绿色创新发展中心
Innovative Green Development Program

Food Cold Chain Non-CO_2 GHG Emission Reductions in China: Challenges and Opportunities

Background

Compared with developed countries in Europe and the United States, China's food cold chain industry is currently at a relatively low level of development. However, along with China's growing economy and improving living standards, demand for food delivery has surged, especially under the COVID pandemic. This has placed more attention on food quality, revealing that refrigerated fresh food is in short supply and pushing the cold chain logistics industry into a period of rapid development.

The picture is complex. While improvements in the cold chain industry can significantly reduce methane emissions from food spoilage, the low-temperatures necessary in the cold chain's freezing, refrigeration and transportation logistics consume a large amount of energy, leading to CO_2 emissions. Moreover, the leakage of refrigerants with a high greenhouse effect contribute to non-CO_2 GHG emissions.

1. The Chinese food cold chain industry has significant potential for development

There is still a significant gap in scale and development level between China's cold chain industry and that of developed countries. The current rate of cold chain transportation in China (the ratio of the number of goods that have been transported by cold chain to the number of goods that should be) is only 19%, far below 100% in the United States and 98% in Japan[1].

A study by the Global Food Cold Chain Council[2] concluded that GHG emissions from food losses due to lack of a well-developed cold chain system were about 1 billion tons of CO_2e in 2011, comparable to the level of road transport emissions in the EU the same year. Chinese total GHG emissions from food losses in 2019 were about 210 million tons of CO_2e[3], equivalent to 1.7% of Chinese 2014 GHG emissions (12.3 billion tons of CO_2e[4]).

iGDP research indicates that if China's cold chain coverage remains at its current low level, GHG emissions due to food losses are expected to reach 240 million tons of CO_2e in 2035. But if China's cold chain industry were to catch up with developed countries, the food loss rate would quickly decline significantly and corresponding GHG emissions would be reduced to 80.67 million tons in 2035, i.e. a 70% emission reduction from 240 million tons.

[1] Chinese Cold Chain Logistics Development Report 2019

[2] BIO Intelligence Service, Assessing the Potential of the Cold Chain Sector to Reduce GHG Emissions through Food Loss and Waste Reduction 2015

[3] Crippa, M., Fossil CO2 and GHG emissions of all world countries- 2019 Report

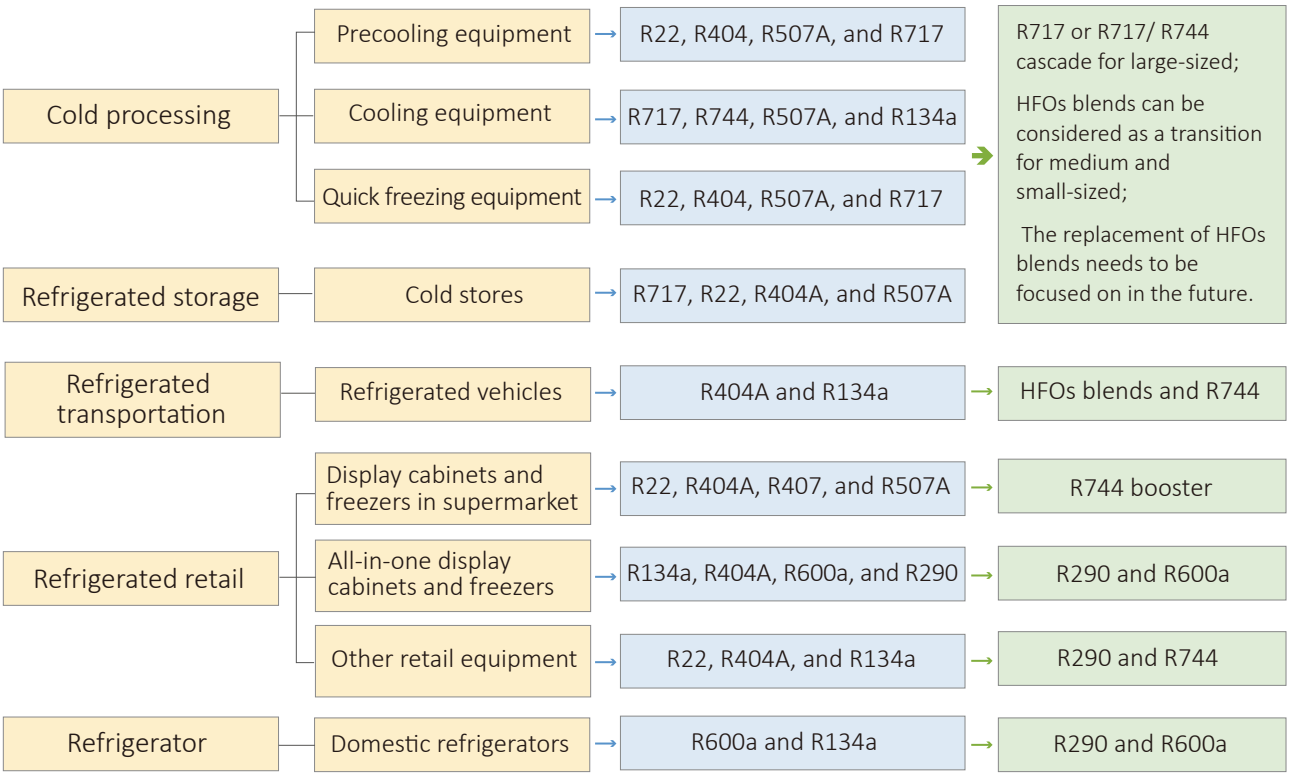
[4] Second Biennial Update Report on Climate Change of People's Republic of China 2018

2. F-Gas reduction through refrigerant replacement and leakage control

Refrigeration is applied in all links of the cold chain. Commonly used refrigerants such as R-404A, HFC-134a, and HCFC-22 have GWP values that are 3,920, 1,360, and 1,810 times higher than those of carbon dioxide, respectively. Since January 1, 2019, the Kigali Amendment to the Montreal Protocol, a global agreement aimed at reducing the production and use of HFCs, has been in effect, requiring countries to develop plans for a gradual transition to refrigerants with low GWP. As R&D technology continuously develops, an increasing number of low-GWP refrigerants are becoming available. These include R-744, R-290, R-717, HFC-513A, among others. Most large and medium-sized cold storage units in China now use ammonia refrigeration technology, but liquid ammonia leaks easily and can explode, posing a safety hazard. Use of an ammonia/carbon dioxide compound refrigeration system, with carbon dioxide as low-pressure refrigerant and ammonia as high-pressure refrigerant, can reduce the amount of ammonia use and enhance system safety, while lowering energy consumption and increasing efficiency.

Refrigerant leakage occurs mainly in transportation, storage and refrigeration during sales, and there is significant variation in leakage rates. According to 2006 "IPCC Guidelines for National Greenhouse Gas Inventories", refrigerant leakage is most serious during transportation, with an annual leakage rate of 15%; followed by large warehousing, with an average annual leakage rate of 10%. Refrigerant leakage not only intensifies direct non-CO_2 GHG emissions, but also increases energy consumption due to insufficient refrigeration levels. This also reduces the lifespan of refrigeration equipment. The current state of refrigerant application and replacement in China's cold chain is shown in Fig. 1.

Figure 1: Application status and replacement progress of refrigerants in China's cold chain industry[5]



[5] Enyuan Gao, A review of application status and replacement progress of refrigerants in the Chinese cold chain industry 2021

3. Scenario analysis of low carbon paths in the cold chain industry[6]

The overall emissions from China's cold chain industry will be determined by the low-carbon policy measures and technology paths adopted during this period of rapid development. The right choices could make a significant contribution to global GHG reductions.

With 2019 as the base year, iGDP analyzed three development scenarios under the assumption that China's cold chain industry will reach the current level of developed countries in 2035.

- BAU scenario: Only currently implemented policies on energy and carbon emission related to the cold chain are continued (as of 2019). This scenario looks at the subsequent GHG emissions if China's cold chain industry reaches the current level of developed countries by 2035 under existing GHG emission control policies.
- Enhanced emission reduction scenario: Based on the BAU scenario, the energy and carbon emission policies related to cold chain in the 14th Five-Year Plan and subsequent possible policy announcements are considered. This scenario analyzes subsequent GHG emissions if China's cold chain industry reaches the current level of developed countries by 2035 under future policies or commitments to reduce GHG emissions.
- Net-Zero Scenario: A vision of near-zero emissions from cold chain logistics, with the cold chain industry adopting the optimal energy efficiency, energy replacement technologies and green refrigerant substitutions for stocking facilities by 2035, and zero-carbon technologies for new additions where possible. This scenario provides possible emission reduction pathways to achieve near-zero emissions from cold chain logistics and to promote an early carbon peak and carbon neutralization by 2060.

The three scenarios use consistent economic, demographic, and food cold chain development demand assumptions. The emission reduction measures used in the scenarios are listed in Table 1.

[6] Read more in the special report: Hu, M., Yang L., Hong J. Challenges and Opportunities of Low-Carbon Development of Chinese Food Cold Chain in The Context of Global Zero Emissions. iGDP. 2020

Table 1: Scenario settings on mitigation measures and refrigerant application

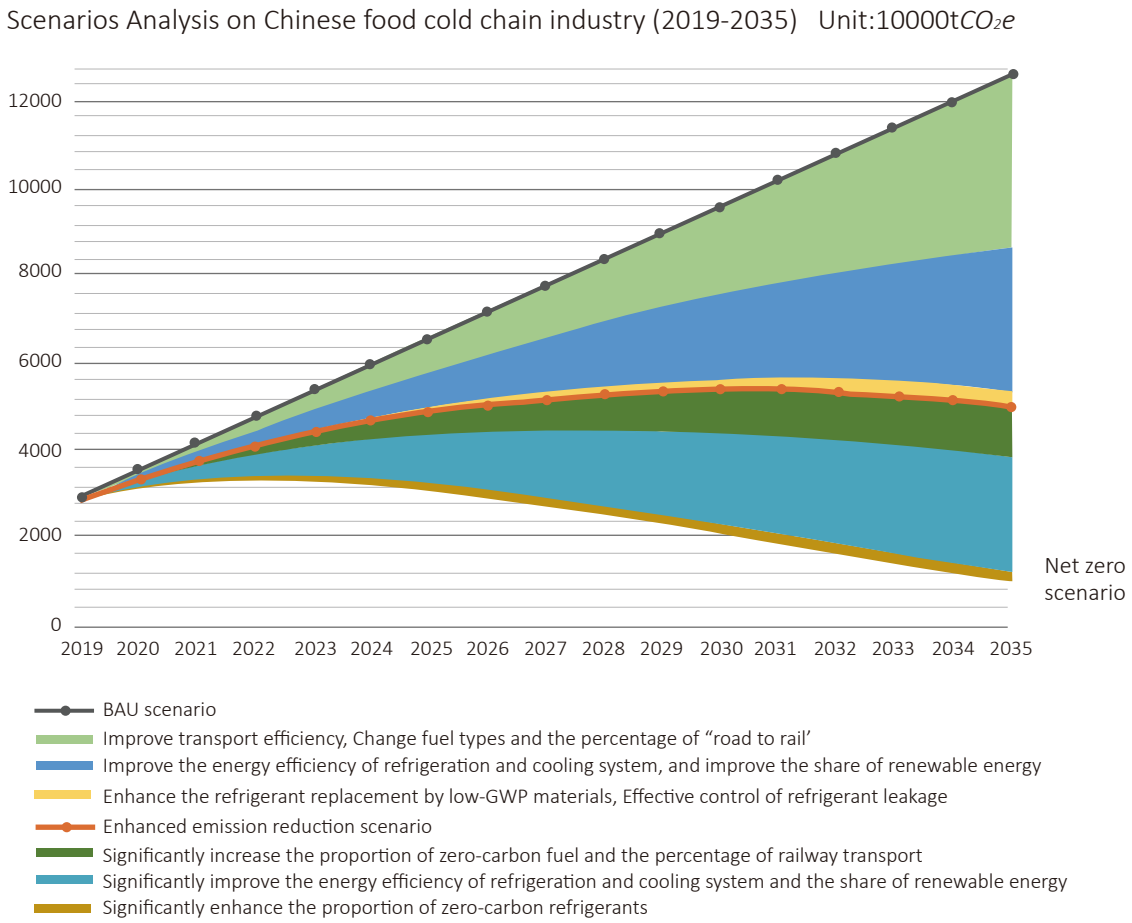
	BAU scenario	Enhanced emission reduction scenario	Net-zero scenario
Emission reduction measures			
1 Transportation			
Improve energy efficiency	Fuel economy in 2035 remains at the 2019 level	Fuel economy in 2035 improves by 30% over 2019	Fuel economy in 2035 improves by 43% over 2019
Change fuel types	Diversify fuels of cold chain vehicles, but with diesel as the main fuel type, and the percentage of "road to rail" as 1%	Accelerate the fuel diversification of cold chain vehicles. The proportion of electric vehicles in the same city is 60% and diesel vehicles is 40%. The proportion of natural gas vehicles and the diesel vehicles is 18% and 82%; the proportion of "road to rail" is 70%	All refrigerated vehicles in the same city are electric vehicles The proportion of natural gas vehicles and hydrogen fuel trucks in artery transportation is 70% and 30%; the proportion of "road to rail" is 90%
2 Refrigeration			
Improve energy efficiency	Electricity consumption and power supply structure of refrigeration in cold stores maintained at the 2019 level	Electricity consumption of refrigeration in cold storage reduced by 35% relative to the 2019 level	Electricity consumption of refrigeration in cold stores reduced by 80% relative to the 2019 level
Increase the proportion of renewable energy		Significant increase in the proportion of non-fossil energy electricity to around 70%	100% distributed renewable energy for electricity supply
3 Refrigeration and cooling system for transportation			
Enhance the refrigerant replacement by low-GWP materials Effectively control refrigerant leakage	HFCs are not controlled by Montreal Protocol (Kigali Amendment)	HFCs are not controlled by Montreal Protocol (Kigali Amendment); Refrigerant leakage control	Use natural refrigerants that do no harm to ozone layer and have low GWP

According to preliminary iGDP estimates, Chinese cold chain GHG emissions in 2019 were about 29 million tons of CO_2e, accounting for about 0.3% of Chinese energy-related CO_2 emissions the same year. Among these cold chain emissions, energy-related emissions from cold storage were the largest emission source, accounting for about 50% of the total, followed by energy-related emissions from cold chain transportation, accounting for about 39% of emissions. CO_2e emissions from HFCs refrigerant leakage take up approximately 11%.

Under the BAU scenario, China's cold chain industry will emit about 130 million tons of CO_2e in 2035, equivalent to 4.3 times the 2019 level. Under the enhanced emission reduction scenario, emissions will be reduced to about 50 million tons of CO_2e in 2035, which is around 40% of the total emissions (130 million tons) in 2035 under the BAU scenario. These emission reductions are mainly due to the rapid rise in the proportion of non-fossil energy power and clean energy in the transportation and refrigeration links.

In the net-zero scenario, by 2035, all the required energy consumption for the refrigeration link of the cold chain is supplied by renewable energy, and refrigerants basically use natural materials (ammonia and CO_2) that cause little damage to the ozone layer and have low GWP. Thus, while these two links are likely to achieve zero carbon emissions, cold chain transportation will be the only emissions source, at about 9.82 million tons of CO_2e. The transportation link represents the biggest challenge in China's net-zero cold chain scenario. See Fig. 2 and Table 2 for details.

Figure 2: GHG emission trends in Chinese cold chain industry (2019-2035) (unit: 10,000 tons CO_2e)



[7] China's fossil energy-related CO_2 emissions in 2019 were about 9.826 billion tons 《BP Energy Outlook 2019》

Table 2: Estimates of GHG emissions from China's cold chain industry if a development level equivalent to developed countries is reached by 2035

	Total emission estimates in 2035 (million tons CO_2e)		Emission estimates in major links (million tons CO_2e)	Emission proportions
BAU scenario	125.15	Refrigeration	58.67	39%
		Cold-chain transportation	61.62	50%
		Refrigerant	4.86	11%
Enhanced emission reduction scenario	50.55	Refrigeration	26.17	49%
		Cold-chain transportation	22.32	47%
		Refrigerant	2.06	4%
Net-zero scenario	9.82	Refrigeration	0	0
		Cold-chain transportation	9.82	100%
		Refrigerant	0	0

The scenario analysis shows that under "carbon peaking and carbon neutrality goals", the promotion and application of low-carbon and zero-carbon technologies in the cold chain industry should be accelerated. This would rapidly develop the cold chain industry, improve food safety, and promote low-carbon transformation.

4. Suggestions for policy measures to reduce non-CO_2 GHG emissions in the cold chain industry

- There is an urgent need for a national top-level design for non-CO_2 GHG emission reduction in the cold chain industry, combined with a compliance process for the Kigali Amendment, and the formulation of specific emission reduction targets and action plans, requiring cross-sectoral and cross-regional collaboration.
- Promote the establishment of an evaluation system for cold chain logistics statistics, and accurately ascertain the base number of the basic elements in cold chain logistics, especially the statistics and supervision of the numerous small and scattered cold storage facilities and equipment that use high-GWP refrigerants.
- Improve the energy efficiency of cold chain facilities, optimize the energy use structure, and increase the proportion of renewable energy applications; improve the fuel economy of cold chain transport vehicles, change fuel types, and enhance the proportion of electric vehicles.
- Restrict the use of high-GWP refrigerants and accelerate the market expansion of low-GWP refrigerants.
- Strengthen the capacity training and qualification management of cold storage engineers as well as installation and maintenance personnel for cold chain equipment, install refrigerant leakage detection equipment, and properly recover and dispose of refrigerants.

Authors:

Contributing authors: Hong Jialing, Yang Li, Hu Min, Kevin Mo

Editors: Diego Montero, Yefren Nye

Translator: Song Manjiao

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:

- Energy Transition
- Green Economics
- Climate Strategies
- Sustainable Cities
- Strategic Communication

iGDP
Address:7-1-51, JIANGUOMENWAI DIPLOMATIC RESIDENCE COMPOUND, NO.1 XIUSHUI STREET, CHAOYANG DISTRICT, BEIJING, 100600, PEOPLE'S REPUBLIC OF CHINA, 100600
TEL: 86-10-8532-3096
FAX: 86-10-8532-2632
EMAIL: igdpoffice@igdp.cn
WEBSITE: www.igdp.cn