to pursue further methane reductions from these sources. If EPA decides to develop additional regulations, it will complete those regulations by the end of 2016. Through the Natural Gas STAR program, EPA will work with the industry to expand voluntary efforts to reduce methane emissions.

- Later this year, the BLM will propose updated standards to reduce venting and flaring from oil and gas production on public lands.
- As part of the Quadrennial Energy Review, and through DOE-convened roundtables, the Administration will identify “downstream” methane reduction opportunities.

Beyond these actions to reduce domestic methane emissions, the United States is also helping partners around the world to reduce methane emissions, including through the Climate and Clean Air Coalition and the Global Methane Initiative.

Improving Methane Measurement

Methane emissions come from diverse sources and sectors of the economy, unevenly dispersed across the landscape. These characteristics complicate measurement and attribution and lead to significant uncertainties in estimates of current and projected methane emissions. Better data collection and measurement will improve our understanding of methane sources and trends, and enable more effective management of opportunities to reduce methane emissions. Key steps under the strategy to improve data quality include:

- Developing new measurement technologies, including lower-cost emissions sensing equipment.
- Addressing areas of higher uncertainty in bottom-up inventories through additional data collection, direct emission measurements, and research and analysis.
- Enhancing top-down modeling and monitoring based on direct measurement of atmospheric concentrations.

I. SOURCES AND TRENDS IN METHANE EMISSIONS

Methane has a global warming potential more than 20 times greater than that of carbon dioxide, per metric ton; on this basis, emissions of methane from human-related sources were equivalent to approximately 560 million metric tons of carbon dioxide pollution in 2012 – making up nearly 9 percent of all the greenhouse gases emitted as a result of human activity in the United States¹. Since 1990, methane emissions in the United States have decreased by 11 percent, even as many activities that can produce methane have increased. However, methane emissions are projected to increase to a level equivalent to over 620 million tons of carbon dioxide pollution in 2030 absent additional action to reduce emissions. The main sources of human-related methane emissions are agriculture (36 percent), natural gas systems (23 percent), landfills (18 percent), coal mining (10 percent), petroleum systems (6 percent), and wastewater treatment (2 percent)².

II. REDUCING METHANE EMISSIONS

On June 25, 2013, the President issued a broad-based Climate Action Plan to cut the pollution that causes climate change and damages public health. The plan has three key pillars: cutting domestic greenhouse gas emissions, preparing the United States for the impacts of climate change, and continuing American leadership in international efforts to combat global climate change.

Low-cost technologies and best practices to recover methane and cut pollution are already widely available and used in key sectors. In addition to taking on climate change, reducing methane emissions has many other benefits. Recovered methane provides a local source of clean energy that can generate revenue and spur economic development. Reducing methane emissions can also improve safety and reduce local air pollution and odors. For example, landfill gas can be captured with collection systems and used for electricity generation or to provide fuel to a nearby factory. Methane recovered from coal mine degasification systems can be sold to natural gas pipelines or used on site for process heat. Methane generated from livestock manure can be captured through the use of biodigesters and used to generate electricity, avoiding fuel costs or providing a source of additional revenue. Methane that is vented or leaked from oil and natural gas production or processing facilities can be recovered through upgraded equipment and management practices that improve the company's bottom line.

This section outlines cost-effective opportunities to reduce methane emissions in four key sectors of our economy. It highlights new Administration actions to encourage voluntary emissions reductions and to set new standards where appropriate. The section also features key public-private sector initiatives that are cutting methane emissions or improving our understanding about specific sources of emissions. Finally, this section describes key U.S. efforts in helping

¹ Estimates of methane's potency as a greenhouse gas in this document use 100-year global warming potential values from the Second Assessment Report of the Intergovernmental Panel on Climate Change, as required by international reporting standards.

² These estimates are based on the Draft *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012*, EPA, February 2014. The draft 2014 GHG Inventory (calculating emissions from 1990 through 2012) includes several updates to the methane numbers. As a result of the recalculations, in the draft 2014 Inventory, the total methane emissions estimate decreased by about 4 percent from the previous estimate.

international partners to reduce their methane emissions.

Reducing Emissions from Landfills

Municipal solid waste landfills are the third-largest source of human-related methane emissions in the United States, accounting for approximately 18 percent of methane emissions in 2012, equivalent to approximately 100 million metric tons of carbon dioxide pollution. Instead of allowing landfill gas to escape into the air, there is an opportunity to capture this gas and use it as a source of clean energy. In fact, standards and programs already in place have reduced landfill emission considerably, while creating jobs and improving public health. The Administration is committed to further reducing landfill emissions and tapping this important energy resource:

- **Updating Common Sense Rules to Reduce Landfill Emissions:** EPA will release a proposed update to its current standards for new municipal solid waste landfills in the summer of 2014, including assessing opportunities for further minimizing emissions when landfills are built or modified. Since there may be an even bigger opportunity for reducing methane emissions at existing landfills, EPA will also issue an Advanced Notice of Proposed Rulemaking (ANPRM) by June 2014 to engage industry and stakeholders on a range of approaches for cutting methane-rich landfill gases currently being emitted by existing facilities.

Case Study: Blue Ridge Renewable Energy Plant in Pennsylvania

In a true private-public partnership, landfill gas supplier IESI Blue Ridge Landfill, power purchaser Borough of Chambersburg and project developer PPL Renewable Energy (PPLRE) worked closely together to bring this 6.4-megawatt landfill gas electricity project online after only seven months of construction. In addition to designing, constructing, owning, and operating the LFG electricity plant at the landfill, PPLRE designed, permitted, and built the dedicated, 4-mile Express Generator Feeder from the plant to the Borough's Cree substation. Coming full circle, waste that Borough residents and businesses deposited in the landfill now supplies about 15 percent of its 11,000 customers' electric needs, plus the Borough was able to decrease the price of electricity those customers pay. In addition, the project generates 50,000 renewable energy credits annually toward meeting the state renewable energy goal.

- **Enhancing Landfill Gas-to-Energy Projects:** EPA will continue to work with municipalities and landfill owners to advance cost-effective voluntary energy recovery projects at landfills through the Landfill Methane Outreach Program.
- **Reducing Landfill Waste:** Through the U.S. Food Waste Challenge, the USDA and EPA are challenging producers, processors, manufacturers, retailers, communities, and other government agencies to help reduce, recover, or recycle food waste. Less waste in our landfills, means less methane emissions, a win-win.

Capturing Methane Emissions from Coal Mining

In 2012, 10 percent of human-related methane emissions came from the coal mining sector, equivalent to 56 million tons of carbon dioxide pollution. When recovered safely, coal mine methane can be a valuable, clean-burning source of energy. One of the most important co-benefits to reducing methane emissions at coal mines is increasing mine safety since uncontrolled methane emissions can cause fires and explosions. To further reduce coal mine

methane emissions, the Department of Interior's BLM and the Environmental Protection Agency will take actions in two key areas:

- **Establishing a Program to Reduce Waste Coal Mine Emissions on Public Lands:** The BLM will release an Advanced Notice of Proposed Rulemaking (ANPRM) in April 2014, to solicit public input on the development of a program for the capture, sale, or disposal of waste mine methane from Federal coal leases and Federal leases for other solid minerals. The ANPRM will seek public input on preferred technology options for methane capture, whether the BLM should promote partnerships to capture or destroy waste mine methane, and how the agency could encourage cost-effective capture of methane from coal mines.
- **Overcoming Barriers to Reducing Coal Mining Emissions:** Since the Coalbed Methane Outreach Program's launch in 1994, the coal mining industry has nearly doubled its total methane recovery and use. Currently, over 20 mines have installed methane degasification systems. The EPA will continue to work with industry through this voluntary program to encourage recovery and beneficial use of methane by helping to overcome institutional, technical, regulatory, and financial barriers. The EPA will also continue to coordinate with the Department of Labor's Mine Safety and Health Administration to ensure that implementation of methane recovery projects at coal mines is consistent with all applicable safety standards and with the BLM's efforts to facilitate coalbed methane capture and use on Federal lands.

Reducing Emissions from Agriculture

Thirty six percent of human-related methane emissions come from the agricultural sector in the United States, equivalent to over 200 million tons of carbon pollution. This strategy addresses emissions from agriculture exclusively through voluntary actions, not through regulations. The most important voluntary opportunities are through manure management with anaerobic digestion and biogas utilization. Biogas systems are proven and effective technology to process organic waste and generate renewable energy. They can reduce the risk of potential air and water quality issues while providing additional revenue for the operation. Yet, there are still relatively few digesters in operation on farms across America. To encourage adoption of this technology, the Administration is committed to promoting additional, cost-effective actions to reduce methane emissions through voluntary partnerships and programs, including:

- **Developing a Biogas Roadmap:** This June, in partnership with the dairy industry, USDA, EPA and DOE will jointly release a Biogas Roadmap outlining voluntary strategies to accelerate the adoption of biogas systems and other cost-effective technologies to reduce greenhouse gas emissions. This work will support the U.S. dairy industry goal to reduce greenhouse gas emissions by 25 percent by the year 2020 for the entire value chain.

- Enhancing Biogas System Deployment:**
 USDA will continue to support biogas system deployment by providing financial and technical assistance through the Natural Resources Conservation Service's Environmental Quality Incentive Program and Rural Development's Rural Energy for America Program, Bioenergy Program for Advanced Biofuels, and Biorefinery Assistance Program. The Natural Resources Conservation Service Conservation's Innovation Grants program is already catalyzing reductions in methane emissions through projects on rice cultivation and manure management. Through the AgSTAR program, EPA and USDA will continue working together to overcome barriers to expanding the use of agricultural biogas systems, and provide a forum for industry and other stakeholders to access information.

The Dairy Innovation Center "Dairy Power" Project

The Innovation Center for U.S. Dairy's "Dairy Power™" project is focused on realizing the significant potential of anaerobic digester systems that can produce clean energy and value-added products, generate revenue for dairy producers and create jobs. The Dairy Power project report findings show a \$3 billion market potential through the products and co-products developed by mature digester systems that process manure and commercial food waste, with additional value for potential nutrient trading markets, and renewable energy and low-carbon energy production incentives.

Reducing Methane Emissions from the Oil and Natural Gas Sectors

In 2012, 28 percent of methane emissions were attributed to the oil and natural gas sectors. Methane equivalent to 127 million tons of carbon dioxide pollution was emitted from production, processing, transmission, storage, and distribution of natural gas. Methane equivalent to 32 million tons of carbon dioxide pollution was emitted from production and refining, of oil. Within the natural gas industry, approximately 31 percent of this methane came from production sources, 15 percent from processing, 34 percent from the transmission and storage, and 20 percent from distribution. As our use of natural gas in manufacturing, transportation, and power generation increases – creating jobs, reducing costs, cutting carbon pollution, and reducing dependence on foreign oil in our nation – we must continue to build on progress in reducing methane emissions from this vital sector of our economy.

There are cost-effective technologies and best management practices to capture methane from venting and leaks across the entire oil and natural gas value chain. These range from equipment upgrades or replacements, to process or operational changes. Building on progress to date, the Administration will undertake new steps, including:

- Working with States:** States are the primary regulators of many aspects of oil and gas production activities and the distribution of natural gas. DOE and EPA will continue to provide technical assistance in support of effective state policy actions to reduce emissions, and to encourage broader adoption of proven mitigation strategies.
- Building on Common-Sense Federal Standards:** Since 2012, the EPA has taken a series of steps to address air pollution from the oil and gas sector. On April 17, 2012, the EPA issued final regulations to reduce the emissions of volatile organic compounds (VOCs), some of which are hazardous air pollutants, establishing, among other things, the first Federal air pollution standards for natural gas wells that are hydraulically

fractured, along with requirements for other sources, such as compressors, that were not previously regulated at the Federal level. Although these regulations targeted VOCs, they also reduced methane emissions substantially. EPA estimates that when fully implemented in 2015, the 2012 rules will decrease methane equivalent to 33 million tons of carbon pollution per year. Going forward, the EPA will deploy a carefully selected combination of policy tools to maximize cost-effective methane and VOC reductions from the oil and gas sector.

During the spring of 2014, the EPA will release a series of white papers on several potentially significant sources of methane in the oil and gas sector and solicit input from independent experts. The papers will focus on technical issues, covering emissions and control technologies that target both VOC and methane—with particular focus on oil and co-producing wells, liquids unloading, leaks, pneumatic devices and compressors. The agency will use these technical documents to solidify its understanding of these potentially significant sources of methane. This robust technical understanding will allow the agency to fully evaluate the range of policy mechanisms that will cost-effectively cut methane waste and emissions. The EPA will make peer reviewer comments available this summer. This fall, the EPA will determine what if any regulatory authorities, including setting standards under section 111 of the Clean Air Act or issuing Control Techniques Guidelines under section 182 of the Act, the agency will apply to emissions from these sources. If the agency determines to follow a regulatory course of action, it will undertake a schedule that will ensure that both rulemaking and any ensuing regulatory requirements for the states are completed by the end of 2016.

- **Enhanced Partnerships and Stakeholder Engagement:** The Administration will work collaboratively with key stakeholders to reduce methane emissions from natural gas systems.
 - In coordination with the Executive Office of the President and other Federal agencies, Secretary of Energy Ernest Moniz hosted a roundtable discussion on March 19, 2014 with leaders from industry, state governments, academic researchers, non-governmental organizations, and labor. DOE will sponsor additional roundtable discussions with stakeholders, with the primary objective of accelerating the adoption of best practices for reducing methane emissions from natural gas systems. Through these DOE roundtables the Administration also aims to:
 - Promote a common understanding of methane emissions from natural gas systems and related abatement opportunities.
 - Develop strategies for cost-effectively reducing methane emissions from processing, transmission and storage and distribution segments of the supply chain.
 - Catalyze greater action and engagement by policymakers at all levels of government, and encourage industry to embrace a common vision, including through participation in existing voluntary programs.
 - EPA will take steps to bolster its voluntary Natural Gas STAR Program, which has already identified over 50 cost-effective technologies and practices that reduce or

avoid methane emissions, by eliciting more robust industry commitments while enhancing transparency and accountability. In the spring of 2014, EPA will begin to engage the industry, states, and other key stakeholders on ways to enhance this program, and will formally launch the new partnership by the end of 2014.

- **Minimizing Venting and Flaring on Public Lands:** DOI's Office of Inspector General and the U.S. Government Accountability Office have both criticized BLM's outdated requirements governing venting and flaring for wasting Federal gas resources and associated royalties to the American taxpayer. To reduce the loss of natural gas through the venting or flaring of methane produced from Federal and Indian oil and gas leases, the BLM will develop a draft rule, known informally as Onshore Order 9, and anticipates releasing this proposed rule later this year. To aid in the development of the rule, DOI has begun outreach to tribes, industry and other stakeholders.

- **Identifying Policy Recommendations for Reducing Emissions from Energy**

Infrastructure: The first installment of the Quadrennial Energy Review (QER), to be released in January of 2015, will recommend actions that industry, and Federal and state governments can take to improve the performance of our energy transmission, storage and distributions systems. Building on the DOE roundtables, the QER will evaluate methane emissions abatement opportunities from the processing, transmission, storage and distribution segments of the natural gas supply chain. To help identify the most cost-effective mitigation options, DOE's Office of Energy Policy and Systems Analysis will work with the National Labs and EPA to evaluate technology cost estimates developed by NGOs and industry, and combine analysis with associated emissions data, recently updated by EPA.

- **Supporting Development of New Technologies to Reduce Emissions:** DOE will support the development of new technologies to enable more cost-effective emission reductions through several programs:

Reducing Downstream Emissions

Safety is a top priority for natural gas distribution companies and state regulators. Thirty-eight states have some form of accelerated infrastructure replacement cost recovery program in place. Many companies are working with their state regulators to accelerate the modernization, replacement and expansion of the nation's natural gas pipeline system. These efforts to enhance safety also put people to work and reduce methane emissions. Several cooperative efforts are also underway. A group of 13 American Gas Association members are working with the Environmental Defense Fund on a project to improve measurement of methane emissions from natural gas distribution systems. In addition, the Natural Gas Downstream Initiative, a group of natural gas utilities, is collaborating to address key technical and regulatory factors affecting methane emission reduction opportunities from natural gas distribution systems. Through the initiative, partners are working to identify and encourage programs that accelerate investments in infrastructure and promote outstanding operations, including modernizing their systems and utilizing next generation technologies. The initiative is focused on opportunities that can substantially reduce methane emissions and support safe, reliable and cost-effective service. Current partners include Consolidated Edison Company of New York, National Grid, Pacific Gas & Electric Company, Public Service Electric and Gas Company, and Xcel Energy.

- In December 2013, the DOE made up to \$8 billion in loan guarantee authority available for a wide array of advanced fossil energy projects under its Section 1703 loan guarantee program. Innovative technologies to reduce methane emissions from the coal mining and oil and gas sectors is one specific focus of this initiative, which will include regular solicitations for new loan applications.
- The 2015 Budget proposes a new \$4.7 million DOE program to speed development of technologies for leak detection and monitoring, pipeline leak repair without having to evacuate gas from the pipelines, smart pipeline sensors, and compressor controls. The program will be aimed at accelerating the commercialization of advanced pipeline inspection technologies. For example smart sensors could be distributed within the pipeline network and provide real-time continuous tracking of gas volumes and pipeline internal conditions.
- **Continuing to Prioritize Pipeline Safety:** The Pipeline and Hazardous Materials Safety Administration (PHMSA) will continue monitoring natural gas pipeline systems for safety, including requiring pipeline operators to take steps to eliminate leaks and prevent accidental releases of methane. Through this effort PHMSA has conducted a survey to evaluate each states progress to replace old, high-risk cast iron pipelines in their systems with new technologies that reduce leakage and accidental releases of methane over time.

U.S. Leadership in Reducing Global Methane Emissions

Methane accounts for approximately 15 percent of global annual greenhouse gas emissions. The United States is the recognized global leader in helping partners around the world to reduce methane emissions, including through the following two key actions:

- **Spearheading Key Initiatives in the Climate and Clean Air Coalition:** As a founding partner of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC) – which now includes nearly 40 country partners and key actors like the World Bank, UN Environment Programme, and World Health Assembly – the United States is helping to spearhead initiatives to across key sectors:
 - The CCAC Municipal Solid Waste Initiative is currently working with 26 cities in Africa, Asia and Latin America to develop sustainable municipal solid waste practices to reduce methane emissions from landfills and improve air quality, public health, and the environment. To scale-up and replicate these efforts, the initiative is helping to build the capacity of national governments; has created a global city network that promotes peer-to-peer learning and sharing of best practices; and is developing innovative, sustainable financing solutions.
 - The recently-launched CCAC Agriculture Initiative will promote improved manure management and rice cultivation practices through new global knowledge platforms, regional centers providing targeted assistance, and support to national and local early adopters of policies and technologies to catalyze large-scale practice change. This effort will not only reduce methane emissions and local pollution from the agriculture sector, it will also increase food security and productivity.

- The United States is working with international and corporate partners to launch the CCAC Oil and Gas Methane Partnership in 2014 with an initial group of oil and gas companies agreeing to systematically survey, report, and reduce methane emissions across a range of their participating operations. Participating companies will deploy proven and cost-effective technologies and practices across the largest sources of methane emissions in the oil and gas sector.
- Leveraging U.S. Technical Expertise through the Global Methane Initiative: Through the Global Methane Initiative (GMI), the United States leverages U.S. technical expertise to help partners around the world substantially reduce their methane emissions in five key sectors: agriculture; coal mines; municipal solid waste; oil and gas systems; and municipal wastewater. GMI is a public-private initiative with 43 partner countries, including all of the top 10 leading methane emitters, and over 1,000 members of the Project Network, including private sector, nongovernmental organizations, and multilateral organizations such as the World Bank, the Asian Development Bank, and the Inter-American Development Bank. GMI advances cost-effective, near-term methane recovery and use as a clean energy source, with a proven track record of helping to reduce methane emissions of over 220 million metric tons carbon dioxide since 2004, and identifying additional potential reductions that can be achieved cost-effectively. GMI has also developed a suite of tools and resources to help overcome barriers to methane capture and recovery and has built institutional capacity in Partner countries to ensure the long-term success of these efforts. These projects reduce greenhouse gas emissions in the near term and provide important environmental, safety, and economic co-benefits. The EPA is the lead agency from the U.S. Government and coordinates with the Department of State, Department of Energy, Department of Agriculture, USAID, and the Trade and Development Agency.

NGO-Industry Cooperative Research Initiative

In 2012, Environmental Defense Fund kicked off a series of studies — collaborating with more than 90 academic, research and industry partners — to better understand how much and from where methane is lost from the natural gas system today.

This project is investigating emissions from five key areas that make up the natural gas supply chain: production, gathering lines and processing facilities, long-distance pipelines and storage, local distribution and commercial trucks and refueling stations. The initiative includes 16 independent projects, all expected to be completed by the end of 2014.

III. IMPROVING MEASUREMENT OF METHANE SOURCES AND EMISSIONS

Our current understanding of methane sources and trends supports the steps to reduce emissions outlined in this strategy. At the same time, sharpening our ability to measure emissions will enable more targeted efforts in the future. For this reason, in addition to identifying technologies and best practices for reducing emissions, the Climate Action Plan also calls for an assessment of current methane emissions data. Unlike carbon dioxide, where emissions are easily estimated from well-tracked energy statistics, many sources of methane are more diffuse, not systematically tracked by statistics agencies, and thus considerably more uncertain.

Methods for Measuring Methane Emissions

The measurement and estimation of methane emissions currently occurs in two primary ways: through “bottom-up” greenhouse gas inventories, which focus on the specific source or activity causing the emissions, and through “top-down” methods that infer emissions from measurements of atmospheric methane concentrations. Each approach has different strengths, weaknesses, and uncertainties, and they play complementary roles. Bottom-up inventories provide the foundation for policy and programs and top-down approaches are utilized for independent validation and overall assessments of the efficacy of national and international efforts to reduce methane in the atmosphere.

Nationally, emissions are tracked by the EPA through a bottom-up inventory, the U.S. Greenhouse Gas Inventory (GHGI), a document all parties to the UN Framework Convention on Climate Change (UNFCCC) are required to produce. A suite of methods for such inventories are published by the Intergovernmental Panel on Climate Change and generally consist of statistical approaches involving activity factors (*e.g.*, number of gas wells, number of landfills), emissions factors (*e.g.*, methane emissions per gas well, methane emissions per landfill), and reductions data (*e.g.*, counts of devices or practices that reduce methane emissions, such as flares and anaerobic digesters). The quality of methane data for some sources in the GHGI can be highly variable, and consequently, emissions estimates for some sources entail considerable uncertainty.

The GHGI is also beginning to be supplemented by new data from the Greenhouse Gas Reporting Program (GHGRP), a congressionally mandated EPA program requiring large emitters of GHGs from many sectors to estimate and report their emissions to EPA. Methane data are now available for several important sectors (*i.e.*, landfills, petroleum and natural gas systems, underground coal mines, and industrial wastewater systems) and are generally consistent with the GHGI, although more analysis is planned.

In addition to estimating human-related emissions using bottom-up statistical approaches, aggregate emissions can be inferred using top-down atmospheric models and measured concentrations of methane in the atmosphere. Atmospheric methane concentrations are sampled in the United States, as well as globally, by a variety of instruments on towers, ships, and aircraft. The network is adequate to estimate average global emissions, but it lacks the density to quantify emissions in all regions or to systematically identify emissions sources.

In sum, bottom-up methods are necessary to characterize emissions sources with precision, which is critical for designing mitigation strategies. Top-down methods, while they cannot generally perform such attribution with high confidence, can help to validate bottom-up estimates using measured values and can help to identify emissions ‘hot spots’ for closer measurement.

Key Actions to Improve Methane Emissions Measurement and Monitoring

Administration efforts to improve U.S. methane measurement support two broad goals: 1) improving the bottom-up emissions data relevant for mitigation; and, 2) advancing the science and technology for monitoring and validating atmospheric concentrations. Within these broad goals, improvement opportunities exist across input data (*i.e.*, emissions factors, activity factors, and reductions data), atmospheric observations data, and the science needed to bridge between

atmospheric observations and bottom-up emissions data (*i.e.*, monitoring and validation science). Federal agencies are already investing in related enhancements, and this strategy announces several critical new activities to further improve methane emissions measurement. Examples of both include:

- **Encouraging the Development of Cost-Effective Measurement Technologies:** DOE's ARPA-E program is preparing a new methane program that will fund technologies to deliver an order-of-magnitude reduction on the cost of methane sensing, thus facilitating much wider deployment throughout all segments of natural gas systems.
- **Enhancing the US Greenhouse Gas Inventory:** EPA will continue to update and enhance the data published in its annual GHGI as new scientific evidence and data sources emerge. EPA will also continue to use the data collected through the GHGRP to improve the GHGI, particularly for the petroleum, natural gas, coal mining, and landfill sectors. This data will improve as additional reporting of inputs to emissions equations began in 2013 and, in 2015, EPA also plans to make ongoing improvements to the GHGRP regulatory requirements for petroleum and natural gas systems. In March 2014, EPA proposed revisions to GHGRP calculation methods, monitoring and data reporting requirements that would enhance the clarity and consistency of the reported data from petroleum and natural gas systems, such as for liquids unloading, completions and workovers, and compressors. The EPA will continue to review regulatory requirements to address potential gaps in coverage, improve methods, and help ensure high quality data reporting. DOE and USDA will also provide support to improve emissions factors. EPA efforts to improve the GHGI will promote transparency and stakeholder input by means of annual expert, public and international review periods.
- **Building our National Methane Monitoring Network:** National Oceanic and Atmospheric Administration (NOAA) scientists maintain a network of methane monitoring sites in the United States, including tall towers, periodic aircraft measurements, and surface measurements. NOAA has also conducted periodic aircraft-based methane measurements in six major U.S. oil and gas production regions. At its current funding level, this Carbon Observation and Analysis Program provides the minimum needed for climate modeling. To expand capabilities, the President's budget requests \$8 million above current funding of \$6.5 million for this program to:
 - Add 6 tall towers to the network, increasing the network to 14;
 - Enhance the measurement capabilities of all 14 towers;
 - Triple the frequency of aircraft-based observations.
- **Improving Local & Regional Emissions Modeling:** As part of DOE's ongoing unconventional gas program, DOE is funding two projects - one at Pennsylvania State University and one at Carnegie Mellon University - using tracer release methods and tower, automobile, aircraft monitoring, and other methods to measure and model methane emissions from the Marcellus region in Pennsylvania. A regional inventory of other methane sources including landfills, wetlands, water treatment facilities, and agriculture sources will also be obtained. The project is scheduled to begin in 2015 and end in 2017. Additionally, NASA's Jet Propulsion Laboratory JPL, is carrying out a Carbon in Arctic

Reservoirs Vulnerability Experiment, which includes regular monitoring of methane concentrations over Alaska's North Slope.

- **Improving Global Emissions Monitoring and Estimates:** EPA is collecting emissions reduction data through the Global Methane Initiative. EPA will also continue to update and publish detailed estimates and projections of global human-related non-CO₂ greenhouse gas emissions, and the mitigation potential from these sources. DOE's Atmospheric Radiation Measurement Climate Research Facility is making long-term methane flux measurements at multiple permanent locations around the world. NOAA runs the largest global network of GHG measurements and works closely with international partners and the World Meteorological Organization to ensure global measurements of GHG concentrations, including methane, are standardized. NOAA also consolidates data from this global network and releases the data to the public. Other Federal agencies (e.g. NASA and DOE) also contribute to these networks. NASA and the National Institute of Standards and Technology are helping to fund the Megacities Carbon Project, an international research effort to develop and demonstrate a scientifically robust capability to measure multi-year emission trends of CO₂, methane, and carbon monoxide attributed to individual megacities and selected major sectors in those cities. In addition, USDA's Forest Service is working with international partners, universities and the USAID on international efforts that monitor methane on sites in Mexico, Ecuador, Colombia, and Peru.