

Non-CO₂ GHG Emissions Mitigation in China

Challenges and Opportunities

With the announcement of China's 2030 carbon peaking and 2060 carbon neutrality targets, the pathways to carbon emissions reduction have become clear. Taking actions to reduce non-CO₂ GHG emissions (mainly including six types of gases, namely methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride (NF₃), hereafter referred to as non-CO₂ GHGs) will strengthen China's efforts in GHG emissions reduction.

Recent scientific assessments indicate that rapid action to reduce non-CO₂ GHG emissions could significantly slow the rate of temperature rise over the next 25 years (Dreyfus et al., 2022; Xu & Ramanathan, 2017). Many countries and regions, including the EU and the US, have already begun to control non-CO₂ emissions. For example, the Global Methane Pledge, launched by the EU and the US, aims to reduce methane emissions by at least 30% by 2030 from 2020 levels. The EU also set a Methane Reduction Strategy in 2021 and has implemented the F-Gas Reduction Act.

An Overview of Existing Non-CO₂ GHG Emissions Reduction Actions

1. Non-CO₂ GHGs mitigation strategies and measures

Table 1: Policy actions to promote Non-CO₂ GHG emissions mitigation

Non-CO ₂ GHGs by gas	Major emission sources	2021 NDC	Domestic implementation	
			Existing non-CO ₂ GHGs mitigation measures	Existing policies
Total non-CO ₂ GHG emissions		Study and implement non-CO ₂ GHG emissions control action plans, continue to improve non-CO ₂ GHGs monitoring, reporting and verification systems,	Strengthen the control of methane and other non-CO ₂ GHG Emissions.	Opinions of the CPC and the State Council on the Complete and Accurate Implementation of the New Development Concept for Carbon Peaking and Carbon Neutrality.

¹ Institute of Climate Change and Sustainable Development of Tsinghua University. (2021). *China's Long-Term Low-Carbon Development Strategies and Pathways*. China Environment Publishing Group.

	Non-CO ₂ GHGs by gas	Major emission sources	2021 NDC	Domestic implementation	
				Existing non-CO ₂ GHGs mitigation measures	Existing policies
			and gradually establish and improve non-CO ₂ emissions data statistics and inventory, policies, and governance.		
Energy supply	CH ₄	Coal mining	Effectively control methane emissions from coal mining, oil and gas, properly restrict coal production capacity, improve coalbed methane capture and use, and control VOC emissions from the petrochemical industry, encourage the adoption of green completions and associated gas recovery technologies.	Strictly restrict the growth of coal consumption during the 14th Five-Year Plan period.	The 13th Five-Year Plan on Development and Utilization of Coalbed Methane (Coal Mine Methane), The 13th Five-Year Plan on Energy Development, Energy Production and Consumption Revolution Strategy (2016-2030), Opinions of the CPC and the State Council on the Complete and Accurate Implementation of the New Development Concept for Carbon Peaking and Carbon Neutrality, The Action Plan for Carbon Peaking by 2030.
		Oil and gas		Oil consumption should peak during the 15th Five-Year Plan period.	
Industry	N ₂ O	Nitric acid and adipic acid	Study and develop N ₂ O mitigation plans for key industry.	Improve the production process of chemical fertilizers, adipic acid, nitric acid and caprolactam. Mitigate N ₂ O emissions from industrial processes.	Industrial Green Development Plan (2016-2020), Implementation Guide on Green Manufacturing Projects (2016-2020).
	PFCs	Electrolytic aluminium			
	SF ₆	Power industry	Promote low-GWP power facilities		

	Non-CO ₂ GHGs by gas	Major emission sources	2021 NDC	Domestic implementation	
				Existing non-CO ₂ GHGs mitigation measures	Existing policies
Building	HFCs	Household air conditioning	China accepted the Kigali Amendment.	<p>Use subsidies and incentives, such as energy-saving subsidies, "old for green", to encourage residents to buy green and efficient refrigeration products.</p> <p>By 2030, the overall energy efficiency of major refrigeration products will be improved by 30%.</p> <p>The Kigali Amendment enter into force.</p>	<p>Kigali Amendment, Technical Safety Specifications for the Manufacture of Air Conditioners for Domestic and Similar Purposes Using Flammable Refrigerants,</p> <p>Special Requirements for the Transportation of Household Air Conditioner Products Using Flammable Refrigerants,</p> <p>Requirements for the Disposal of Waste Electrical and Electronic Equipment Part 2: Electrical Appliances Containing Refrigerants.</p>
Transport	HFCs	Mobile air conditioning Food cold chain transportation		<p>Implement green transformation projects for cold chain logistics, and support leading cold chain logistics enterprises in the fields of agricultural products, food and medicine in replacing refrigerators, refrigerated display cabinets, commercial freezers, refrigerated trucks, cold storage and other refrigeration equipment and facilities with green and efficient versions.</p>	<p>Kigali Amendment, Action Plan on Green and Efficient Refrigeration,</p> <p>Opinions on Accelerating the Development of Cold Chain Logistics to Safeguard Food Safety and Promote Consumption Upgrading.</p>

	Non-CO ₂ GHGs by gas	Major emission sources	2021 NDC	Domestic implementation	
				Existing non-CO ₂ GHGs mitigation measures	Existing policies
Agriculture	CH ₄ /N ₂ O	Manure management	Reinforce the promotion on the amount reduction and efficiency enhancement of chemical fertilizers and pesticides, improve the disposal and utilization of livestock and poultry manure, and mitigate emissions from livestock and poultry breeding industries.	The comprehensive utilization rate of livestock and poultry manure will reach 80% by 2025.	National Plan for Sustainable Agricultural Development (2015-2030), 14th Five-Year Plan on National Green Agricultural Development Planning, Digital Agricultural and Rural Development Plan (2019-2025), Opinions of CPC and the State Council on the Complete and Accurate Implementation of the New Development Concept for Carbon Peaking and Carbon Neutrality, Carbon Peaking Action Plan by 2030, Implementation Plan for Carbon Emission Reduction and Sequestration in Agriculture and Rural Areas.
	CH ₄	Rice cultivation		Optimize irrigation management in rice fields to reduce methane emissions. Promote green and efficient cultivation techniques.	
		Enteric fermentation		Promote precise feeding technology and breed improvements, reduce methane emissions from ruminants.	
	N ₂ O	Nitrogen fertilizer use		Promote knowledge-based N management, reduce chemical fertilizer use and improve their efficiency. Substitute with organic fertilizers. Improve the utilization efficiency of nitrogen fertilizer and reduce N ₂ O emission.	
Waste	CH ₄	Domestic waste	Accelerate the development of the circular economy	By 2025, the municipal solid waste (MSW) classification system should be basically developed, and the proportion of MSW resource utilization should be increased to about 60%. By 2030, full coverage of MSW sorting will be achieved, and the proportion of MSW resource utilization will be increased to 65%. Implement a tax policy conducive to preventing food waste.	Domestic Waste Separation Implementation Plan, Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste, Anti-Food Waste Law of the People's Republic of China, 14th Five-Year Plan on the Development of Municipal Sewage Treatment and Resource Utilization.
	N ₂ O	Wastewater treatment		Strengthen the harmless disposal and resource utilization of municipal sewage sludge.	

2. Methane mitigation policy measures

Table 2: Policy actions to promote methane emissions mitigation

Major emission sources by sector		Existing mitigation policies and measures	Mitigation measures to be strengthened
Energy supply	Coal mining	<ul style="list-style-type: none"> • Target coalbed methane utilization. • Measures to strictly control the growth of coal consumption • Subsidies for coalbed methane capture and use. 	<ul style="list-style-type: none"> • Control coalbed methane emissions with ultra-low methane concentration
	Oil and gas	<ul style="list-style-type: none"> • Oil consumption will peak during the 15th Five-Year Plan period. 	
Agriculture	Enteric fermentation	<ul style="list-style-type: none"> • Promote precise feeding technology and breed improvements, reduce methane emissions from ruminants. 	<ul style="list-style-type: none"> • Set quantified targets for existing mitigation actions
	Rice cultivation	<ul style="list-style-type: none"> • Optimize irrigation management in rice fields to reduce methane emissions. Promote green and efficient cultivation techniques. 	<ul style="list-style-type: none"> • Develop pilot demonstrations of emission mitigation from rice cultivation
	Manure management	<ul style="list-style-type: none"> • Comprehensive utilization targets for livestock and poultry manure • Subsidies for infrastructure construction for livestock and poultry manure treatment and resource utilization • Resource utilization pilots for livestock and poultry manure 	
Waste	Domestic waste	<ul style="list-style-type: none"> • Domestic waste sorting pilots • Target the domestic waste recycling rate • Anti-Food Waste Law 	<ul style="list-style-type: none"> • Resource utilization of food waste after MSW sorting
	Wastewater treatment	<ul style="list-style-type: none"> • Target harmless disposal and resource utilization of municipal sewage sludge 	

3. Nitrous oxide mitigation policy measures

Table 3: Policy actions to promote nitrous oxide emissions mitigation

Major emission sources by sector		Existing mitigation policies and measures	Mitigation measures to be strengthened
Agriculture	Nitrogen fertilizer use	<ul style="list-style-type: none"> Promote knowledge-based N management, reduce chemical fertilizer use and improve its efficiency. Substitute it with organic fertilizer. Build a long-term mechanism to replace chemical fertilizers with organic fertilizers for fruits, vegetables and tea Provide subsidies for the purchase and use of organic fertilizers 	<ul style="list-style-type: none"> Set quantitative targets for existing mitigation actions
	Livestock and poultry	<ul style="list-style-type: none"> Resource utilization targets for livestock and poultry manure Financial subsidies for resource utilization of livestock and poultry manure 	
Chemical	Nitric acid and adipic acid	<ul style="list-style-type: none"> Improve the production process of chemical fertilizers, adipic acid, nitric acid and caprolactam. 	<ul style="list-style-type: none"> Economic incentives to promote mitigation technologies
	Wastewater treatment	<ul style="list-style-type: none"> Target harmless disposal and resource utilization of municipal sewage sludge 	

4. F-gases mitigation policy measures

Table 4: Policy actions to promote F-gases emissions mitigation

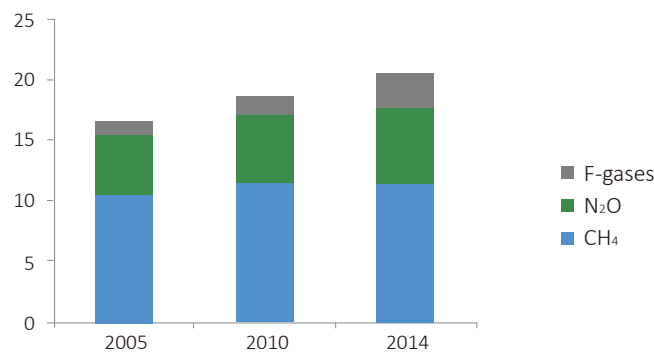
Major emission sources by sector			Existing mitigation policies and measures	Mitigation measures to be strengthened
Building	HFCs	Household air conditioning	<ul style="list-style-type: none"> Reduce the production and consumption of HFCs based on the Kigali Amendment 	<ul style="list-style-type: none"> Set quantitative targets for existing mitigation actions
Transport	HFCs	Mobile air conditioning	<ul style="list-style-type: none"> Extended producer responsibility pilot for electrical and electronic products Develop specifications for the application of low-GWP refrigerants 	
Industry	PFCs	Electrolytic aluminium		
Industry	SF ₆	Power industry	<ul style="list-style-type: none"> Promote low-GWP power facilities 	

Status Quo and Mitigation Potential

1. Existing research

Data from China’s official GHG inventory show that China's non-CO₂ GHG emissions maintained an upward trend from 2005 to 2014. As shown in Figure 1, China's non-CO₂ GHG emissions have exceeded 2 billion tons of carbon dioxide equivalent (CO₂e) in 2014, accounting for 18% of the total GHG emissions in that year, with methane, nitrous oxide and F-gases contributing 10.4%, 5.4% and 2.6%, respectively.

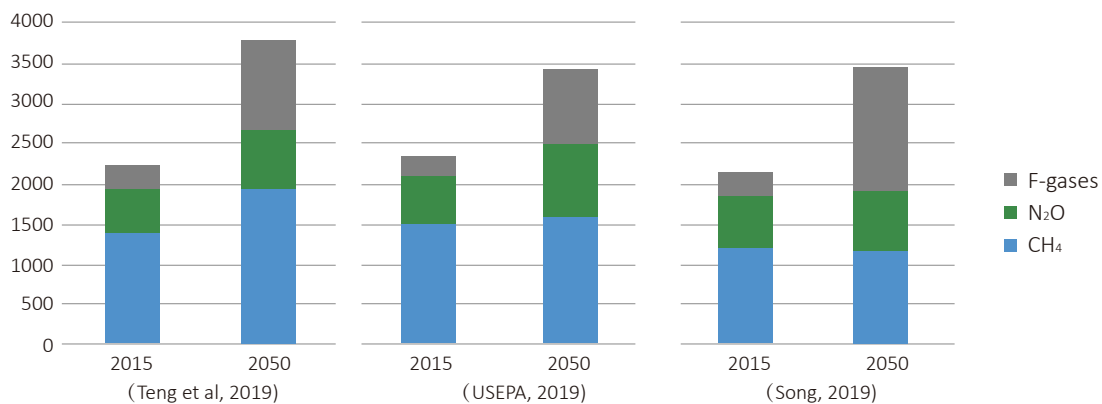
Figure 1: Historical trends of non-CO₂ emissions in China (100 MMT CO₂e)



Data source: Second Biennial Update on Climate Change of the People's Republic of China. (2018) and Third National Communication on Climate Change of the People's Republic of China. (2019), where 2005 data are from the latter back-calculation of the 2005 national inventory.

In addition, different studies have estimated the trend of non-CO₂ emissions in China (R. Song, 2019; Teng et al., 2019b; USEPA, 2019). As indicated in Figure 2, China's non-CO₂ GHG emissions will continue to rise from 2015 to 2050 and are expected to reach about 3.4-3.7 billion tons of CO₂e by 2050, an increase of nearly half from 2015. Methane is projected to still account for a significant share of the increase, while F-gas emissions exhibit the fastest growth.

Figure 2: Trends in non-CO₂ emissions in China in different studies (Mt CO₂e)



Data source: There are differences in the covered range of F-gases and GWP references in the three studies. For the GWP values, (Teng et al., 2019a) and (EPA, 2019) employed estimates in AR4, while (WRI, 2019) chose GWP values based mainly on SAR.

2. Mitigation potential analysis

Building on previous research, iGDP has conducted a scenario analysis to estimate the non-CO₂ GHG emission trends and potential for mitigation based on the EPS ((Energy Policy Simulator) model. As shown in Figure 3, in the reference scenario (based on China's implementation of the announced policy targets in 2020), China's non-CO₂ GHG emissions will continue to increase from 2.63 billion tons of CO₂e in 2019 to 3.34 billion tons of CO₂e in 2050. In new policy scenario (strengthening and continuing policies included in the 14th Five-Year Plan), China's non-CO₂ GHG emissions would peak around 2029 at 2.885 billion tons of CO₂e. In the best policy scenario (based on all feasible emission mitigation practices), China's non-CO₂ GHG emissions could peak around 2022, but still emit about 1.56 billion tons of CO₂e by 2050, including 7.3, 3.3, and 0.5 billion tons of CO₂e for methane, nitrous oxide, and F-gases, respectively.

Table 5: Projected non-CO₂ GHG emissions by gas in different scenarios

	New policy scenario 2050 vs. 2019	Best policy scenario 2050 vs. 2019
Methane	36% decrease	55% decrease
Nitrous oxide	Peak around 2030, with a 22% decrease by 2050 compared to 2019	Peak around 2022, with a 36% decrease by 2050 compared to 2019
F-gases	Peak around 2025, with a 32% rise by 2050 compared to 2019	Peak around 2030, with a 19% decrease by 2050 compared to 2019

Figure 3: Non-CO₂ emissions in different scenarios (MMT CO₂e)

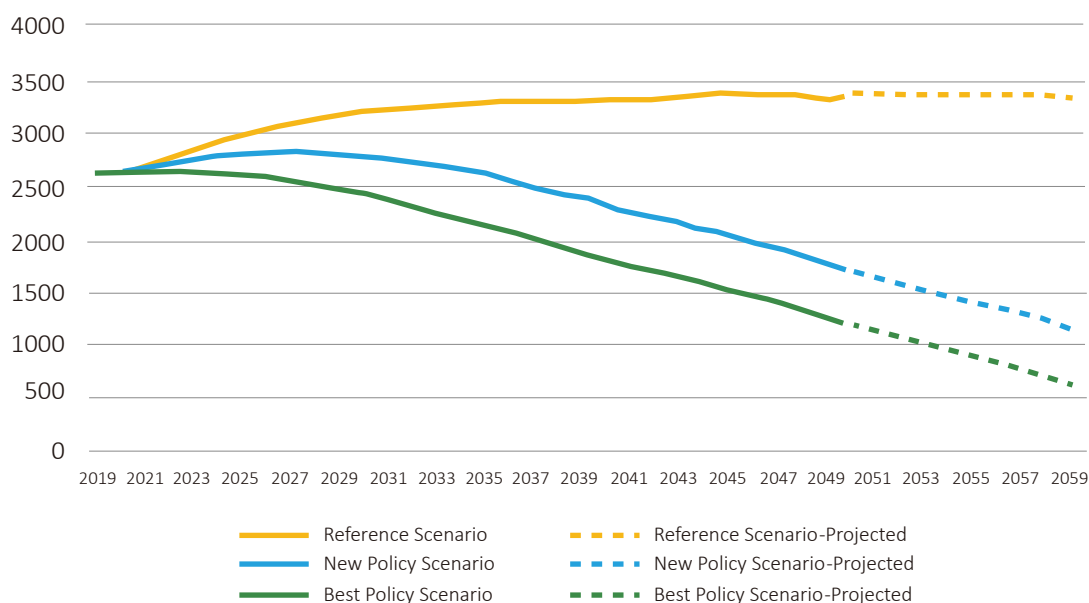


Figure 4: Non-CO₂ emissions by gas in the best policy scenario (MMT CO₂e)

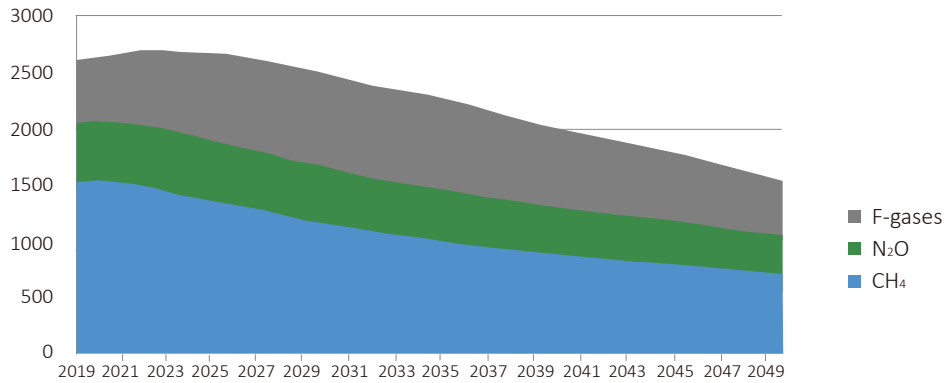
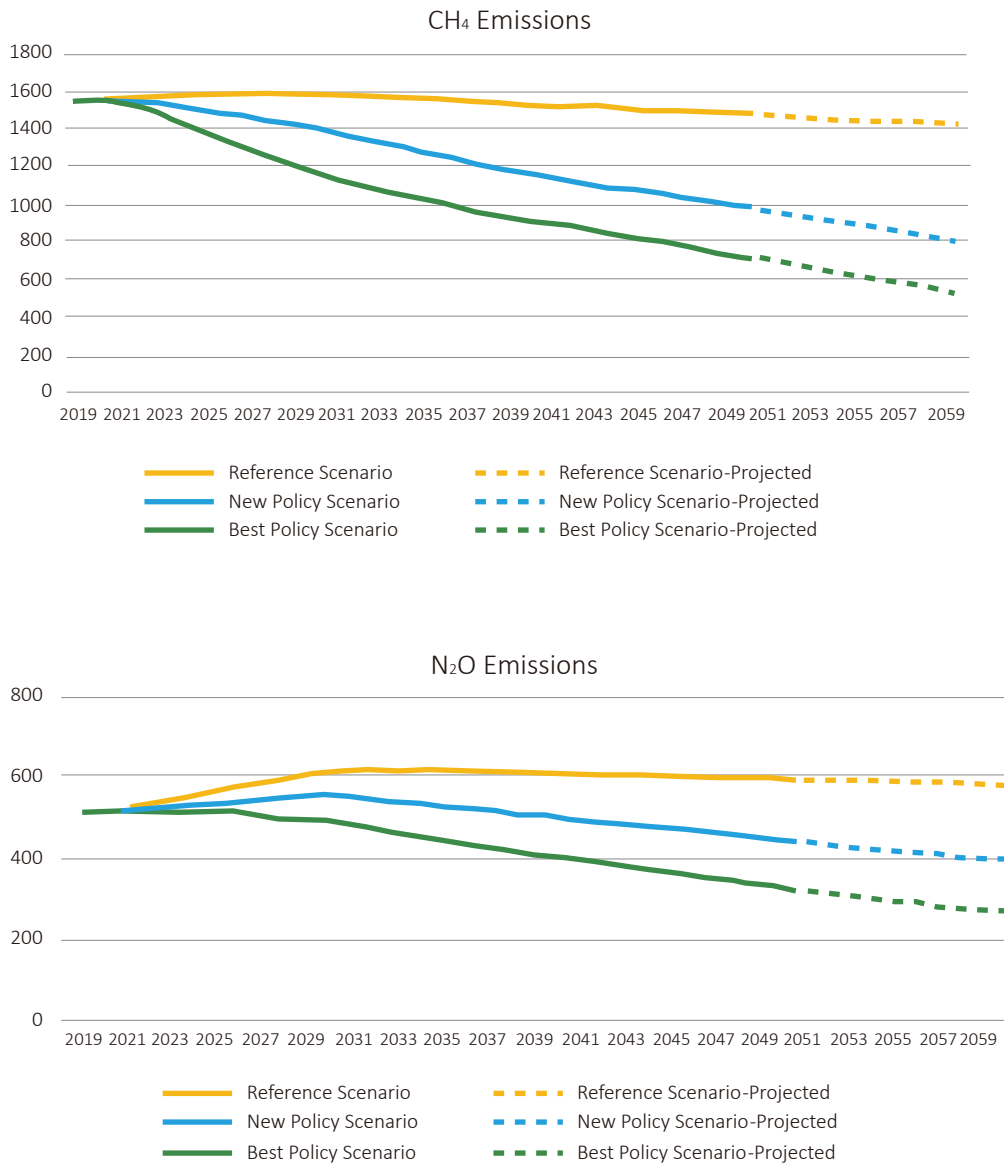
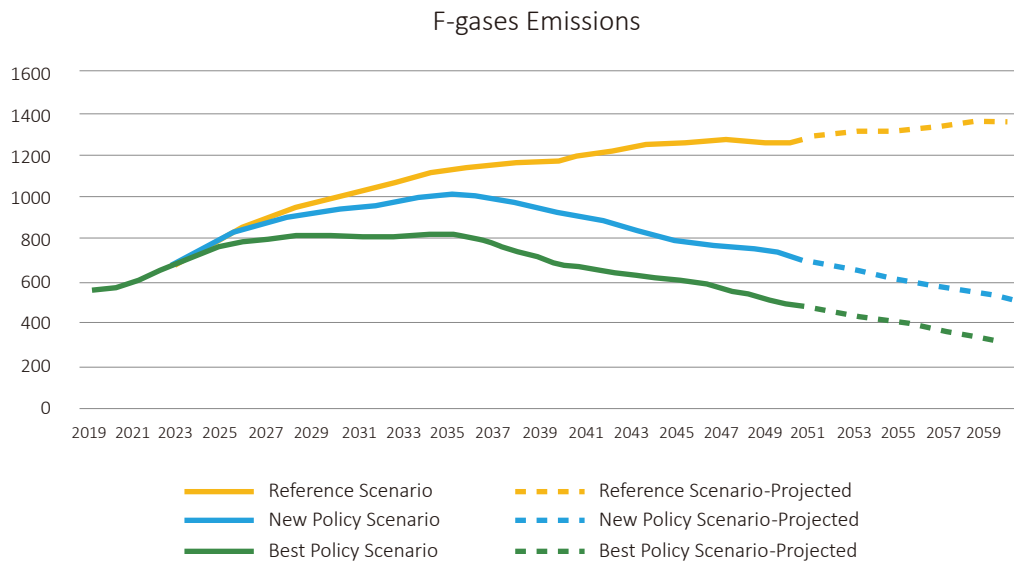


Figure 5: Non-CO₂ emissions reduction by gas (MMT CO₂e)





3. Major mitigation actions (based on the best policy scenario)

Figure 6: Mitigation potential by sector in the best policy scenario (2050)

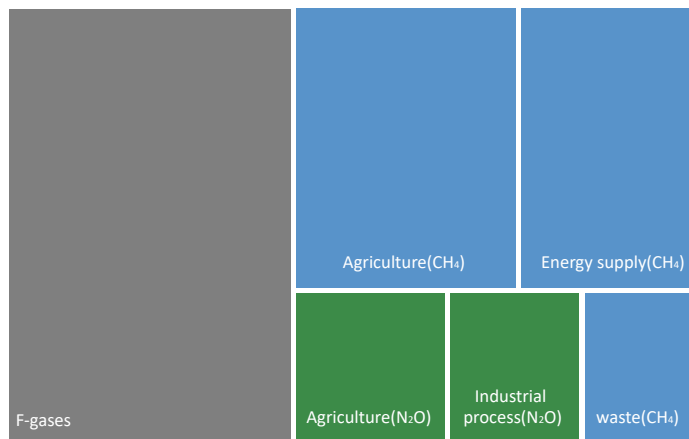


Table 6: Major non-CO₂ GHG emissions mitigation actions by gas

	Major mitigation actions	Mitigation potential(2050)
Methane	Energy: reduce coal consumption, improve coalbed methane capture and use, especially of ultra-low concentration coalbed methane.	17%
	Agriculture: methane capture and utilization from livestock and poultry manure, improve rice irrigation methods, promote high-yielding and low-emission rice varieties, improve feed additives and promote dietary shift.	21%
	Waste: improve waste sorting and resource utilization of kitchen waste.	6%

Major non-CO₂ GHG emissions mitigation actions by gas

Nitrous oxide	Agriculture: reduce nitrogen fertilizer use, adopt slow-release fertilizers and organic fertilizers, manage livestock and poultry manure.	8%
	Industry: reduce emissions from nitric acid and adipic acid production through catalytic decomposition technology in the industrial sector.	7%
F-gases	Promote the application of low GWP refrigerants in household air conditioners and the cold chain supply system.	41%

POLICY SUGGESTIONS

Although China has not yet issued an overall plan and targets for controlling non-CO₂ GHG emissions, mitigation measures for different non-CO₂ GHGs have been developed and implemented in different sectors, including policies that directly address non-CO₂ GHG emission control as well as ones developed for energy security and environmental pollution prevention with secondary benefits in reducing non-CO₂ GHGs. Based on existing policy and mitigation practices, enhancing non-CO₂ GHG emissions mitigation actions could lead to greater mitigation potential, particularly in the the following areas:

1. Developing a national non-CO₂ GHG emissions strategy

Non-CO₂ GHG emissions cover various sectors, from energy supply to transport, agriculture, and waste, but policy measures for non-CO₂ emissions are currently scattered across different sectors without an overall national strategy or target for non-CO₂ GHG emission mitigation. China's updated NDC proposes a study of the implementation of non-CO₂ GHG emission control action programs, and a number of emissions mitigation measures currently implemented in China under different sectors will provide policy support for the development of an overall non-CO₂ national strategy.

2. Set specific mitigation targets and actions for methane, nitrous oxide and F-gases

- Methane: Methane is the non-CO₂ GHG with the largest emissions, produced in the energy supply, transportation, agriculture, and waste sectors. Setting targets for total methane emissions and strengthening the collection and inventory of methane emissions data at the national level will provide both policy and data support for methane emission mitigation. At the same time, development of local methane reduction action plans to accommodate local conditions is also recommended. The primary aim is to develop non-CO₂ GHG emissions inventory at the local level and estimate the methane mitigation potential with existing strategies such as circular economy, energy transition, and green agriculture.
- Nitrous oxide: Nitrous oxide is the second most prominent non-CO₂ GHG after methane, with a large share of emissions from nitrogen fertilizer, nitric acid and adipic acid industries. With the implementation of the zero-growth fertilizer policy, nitrogen fertilizer application is expected to decline. The setting of emissions

mitigation targets and actions for nitric acid and adipic acid in the industrial sector is recommended.

- F-gases: As required by the 2016 Kigali Amendment, China is obligated to freeze the production and consumption of HFCs at baseline levels from 2024 and to gradually start reducing the production and consumption of HFCs, which will determine the emission path of F-gases in China. It is recommended that policy targets for China's HFCs emissions in industry, building, and transportation refer to the above targets and develop specific mitigation action plans to achieve the targets, such as set a cap for HFCs emissions and restrictions on the use of high GWP refrigerants.

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About iGDP:

innovative Green Development Program is a non-profit consultancy that focuses on green and low-carbon development. It works to strengthen China's low-carbon environmental policy design and implementation through interdisciplinary, systematic and empirical research. We work with all stakeholders to promote a zero-emissions future and tell the story of China's green and low-carbon development. iGDP's research, consulting and communications focus on the following areas:

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- Green Economics
- Climate Strategies
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