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Co-benefits of efficient and climate friendly cooling in China

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The cooling sector plays a pivotal role in the global economy but significantly contributes to global warming. In 2022, cooling-related emissions accounted for 13% of global greenhouse gas (GHG) emissions. China, in particular, played a substantial role in cooling accounting for 10% of its national emissions and consuming 15% of its total electricity. This substantial environmental impact stems largely from the sector's reliance on refrigerants with high Global Warming Potential (GWP) and energy-intensive equipment. The refrigeration and air conditioning sector widely adopted hydrofluorocarbons (HFCs) as replacements for ozone-depleting substances regulated under the Montreal Protocol. However, as potent GHG, HFCs significantly contribute to global warming and are now subject to a global phase-down under the Kigali Amendment to the Montreal Protocol. Improving the energy efficiency of cooling equipment alongside the phasedown of HFCs could potentially double the mitigation benefits of the Kigali Amendment. With the growing demand for cooling in China, it is essential to explore mitigation strategies that simultaneously reduce HFC emissions and enhance energy efficiency. This study evaluates the co-benefits of efficient and climate-friendly cooling solutions in China.

This study adopts a bottom-up approach to integrate the Refrigeration and Air Conditioning - Demand, Emission, and Cost (RAC-DEC) model with Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) models. The research focuses on four key cooling subsectors: room air conditioning, mobile air conditioning, commercial air conditioning, and cold chain. The analysis is conducted under three scenarios: Business-as-Usual (BAU), reflecting current policies and practices; Kigali Amendment with enhanced energy efficiency of cooling equipment (KAE); and Accelerated Transformational Energy Efficiency (ATE). This study projects medium- and long-term trends in refrigerant and energy consumption, driven by key demand drivers for each subsector. It then quantifies both direct refrigerant emissions following the IPCC inventory methodology and indirect emissions from energy consumption. Finally, it evaluates the combined emission reduction potential under the alternative KAE and ATE scenarios.

The preliminary results indicate that among China's cooling sector, the commercial refrigeration sector offers the highest potential for emission reduction, accounting for approximately 40% of the total cumulative emission reductions from 2023 to 2060. By 2060, China's cooling sector could achieve cumulative emission reductions of approximately 11.5 Gt CO_2-eq in the KAE scenario and

16.5 Gt CO_2-eq in the ATE scenario. In the KAE scenario, emissions are expected to decline by 48% from 2022 to 2050. In contrast, the ATE scenario predicts a 70% reduction in annual emissions, dropping from 714–721 Mt CO_2-eq in 2022 to 217–218 Mt CO_2-eq by 2050. These significant reductions are primarily driven by the accelerated phase-out of HFC refrigerants, enhanced energy efficiency, and the deep decarbonization of the power system.

This study underscores the critical role of the cooling sector in contributing to global climate goals, including the COP28 Global Cooling Pledge and the Kigali Amendment. By providing a methodological framework, our findings offer essential scientific support for policymakers in China and beyond, facilitating coordinated efforts to actively reduce fluorinated GHGs and enhance energy efficiency within the cooling sector.