

# ISSUE BRIEF



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## Beyond CO<sub>2</sub>: mitigation of methane and HFCs' emissions in China

This policy brief presents the main conclusions and policy recommendations issued by experts and panelists during the April 2022 United Nations Stockholm+50 National Consultation's dedicated Panel titled "Beyond CO<sub>2</sub>: opportunities and challenges for the mitigation of non-CO<sub>2</sub> greenhouse gases."

Its aim is to highlight the importance of non-CO<sub>2</sub> gases in reaching the 1.5°C Paris Agreement target, alongside challenges and opportunities for policy makers and key stakeholders.

A broader overview of the discussions and agenda of the Stockholm+50 Consultation can be found in the Summary Report of the event.<sup>1</sup>

The views expressed in this publication are those of the authors and do not necessarily reflect the views or policies of the United Nations (UN) and the United Nations Development Programme (UNDP).

1. United Nations Development Programme (2022). *Stockholm+50 Stakeholder Consultation in China. A Summary Report.* <https://www.undp.org/china/publications/stockholm50-stakeholder-consultation-china-summary-report>.



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## 1. Introduction

The mitigation of greenhouse gases such as methane or hydrofluorocarbons (HFCs) represents a crucial factor whether or not global warming can be limited to 1.5°C by 2100, a global objective shared by 192 countries under the framework of the 2015 Paris Treaty. **Methane** is a colorless and odorless gas, whose anthropogenic causes come from coal and gas production and combustion, biomass burning, livestock farming and waste management.<sup>2</sup> **HFCs** are a type of organic compounds in gas or liquid states composed of hydrogen, fluorine and carbon that are used mostly as refrigerants; HFCs belong to the fluorinated gases' category.<sup>3</sup> Methane and fluorinated gases account together for 20% of global anthropogenic greenhouse gases (see Box n°1).

2021 was a decisive year for China in terms of both methane and HFCs. First, on the mitigation of HFCs, China formally accepted the Kigali Amendment of the Montreal Protocol in June 2021.<sup>4</sup> This led to the Kigali Amendment entering into force in China on 15 September 2021.<sup>5</sup> Second, during COP26 in November 2021, China and the US issued the China-US Joint Glasgow Declaration that announced China's intention to publish a National Action Plan on methane, "aiming to achieve a significant effect on methane emissions control and reduction in the 2020s", as well as enhance cooperation around issues related to methane.<sup>6</sup>

Despite methane and HFCs being two separate greenhouse gases that impact different sectors of the economy (mining, agriculture, and waste for methane; refrigeration, cooling, and foam industries for HFCs), they share a set of common challenges and policy opportunities in terms of climate change mitigation. This brief presents these challenges in section 2, followed by policy recommendations that encompass a whole-of-society transformation towards 1.5°C (section 3), specifically looking at technology deployment, international and local cooperation, as well as financing and carbon pricing.

### Box 1. Methane and HFCs, two crucial gases in the fight against climate degradation

In its report published in April 2022, the International Panel on Climate Change (IPCC), the highest scientific authority on climate change, estimated that non-CO<sub>2</sub> greenhouse gases currently represent 24% of total net greenhouse gas emissions released by industrial use and fossil fuel combustion (see Figure 1).<sup>7</sup> These gases include methane, which accounts for 18% of total net greenhouse gas emissions, nitrous oxide (4%), and fluorinated gases - also called F-gases - account for 2%, which include HFCs.<sup>8</sup>

2. Britannica (-). Methane. <https://www.britannica.com/science/methane>.

3. Britannica (-). Hydrofluorocarbon. <https://www.britannica.com/science/hydrofluorocarbon>.

4. The 2016 Kigali Amendment aims to mitigate HFC mitigation at the global level and is part of the Montreal Protocol that regulates ozone-depleting substances. United Nations Treaty Collection (2019). Further Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. [https://ozone.unep.org/sites/default/files/2019-04/Original\\_depository\\_notification\\_english\\_version\\_with\\_corrections.pdf](https://ozone.unep.org/sites/default/files/2019-04/Original_depository_notification_english_version_with_corrections.pdf).

5. China's Ministry of Ecology and Environment, Foreign Environmental Cooperation Center (2021, June 25). China has officially accepted the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer.

[http://en.fecomee.org.cn/News\\_1011/202106/t20210625\\_841831.html](http://en.fecomee.org.cn/News_1011/202106/t20210625_841831.html).

6. US Department of State (2021, November 10).

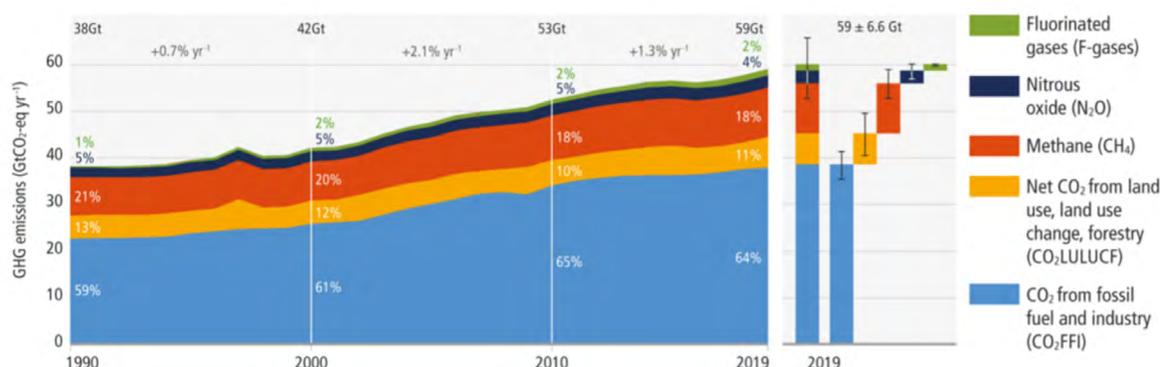
<https://www.state.gov/u-s-china-joint-glasgow-declaration-on-enhancing-climate-action-in-the-2020s/>.

7. IPCC (2022). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, p7.

[https://report.ipcc.ch/ar6wg3/pdf/IPCC\\_AR6\\_WGIII\\_FinalDraft\\_FullReport.pdf](https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf).

8. *Ibid.*, p7.

Figure 1. Global net anthropogenic greenhouse gas emissions<sup>9</sup>



However, while these percentages are significant, the importance of including these gases in addressing climate change goes beyond the current share in total greenhouse gases GHGs:

- **Methane's** importance is crucial because it is more potent than CO<sub>2</sub> in warming the atmosphere. Its detrimental effects to climate are thus more impactful than CO<sub>2</sub>. According to IPCC, methane emissions should be reduced by one third by 2030 to keep the world on track with a 1.5°C scenario.<sup>10</sup>
- **Fluorinated gases (F-gases) are the fastest increasing of all GHGs.** According to the IPCC, F-gases' emissions have more than tripled since 1990, two-times faster than the relative increase of CO<sub>2</sub>.<sup>11</sup> HFCs have significantly contributed to this increase since the implementation of the Montreal Protocol, as they have been used as alternatives to traditional Ozone-Depleting Substances such as hydrochlorofluorocarbons (HCFCs) or chlorofluorocarbons (CFCs), meanwhile the demand in the refrigeration sector has continued rising.<sup>12</sup> Other F-gases include perfluorocarbons (PFCs), sulphur hexafluoride (SF<sub>6</sub>) as well as nitrogen trifluoride (NF<sub>3</sub>).<sup>13</sup>
- **Environmental challenges**, beyond the effects on climate, must be considered as all of these non-CO<sub>2</sub> gases also have environmental consequences that range from air pollution to depleting the ozone layer.

## 2. Mitigation challenges

Despite methane and HFCs being very different types of gases, they share an important set of common challenges:

- **Timing of implementation for effective mitigation.** According to the 2022 IPCC Report, there is very little time to implement measures to mitigate climate change; the urgency is even greater for non-CO<sub>2</sub> GHGs such as HFCs or methane, which are expected to have exponentially increasing long-term impact.<sup>14</sup> HFCs and methane production

9. *Ibid.*

10. IPCC (2022), p156.

11. *Ibid.*, p7.

12. Britannica (-). Hydrofluorocarbon. <https://www.britannica.com/science/hydrofluorocarbon>.

13. IPCC (2022). SPM, p4.

14. *Ibid.*

in 2022 will have a bigger effect on global warming than CO<sub>2</sub> for each ton of GHG emitted, due to their high global warming potential (GWP)<sup>15</sup>: methane has a GWP 80 times higher than CO<sub>2</sub> after 20 years, and decreases to 30 times after 100 years. HFCs include many gases, whose GWP range from 53 times to 15,000 times higher than CO<sub>2</sub> after 100 years.<sup>16</sup>

- **Technology.** One key challenge related to timing is technology, as the timetable for actions to keep 1.5°C attainable and the roadmap for technological development are closely linked. While technologies to mitigate non-CO<sub>2</sub> gases are currently available, they are not being deployed at the required scale, due to a lack of commercial availability<sup>17</sup> and the lack of cost-benefit incentives.<sup>18</sup>
- **China is a major producer of methane and HFCs** as a major global manufacturing hub: more than 70% of all global HFC production take place in China,<sup>19</sup> although more than half of this manufacturing output is then exported. China exports 60% of the world's refrigerators and 80% of the world's residential air conditioning units.<sup>20</sup> For methane, China is the largest emitter for fossil-fuel industries (coal, oil and gas) accounting for 21% of global emissions in these sectors.<sup>21</sup>
- **Lack of data accuracy and reliability** for environmental and climate indicators provided by public and private stakeholders remains a challenge. For example, observations of methane emissions from the atmosphere do not match the reporting provided by various countries: the International Energy Agency (IEA) reported in 2022 that actual global emissions are 70% higher than the cumulative sum of those reported by governments.<sup>22</sup> The emergence of new technologies to measure and report emissions is an opportunity that needs to be maximized.<sup>23</sup>
- **Lack of education and awareness** among policymakers and the general public on greenhouse gases, in particular on non-CO<sub>2</sub> GHGs, hinders the implementation of mitigation measures.

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15. "The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO<sub>2</sub>). The larger the GWP, the more that a given gas warms the Earth compared to CO<sub>2</sub> over that time period." United States Environmental Protection Agency. (-). Greenhouse gas emissions. Understanding global warming potential. <https://www.epa.gov/ghgemissions/understanding-global-warming-potentials>.

16. UNDP (2021, September 15). The Kigali Amendment has entered into force for China! UNDP WeChat Account Post. [https://mp.weixin.qq.com/s/e4tkuqL\\_QFsifGGQFwqV9w](https://mp.weixin.qq.com/s/e4tkuqL_QFsifGGQFwqV9w).

17. European Commission (-). Climate-friendly alternatives to HFCs. [https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs\\_en](https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs_en).

18. Feng, H. (2016, November 28). Chinese manufacturers under pressure to phase out HFCs. ChinaDialogue. <https://chinadialogue.net/en/pollution/9426-chinese-manufacturers-under-pressure-to-phase-out-hfcs/>.

19. Ibid.

20. China Climate Change, Center on Global Energy Policy (-). HFCs and CFCs. <https://chineseclimatepolicy.energypolicy.columbia.edu/en/hfcs-and-cfcs#/ftn1>.

21. International Energy Agency (2022). Global Methane Tracker 2022. Estimating methane emissions. <https://www.iea.org/reports/global-methane-tracker-2022/estimating-methane-emissions>.

22. Ibid.

23. International Energy Agency (2022). Global Methane Tracker 2022. Estimating methane emissions. <https://www.iea.org/reports/global-methane-tracker-2022/estimating-methane-emissions>.

### 3. Pathways towards 1.5°C

Considering the listed challenges above, this section presents the main conclusions and policy recommendations issued by experts and panelists during the 29 April 2022 United Nations Stockholm+50 National Consultation's dedicated Panel co-organized by UNDP and UNEP titled "Beyond CO<sub>2</sub>: opportunities and challenges for the mitigation of non-CO<sub>2</sub> greenhouse gases", as a step to further the debate and promote concrete actions in this field of non-CO<sub>2</sub> mitigation.

#### 3.1 Whole-of-society transformation

- **There is a need for strategic planning for non-CO<sub>2</sub> greenhouse gases sectors.** A clear national control strategy and control strategies for key industries would be a key step both at the national and international level.

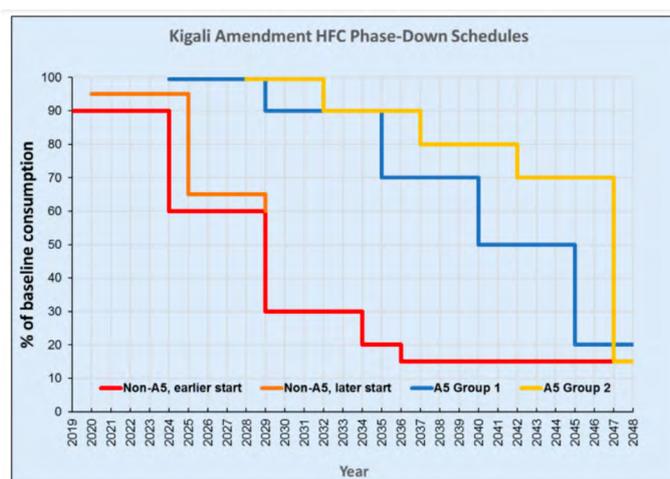
**Table 1. Kigali Amendment  
Timeline for China**

Year	Reduction (2024 baseline level)
2029	10%
2035	30%
2040	50%
2045	80%

- **In the HFC sector**, a clearer and more detailed timeline within the general targets set by the Kigali Amendment that came into force in September 2021 (Table 1), aiming at a reduction of 18 HFC gases' emissions by 80% by 2045. It is worth noting that the Amendment assigns different timelines based on each country's level of development to enable a realistic and ambitious global mitigation target (see Figure 2).

- **For methane**, a similar international agreement would be a crucial step forward, and would likely save decades in the effort to mitigate climate degradation. The Global Methane Pledge launched in 2021 during COP26 could represent a stepping stone towards an international agreement on methane. It includes 122 developing and developed countries which have committed to reduce their methane emissions by at least 30% from their 2020 levels by 2030. This objective could reduce global warming of 0.2°C by 2050, which would represent a very significant progress.<sup>25</sup>

**Figure 2. Kigali Amendment HFC Phase-down Schedules  
(China is part of the Article 5 Group 1 countries in blue)<sup>24</sup>**



24. UNEP. *Introduction to the Kigali Amendment. OzonAction Kigali Fact Sheet 1.*

[https://wedocs.unep.org/bitstream/handle/20.500.11822/26869/7876FS01Intro\\_EN.pdf?sequence=1&isAllowed=y](https://wedocs.unep.org/bitstream/handle/20.500.11822/26869/7876FS01Intro_EN.pdf?sequence=1&isAllowed=y).

25. *Global Methane Pledge (2021). Global coalition on methane to keep a 1.5°C future within reach.*

<https://www.globalmethanepledge.org/>.

- Increase the **level of awareness and education** around the environmental issues and their opportunities. Ensure decision-makers have the tools required to enable change by increasing awareness and scientific understanding of non-carbon dioxide emissions. This level of awareness could be then passed on to all the other levels of society.
- Encourage **public participation** in environmental governance and management, including for non-CO<sub>2</sub> greenhouse gases.
- Improve the **monitoring, reporting and verification (MRV) system** for the implementation of mitigation policies in non-CO<sub>2</sub> greenhouse gases sectors.
- **Continue developing standards** to improve policy on the ground. In coal mine gas control, a large source of methane, there are now six promulgated standards in China to reduce methane emissions, prevent leakage during transportation, and enhance the safety of workers.

### 3.2 Technology

- **Enhance technology development for non-CO<sub>2</sub> GHG emitting sectors.** The research and development, promotion and application of technologies related to HFCs and methane should be strengthened.
  - For HFCs, the focus should be research, application and promotion of refrigerant alternative technologies that are available and low-carbon: there is no "one size fits all solution" due to the variety of sectors involved.<sup>26</sup> Alternatives include natural refrigerants, HFCs with lower GWP, hydrofluorolefins (HFOs) and HFC-HFO blends.<sup>27</sup>
  - For methane, leak detection systems and repairs to locate fugitive emissions, coupled with zero non-emergency flaring and venting, are proven and affordable measures to decrease emissions for gas and oil sectors.<sup>28</sup> For coal, strengthening areas such as overall demand reduction, detecting and repairing leaks, coal mine gas emission reduction, carbon capture and storage (CCS), strictly regulating emissions from abandoned coal mines, and efficient resource utilization are also crucial to enable a fast-paced and impactful decrease of emissions.<sup>29</sup>
- **Adopt a holistic approach** that takes into account global supply chains. This will prevent shifting methane and HFC-intensive production to other countries and take into account life cycle emissions for production and consumption of products.

### 3.3 International and local cooperation

In the field of non-CO<sub>2</sub> greenhouse gases, exchanges between industry, international institutions, and research units need to be promoted. Different viable options are possible, among which:

- **Public and private participation via voluntary collaboration in areas such as carbon accounting would promote effective mitigation policy.** For a successful monitoring, reporting and verification (MRV) of greenhouse gas control, one of the first priorities is to obtain wide participation from all stakeholders including industries and

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26. European Commission (-). *Climate-friendly alternatives to HFCs*.

[https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs\\_en](https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs_en).

27. *Ibid.*

28. International Energy Agency (2021). *Curtailling Methane Emissions from Fossil Fuel Operations*.

<https://iea.blob.core.windows.net/assets/ba5d143a-f3ab-47e6-b528-049f81eb31ae/CurtaillingMethaneEmissionsfromFossilFuelOperations.pdf>.

29. *Ibid.*

businesses. Therefore, their participation to establish a credible GHGs accounting collaboration system could be considered. This would allow producers and operators to better understand their own impact and initiate change.

- **Harmonization of international standards and norms.** Another crucial step forward would be the harmonization of standards and norms for methane, HFCs, and their related industries (mining, waste, agriculture, refrigeration) at the international level.
- **Cooperation with international institutions** and with the private sector needs to be continued. Previous cooperation has enabled significant progress, such as Ozone Layer protection supported by the Montreal Protocol adopted in 1987 and its Multilateral Fund for its implementation.
- **Promote North-South and South-South Cooperation.** Due to the limited timeframe to implement mitigation policies, it is important to share emission reduction technologies through North-South cooperation and South-South cooperation in sectors such as air conditioning or refrigeration.

### 3.4 Carbon pricing and financing

- It is vital to establish a **carbon market**, which can effectively generate price signals, and reflect costs and benefits of carbon reduction, that incorporate methane and HFC emission reduction projects into its carbon market.
- It is crucial to providing corresponding **financial or taxation support** for non-CO<sub>2</sub> GHG reduction technologies, promoting more methane emission reduction projects.
- **SMEs supporting measures should be developed** with specific measures for methane reduction, as well as HFC phase-down to align with the Kigali Amendment.

#### Box 2: Best practices

Since 1991, UNDP has cooperated with local governments and enterprises in about 120 countries in the world in the field of the implementation of the Montreal Protocol to protect and regenerate the ozone layer, and improve energy efficiency. As the lead agency for the HCFCs (Hydrochlorofluorocarbons) phase-out plans in the Industrial and Commercial Refrigeration and Air-conditioning (ICR) and Solvent sectors, UNDP has implemented more than 2,496 projects that have eliminated 70,321 Ozone Depletion Potential (ODP) tons of HCFCs per year and achieved cumulative climate benefits equivalent to 6.48 billion tons of carbon dioxide emissions. In China, UNDP has been working with the Foreign Economic Cooperation Office of Ministry of Ecology and Environment (FECO/MEE) in extending a new phaseout stage of Ozone Depleting Substances (ODS) to comply with the Montreal Protocol and curb the releasing of pollutants through establishing policy and regulations as well as introducing and demonstrating innovative industrial practices.

In December 2018, the United Nations Development Programme (UNDP) received the approval from the Multilateral Fund of the Montreal Protocol to carry out the "Hisense HFC-245fa Reduction Demonstration Project" in China.<sup>30</sup> A greenhouse gas that has a global warming potential 1,030 times

30. Reference for the entire paragraph: UNDP China (2021, September 15). The Kigali Amendment has entered into force for China! UNDP WeChat Account Post. [https://mp.weixin.qq.com/s/e4tkuqL\\_QFsifGGQFwqV9w](https://mp.weixin.qq.com/s/e4tkuqL_QFsifGGQFwqV9w).

more than CO<sub>2</sub>, HFC-245fa is one of the 18 HFCs listed in the Kigali Amendment (see Table 2). This demonstration project aims to reduce the emission of HFC-245fa by transforming the production line of household refrigerators with the help of new technology. Completed successfully in 2021, the project reduced the consumption of HFC-245fa by a total of 252 metric tons via a specific foaming technology. This reduction is equivalent to reducing 256,570 tons of CO<sub>2</sub> emissions from the production line each year. Simultaneously, thanks to energy savings brought by the new technology, the annual electricity consumption of the production line fell by 6.57 million kWh, thereby cutting CO<sub>2</sub> emissions by around 5,847.3 tons. By spreading non-HFCs foaming technologies and processes in China's household, industrial and commercial refrigeration sector as well as other industries, this enabled an accumulation of experience in technology conversion to replace HFCs, and driving the entire industry to reduce HFC-245fa emissions. Beyond HFCs' reduction, this demonstration project can also help improve cold chain efficiency, reduce food losses, safeguard vaccine safety, and deliver significant environmental benefits both in China and globally.

**Table 2. Global warming potential of HFC gases included in the Kigali Amendment of the Montreal Protocol and of Methane.<sup>31</sup>**

Group	Substance	100-Year Global Warming Potential
<b>Group I</b>		
CHF <sub>2</sub> CHF <sub>2</sub>	HFC-134	1,100
CH <sub>2</sub> FCF <sub>3</sub>	HFC-134a	1,430
CH <sub>2</sub> FCHF <sub>2</sub>	HFC-143	353
CHF <sub>2</sub> CH <sub>2</sub> CF <sub>3</sub>	HFC-245fa	1,030
CF <sub>3</sub> CH <sub>2</sub> CF <sub>2</sub> CH <sub>3</sub>	HFC-365mfc	794
CF <sub>3</sub> CHF <sub>2</sub> CF <sub>3</sub>	HFC-227ea	3,220
CH <sub>2</sub> FCF <sub>2</sub> CF <sub>3</sub>	HFC-236cb	1,340
CHF <sub>2</sub> CHF <sub>2</sub> CF <sub>3</sub>	HFC-236ea	1,370
CF <sub>3</sub> CH <sub>2</sub> CF <sub>3</sub>	HFC-236fa	9,810
CH <sub>2</sub> FCF <sub>2</sub> CHF <sub>2</sub>	HFC-245ca	693
CF <sub>3</sub> CHF <sub>2</sub> CHF <sub>2</sub> CF <sub>3</sub>	HFC-43-10mee	1,640
CH <sub>2</sub> F <sub>2</sub>	HFC-32	675
CHF <sub>2</sub> CF <sub>3</sub>	HFC-125	3,500
CH <sub>3</sub> CF <sub>3</sub>	HFC-143a	4,470
CH <sub>3</sub> F	HFC-41	92
CH <sub>2</sub> FCH <sub>2</sub> F	HFC-152	53
CH <sub>3</sub> CHF <sub>2</sub>	HFC-152a	124
<b>Group II</b>		
CHF <sub>3</sub>	HFC-23	14,800
<b>Non-Montreal Protocol (for reference).</b>		
CH <sub>4</sub> (methane)	n/a	30 (80) <sup>32</sup>

31. United Nations Treaty Collection (2019). Further Amendment to the Montreal Protocol on Substances that deplete the Ozone Layer. [https://ozone.unep.org/sites/default/files/2019-04/Original\\_depository\\_notification\\_english\\_version\\_with\\_corrections.pdf](https://ozone.unep.org/sites/default/files/2019-04/Original_depository_notification_english_version_with_corrections.pdf).

32. Methane's global warming potential after 20 years is estimated at 80. After 100 years, it decreases to 30.

**Another positive advancement in HFC mitigation** has been China's action on the emissions of HFC-23, **the most potent of the HFC greenhouse gases** (GWP of 14,800; see Table 2). In September 2021, it banned direct emissions of HFC-23 and took actions to control indirect emissions.<sup>33</sup> This very positive policy change will help reduce global warming significantly. The upcoming challenge will be the implementation of the new policy by all stakeholders as emissions still stood at an all-time high in 2018.<sup>34</sup>

Finally, a good example of voluntary commitments by the industry was the creation in 2021 of the **China Oil and Gas Enterprise Methane Emission Control Alliance**, covering over 80% of China's natural gas production. With support from the United Nations Environment Programme (UNEP), the Alliance made the commitment that the average methane intensity from natural gas production in 2025 should be reduced to below 0.25%.<sup>35</sup>

33. China's Ministry of Ecology and Environment (2021, September 14). Circular on Controlling the Emission of By-product Trifluoromethane. [https://www.mee.gov.cn/xxgk2018/xxgk/xxgk06/202109/t20210915\\_943345.html](https://www.mee.gov.cn/xxgk2018/xxgk/xxgk06/202109/t20210915_943345.html).

34. Stanley, K.M., et al. (2020). "Increase in global emissions of HFC-23 despite near-total expected reductions." *Nature Communications*, 11: 397. <https://www.nature.com/articles/s41467-019-13899-4>.

35. For reference, in 2017, average methane intensity for China National Petroleum Corporation (CNPC), a major China's national producer of gas and oil, stood at 0.32%. Reuters (2020, July 2). China's CNPC targets 50% slash in methane emission intensity by 2025. <https://www.reuters.com/article/us-china-cnpc-carbon-idINKBN2430P7>.

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