REDUCING METHANE EMISSIONS IN THE U.S. AND CHINA

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BACKGROUND AND CHALLENGES

Cutting methane emissions is key to slowing climate change in the near-term and can contribute to limiting global temperature rise to within 1.5 degrees Celsius (C). As a short-lived climate pollutant, methane is about 80 times more potent than carbon dioxide over timescales of 10-20 years (IPCC, 2021). Methane is estimated to be responsible for approximately 30% of today's anthropogenic global warming (IPCC, 2013), second to only carbon dioxide (CO_2) (Figure 1).

Taking targeted action on reducing methane could avoid nearly 0.3 C of global warming by the 2040s (UNEP & CCAC, 2021), thus providing more time to adopt more ambitious action to reduce carbon emissions. By 2030, measures that reduce methane can cut warming more significantly than those that reduce CO_2 emissions, which have less impact on mitigating warming in the first 20 to 30 years, due in part to unmasking of co-emitted cooling aerosols (Dreyfus et al., 2022). Additionally, because methane emissions contribute to ozone pollution with adverse effects on human health and productivity of food production, its reduction can provide co-benefits in improved air quality, better health, and increased crop production (UNEP & CCAC, 2021).

Strong evidence suggests that the increase in the atmospheric abundance of methane is due to growth in emissions from fossil fuel activities, agricultural efforts, and waste sources. Among these, the agricultural sectors contribute the most. Globally, to effectively limit the temperature rise to within 1.5 degrees C of preindustrial levels and avoid catastrophic climate impacts, the world must rapidly reduce methane emissions in addition to decarbonizing the global energy sector. Given that technologies exist to cut nearly half of anthropogenic methane emissions by 2030 from the main sources (UNEP & CCAC, 2021), major countries have started pursuing methane mitigation actions.

Recently, there have been several international efforts to address methane emissions reduction through international agreements. Some regional treaties were formed to further reinforce the reduction of methane emissions like the Convention on Long-Range Transboundary Air Pollution (LRTAP), which included Europe, North America, Russia, and former Eastern Bloc countries (State Department's Office of Environmental Quality, 2017). The Global Methane Pledge was launched at the UN Climate Change Conference (COP26) with leading participation from the U.S. and the European Union (and now includes 121 signatories). The Global Methane Pledge commits to a methane emissions reduction target of 30% from 2020 levels by 2030 globally. The U.S. further

Figure 1 | Observed Warming by Contributions from 2010 - 2019

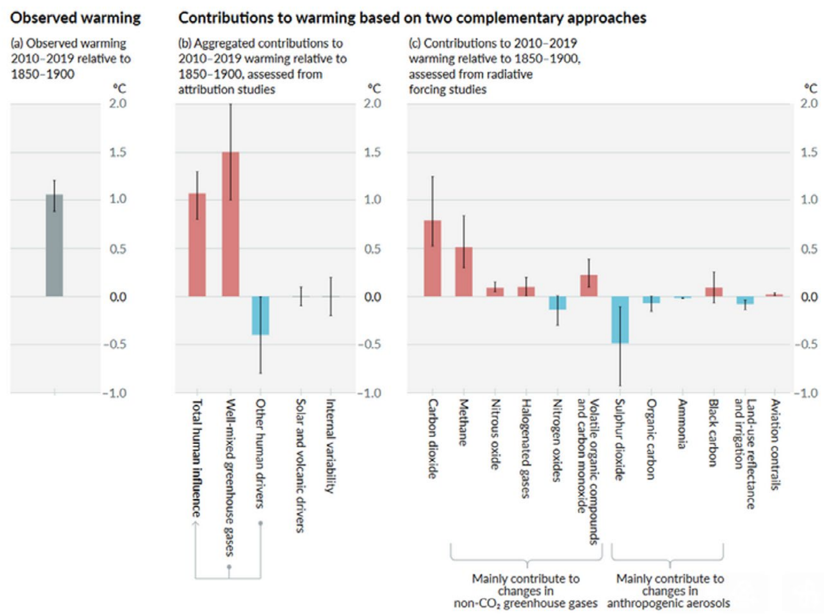


Figure SPM.2 | Assessed contributions to observed warming in 2010–2019 relative to 1850–1900

Panel (a) Observed global warming (increase in global surface temperature). Whiskers show the *very likely* range.

Panel (b) Evidence from attribution studies, which synthesize information from climate models and observations. The panel shows temperature change attributed to: total human influence; changes in well-mixed greenhouse gas concentrations; other human drivers due to aerosols, ozone and land-use change (land-use reflectance); solar and volcanic drivers; and internal climate variability. Whiskers show *likely* ranges.

Panel (c) Evidence from the assessment of radiative forcing and climate sensitivity. The panel shows temperature changes from individual components of human influence: emissions of greenhouse gases, aerosols and their precursors; land-use changes (land-use reflectance and irrigation); and aviation contrails. Whiskers show *very likely* ranges. Estimates account for both direct emissions into the atmosphere and their effect, if any, on other climate drivers. For aerosols, both direct effects (through radiation) and indirect effects (through interactions with clouds) are considered.

{Cross-Chapter Box 2.3, 3.3.1, 6.4.2, 7.3}

Data Source: IPCC, 2021

co-launched the so-called Energy Pathway of the Global Methane Pledge[1] focusing on eliminating routine flaring in fossil fuel operations and cutting methane pollution in the oil and gas sector.

U.S. Background and Challenges

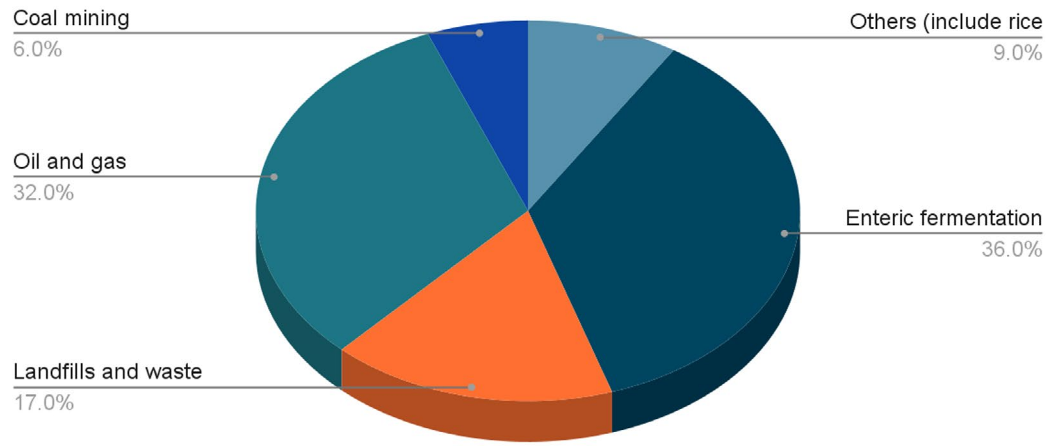
In the U.S. the energy and agricultural sectors are the two biggest contributors to methane emissions. The oil and gas industry accounts for most of the energy-related methane emissions, and when combined with coal mining, contributes a total of 40% of national methane emissions (Figure 2). The agriculture sector contributes another 45% of the methane emissions, with most of it coming from enteric fermentation, which is a natural part of the digestive process in cattle, sheep, and goats.

In advance of COP26, President Biden committed the U.S. to a nationally determined contribution (NDC) target of 50-52% net greenhouse gas (GHG) emissions reduction below 2005 levels by 2030. Domestically, the U.S. released its Methane Emissions Reduction Action Plan in November 2021, which calls for substantial reductions in U.S. methane emissions resulting from updated and new rules for oil and gas infrastructure, the adoption of voluntary initiatives to reduce methane emissions from landfills with a federally-enforceable "backstop" limit for large municipal landfills, and the development of "climate-smart" agriculture programs and initiatives which will, among other goals, drive the capture of agricultural methane to produce renewable energy. In California, the existing policy (Lara, 2016) requires a 40% reduction of methane emissions by 2030, compared to 2013 levels.

Multiple policy opportunities exist at federal and sub-national levels to reduce methane. The Inflation Reduction Act of 2022 (US Congress, 2022) includes a program that would place a

1 *The Global Methane Pledge*, which was first announced at COP26 in Glasgow in November 2021, now has been joined and endorsed by 121 countries, representing about three quarters of the global economy. China is currently not a member of the Pledge.

Figure 2 | U.S. Methane Emissions by Source (2020)



Data Source: U.S. EPA. All emission estimates from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2020

fee on methane emissions from key oil and gas facilities (starting at $900/ton in 2024 and rising to $1500/ton in 2026), which would create a significant new policy to reduce emissions. In addition, the regulatory agenda as outlined in the Methane Action Plan is being implemented, including new Environmental Protection Agency (EPA) regulations on new and existing oil and gas infrastructure. Many of the other options in the recent U.S. Methane Action Plan rely on such regulatory measures.

Such actions do not depend on Congressional approval and would continue to be developed and implemented through at least the end of the Biden Administration's term—with impacts continuing thereafter. Finally, subnational governments in the U.S. have most of the authority to regulate methane emissions from agriculture and landfills. In California, as set forth in its statute SB 1383, California Air Resources Board and California Department of Food and Agriculture are authorized to regulate methane emissions from livestock and dairy, as well as organic waste and landfills (Lara, 2016). Cities and states also have authority on gas pipeline distribution networks and can take actions to reduce leaks. Methane has also been an area for some active public-private partnerships between states, the federal government, and businesses.

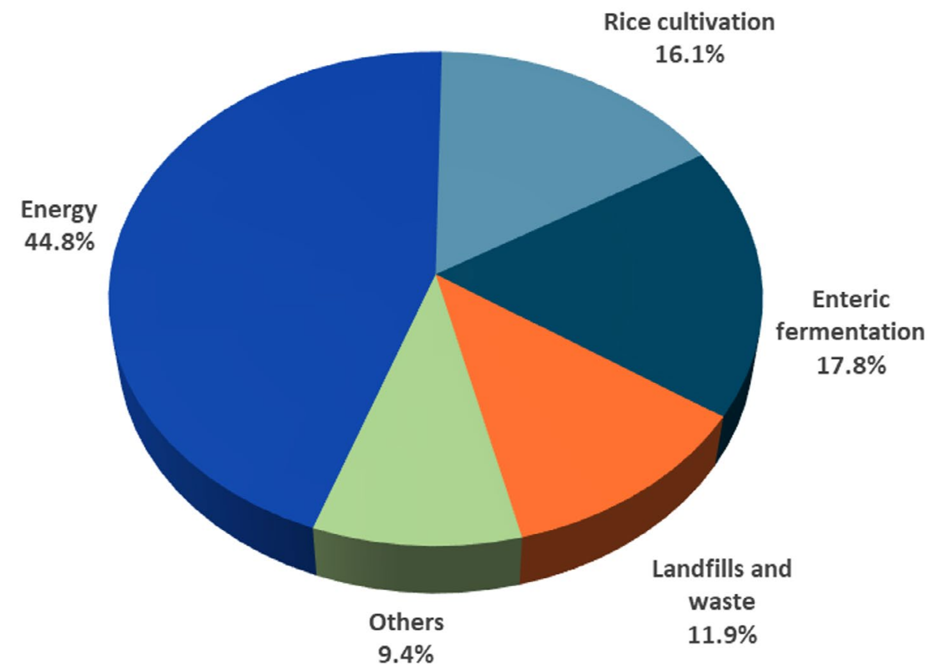
At the same time, the U.S. faces some challenges to increased methane action. With the outcome of the 2022 Congressional elections uncertain, there is a chance that the next Congress would not take further action on methane. In addition, future administrations, if they are not committed to climate action, have some ability to roll back regulations— but these efforts take time and are not always viable. Some questions have also been raised about the implications of the recent Supreme Court ruling regarding the EPA's authority over the electricity sector. While this ruling does constrain certain regulatory strategies from the EPA, it is not a blanket prohibition on regulations, and methane-related regulations are not implicated in the reasoning of the court. However, it is probable that new regulations will continue to be challenged in the courts. Many challenges do not succeed, but some do, and this fact raises some uncertainty about regulatory initiatives.

Further, mitigation strategies on non-CO_2 GHGs are underdeveloped in certain subsectors and available mitigation technologies are often in earlier stages of technological development (U.S. DOS & U.S. EOP, 2021). Moreover, sources of non-CO_2 emissions are also diverse, and individual strategies need to be developed for each subsector and gas. While there are significant improvements in recent years in tracking methane emissions with advanced technologies, there are still significant gaps in measuring and reporting of methane emissions in selected sectors and applications.

China Background and Challenges

China's methane emissions totaled 55.29 million tonnes of methane (with Land Use, Land-Use Change and Forestry) (or 1161 million tonnes of carbon dioxide equivalent (CO_2e), based on 100 year global warming potential (GWP)[2]) in 2014, accounting for 10.4% of national GHG emissions (in CO_2-equivalent). The energy sector, dominated by coal mining, contributes 44.8% of total methane emissions with agriculture accounting for another 40.2% share (Ministry of Ecology and Environment, 2019) (Figure 3).

Figure 3 | China's Methane Emissions by Source (2014)



Data source: Ministry of Ecology and Environment, 2019

Since China's 12th Five-Year Plan (2011-2015), its climate change policies have included some qualitative mentions of the need to control non-CO_2 greenhouse gases, including methane. The need to effectively control GHG emissions, including methane, was part of the Work Plans for the 12th, 13th and 14th Five-Year Plans. Although there is no official confirmation, some Chinese officials expressed that China's carbon neutrality by 2060 pledge includes methane (Xie, 2021), and its updated NDCs include actions to address methane emissions.

In the "U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s" that the two countries announced at COP26 in Glasgow, China expressed its intent to develop a comprehensive and ambitious National Action Plan on methane, aiming to achieve a significant effect on methane emissions control and reductions in the 2020s (US DOS, 2021). Based on remarks by Ministry of Ecology and Environment officials in March 2021, the action plan will likely include the introduction of new policies, technologies, and standards in sectors including oil and gas, coal, and waste, along with the use of market mechanisms for reductions (Li, 2021). Currently, there are no national overarching methane reduction goals or sectoral goals for China's biggest methane emitters in the energy sector (coal mines, and oil and gas facilities[3]). That said, some major oil and gas

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[2] Based on the energy absorbed over 20 years instead of 100 years, 20-year GWP is sometimes used as an alternative to the 100-year GWP. This 20-year GWP prioritizes gases with shorter lifetimes, because GWPs will be larger for gases with lifetimes shorter than that of CO^2. For methane, the 100-year GWP of 27–30 is much less than the 20-year GWP of 81–83. In other words, the amount of CO^2e of methane emission will be higher if 20-year GWP is used.

[3] In China, only the coal sector is subject to legally binding emission standards. In 2008, the former Ministry of Environmental Protection promulgated the "*Emission Standard of Coalbed Methane/Coal Mine Gas (on trial)*". This standard stipulated that coalbed methane with a volume concentration of methane greater than or equal to 30% shall not be discharged directly, laying the foundation for the control of methane emissions in the coal industry. China's National Energy Administration is now working on modifying this standard (National Energy Administration, 2021).

firms have carried out monitoring and announced voluntary targets for methane reductions. Government agencies are working with relevant stakeholders in China, and the National Action Plan is expected to be released prior to COP27 in November 2022.

While China has made some progress in controlling methane emissions, there are still major challenges in mitigation strategy and policy, management system, research on mitigation measures, and data collection and monitoring.

There is a lack of complete emissions data and quantitative targets on controlling and reducing methane emissions in existing policies and programs. Most of the policies and measures adopted so far are qualitative in nature, and there is no systematic tracking and evaluation. Unlike for CO_2, there is currently not a robust monitoring, reporting, and policy evaluation system in place specifically for non-CO_2 greenhouse gases such as methane (Teng, Su, & Wang, 2019). The current data on baseline emissions are also outdated and from the 2014 national greenhouse gas emissions inventory.

There is a lack of comprehensive regulatory and management frameworks on methane emissions. Certain sectoral policies have been adopted, but due to a lack of tracking and monitoring, it is unclear how effective these policies are, such as the 2008 Standard on Coal Mine Methane (CMM) Emissions. For other incentives such as those for CMM and landfill gas utilization, financial subsidies promoted the adoption of mitigation measures. Yet it is difficult to assess systematically their impact on overall emissions reduction due to lack of coordination. There is also a need for greater awareness and capacity building to support methane mitigation efforts at the subnational level. This will be especially important for sectors such as waste and agriculture where the methane emission sources are more dispersed.

There is insufficient foundational research on science, technology, and policies in support of reducing methane and other non-CO_2 GHGs. Most of the techno-economic analysis for methane has been conducted in the U.S. and EU, and there is a lack of China-specific cost data for mitigation measures and technologies, except for rice cultivation. There is also a need for closer coordination between methane policy and overarching climate change strategy development, and for financial resources to support methane reduction policies and programs.

METHANE REDUCTION POTENTIAL IN KEY SECTORS

The latest assessment shows that currently available measures could reduce anthropogenic methane emissions from the energy production, waste, and agriculture sectors by 180 $MtCH_4$/year or 45% by 2030 (UNEP & CCAC, 2021). As two of the world's largest economies and energy consumers, China and the U.S. are also the first and third largest methane emitters in the world, respectively. Both countries hold significant potential in methane emissions reductions over the next decade, including potential for reductions at low or no cost. In the U.S., total methane reduction potential using abatement measures at or below \$100/tCO_2e is 224 $MtCO_2e$ in 2030 (US DOS & US EOP, 2021). A more recent analysis identified a similar reduction potential of 227 $MtCO_2e$ for methane in 2030, or over 30% reduction from 2020 levels, for the U.S. (Zhao et al., 2022). In China, methane reduction potential is estimated to reach 469 $MtCO_2e$ in 2030, or the equivalent of 35% reduction from 2015 levels (Lin et al., 2022). Similar upper bounds of methane reduction of 37% to 41% are found for China for 2030 relative to a Business-as-Usual scenario (U.S. EPA, 2022, Teng et al., 2019).

Energy (Supply) Sectors: Oil and Gas and Coal Mining

It is estimated by the International Energy Agency that emissions from the energy sector based on satellite data were 70% higher than officially reported, indicating substantial methane reduction potential exists in this sector. The greatest potential for methane emissions reductions from worldwide energy production is in the oil and gas sector, where the global reduction potential is 29-57 $MtCH_4$/yr (UNEP & CCAC, 2021). In the U.S., the methane mitigation potential of energy sectors up to \$100/tCO_2e is 144 $MtCO_2e$, with the greatest reduction potential coming from the oil and gas sector. In the oil and gas sector, mitigation measures include various system components that can be implemented through equipment modification or upgrades, changes in operational practices (including maintenance and repair), and new equipment installation (US DOS & US EOP, 2021). Another key to reducing methane emissions from the oil and gas sector is to update and improve monitoring measures to identify hot spots and super emitters.

Measures to reduce methane emissions from worldwide coal mining can reach potentially 12-25 $MtCH_4$/yr. (UNEP & CCAC, 2021) The primary methods for reducing coal emissions from active underground coal mines are ventilation air methane oxidation (which destroys methane at high temperature) and the recovery and use of methane through pre-mining degasification (UNEP & CCAC, 2021). Additionally, managing abandoned coal mines can help prevent leaking methane emissions. China sees much greater reduction potential in coal mining, due to the dominant role of the coal industry in its energy production. In 2030, for instance, 256 $MtCO_2e$ of methane reduction potential is estimated for China if deep mitigation measures are fully adopted in coal mining with average abatement cost of just below US\$14/tCO_2e. (Lin et al., 2022). If higher abatement costs of up to US\$100/tCO_2e are considered, 402 $MtCO_2e$ of reduction potential has been identified for China's coal mining sector (U.S. EPA, 2022). Combined with oil and gas, total energy sector methane reduction potential could reach 308 $MtCO_2e$ in China in 2030 with abatement costs below US\$40/tCO_2e (Lin et al., 2022), and reach 409 $MtCO_2e$ with abatement costs of up to US\$100/tCO_2e (U.S. EPA, 2022).

Agriculture

Globally, the agriculture sector is estimated to provide a reduction of 4-42 $MtCH_4$/yr from the livestock sub-sector–due to greater uncertainties around livestock mitigation measures—and 6-9 $MtCH_4$/yr from rice cultivation (UNEP & CCAC, 2021). Primary methods to reduce emissions from livestock involve improving feeding and manure management, while for rice cultivation emissions, the main mitigation measures are improved water management, alternate flooding and drainage of wetland rice, direct seeding, and improved yield gains (UNEP & CCAC, 2021). In the U.S., methane mitigation potential in 2030 is estimated at 72 $MtCO_2e$ (at \$100/tCO_2e), with the vast majority of reduction potential coming from the livestock subsector (US DOS & US EOP, 2021). In China, methane mitigation potential is estimated at 65-116 $MtCO_2e$ for similar abatement costs for the agriculture sector (U.S. EPA, 2022, Lin et al., 2022).

Waste

The waste sector is estimated to provide 29-36 $MtCH_4$/yr reduction potential globally (UNEP & CCAC, 2021). In the U.S. and China, landfill and waste sectors contribute similar shares of national methane emissions. Key mitigation measures include controlling and flaring of landfill emissions, landfill gas utilization systems, and diversion of organic waste from landfills and reduction of food and solid waste. The U.S. mitigation potential from the waste sector is estimated to be 8 $MtCO_2e$ (up to \$100/tCO_2e) in 2030 (US DOS & US EOP, 2021), while China's mitigation potential is estimated to be 26 - 45 $MtCO_2e$ in 2030 (U.S. EPA, 2022, Lin et al., 2022).

RECOMMENDATIONS AND OPPORTUNITIES FOR COLLABORATION

Review of existing international experiences with non-CO_2 greenhouse gas mitigation policies and programs highlights some common best practices in demonstrating leadership and effectiveness in both design and implementation. These include (Lin et al., 2022):

1. Committing to ambitious quantitative targets with a defined timeline
2. Comprehensiveness in policy scope and mitigation strategy development encompassing multiple gases and sectors

3. A multi-pronged approach to applying different types of policies, programs, and tools to support mitigation efforts
4. Coordination and complementarity between multilateral, national, and subnational mitigation actions
5. Reporting and data tracking to quantify both baseline emissions and emission reduction impacts of mitigation measures

Based on these international best practices and the current challenges related to methane emissions specific to each country, below are some recommendations for enhanced domestic actions by the U.S. and China and potential areas for collaboration.

Recommendations for the U.S.

As the largest economy in the world and the initiator of the Global Methane Pledge, the U.S. should:

- Seek to achieve significant methane reductions to support achieving the U.S. NDC and seek to include quantitative aspects of potential reductions as part of any national climate planning and strategies
- Finalize and adopt oil and gas emission rules and standards for new and existing sources to accomplish the goals listed in the U.S. Methane Action Plan
- Implement programs to remediate abandoned coal mines and plugging of abandoned oil and gas wells
- Develop a robust implementation plan in partnership with states to achieve 70% of methane reduction for large landfills
- Reduce food waste in landfills through composting programs (e.g., CA mandatory composting)
- Expand incentive-based and voluntary partnership efforts to reduce agricultural methane emissions
- Expand and strengthen building electrification programs to reduce methane usage in buildings through adoption of heat pumps and efficient buildings
- Invest in emerging technologies such as feed additives to significantly reduce remaining methane emissions
- Invest in robust MRV (measurement, reporting and verification) systems to ensure national and subnational programs achieve their intended outcomes

Recommendations for China

As the largest emerging economy in the world and the leading emitter of methane, China should:

- Seek to achieve significant methane reductions to support achieving its carbon neutrality by 2060 goal, and endeavor to commit to quantitative aspects of methane reduction as part of its national climate strategy process based on technical and economic feasibility
- Consider specific reduction goals and measures of methane emissions associated with the coal mining process, including updating coal mine methane standards and its implementation plan
- Accelerate transition to renewable electricity sources to reduce demand for coal
- Support remediation of abandoned coal mines and economic development of key mining regions
- Adopt domestic actions or harmonize with emerging international protocols in preventing leakage in the oil and gas industries

- Improve systems for data collection and inventory to support development of policies to track progress
- Adopt best practices in irrigation (e.g., humid and intermittent irrigation), animal feeds (e.g., improving nutritional balance of feed and feed digestibility), manure management and promote behavioral changes to reduce agricultural methane emissions
- Adopt best available solutions and/or technologies such as gas collection and flaring and potential waste reduction strategies (reducing landfills) to reduce waste methane emissions
- Consider allowing methane emission reduction to count as an offset under the national ETS (emissions trading system)

Opportunities for Collaboration

In recognition of the seriousness and urgency of the climate crisis and a significant gap between ongoing efforts and those that need to achieve the goals of the Paris Agreement, China and the U.S. have agreed to work individually, jointly, and with other countries during this decisive decade. Below is a list of areas where cooperation on enhanced actions between the U.S. and China could spur enhanced actions in each country and inspire global effort.

- National-level collaboration on reducing methane emissions in waste, energy, and agricultural sectors, including developing policies and incentives to promote implementation of mitigation measures and protocols;
- Subnational collaboration and pilots in reducing methane emissions in waste, energy, and agricultural sectors, including developing policies and incentives to promote implementation of mitigation measures and protocols, such as the oil and gas protocols in New Mexico, Colorado, and California, and agricultural methane reduction measures adopted in California;
- Enhancing the development of comprehensive inventory and MRV systems, standards and protocols, and the application of technological innovation such as in remote sensing and analytics in concert of better GHG inventories;
- Exchange on experience in coal methane mitigation projects and supporting incentives, including in collaboration with other major coal-producing countries;
- Accelerating the application of key mitigation technologies in the agricultural sector including but not limited to enteric fermentation, application of biochar (a soil additive that also increases crop yield) in rice cultivation that has been shown to reduce methane emissions substantially;
- Exchange on experience in plugging abandoned gas and oil wells that may continue to emit significant amounts of emissions, as well as exchange and cooperation in remediation of abandoned coal mines and economic development of key coal producing regions (including but not limited to Shanxi, Shaanxi, Inner Mongolia, Wyoming, and West Virginia;
- Exchange and collaboration on accelerating the adoption and development of heat pump technology (especially for cold climates) to replace coal and natural gas use in buildings;
- Exchange on designing and implementing programs to help disadvantaged communities (with excessive air pollution and a lack of access to public health services) to maximize the social benefits of a clean energy transition.
- Collaboration on spreading the use of biocover systems to reduce methane emissions from landfills. Biocovers are low-cost, effective, and enduring solutions for reducing landfill and compost methane, and dozens of studies have proven that biocovers are usually more efficient than gas collection systems.

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