The Kigali Amendment's and China's Critical Roles in Evolving the Montreal Protocol

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The following is a review of the continuing evolution of the Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal Protocol), including the Kigali Amendment's critical role in evolving the Montreal Protocol into a full-fledged climate treaty. Before the Kigali Amendment, the Montreal Protocol controlled about 100 ozone-depleting substances (ODSs) including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which are powerful greenhouse gases (GHGs), and thus the Montreal Protocol has always contributed significantly to the mitigation of climate change. Stephen O. Andersen & K. Madhava Sarma, *Protecting the Ozone Layer: The United Nations History* 2 (2002). The Kigali Amendment expanded the scope of the Montreal Protocol to encompass explicitly the phasedown of super GHGs, or those with very high global warming potential (GWP) in the form of hydrofluorocarbons (HFCs), although they have only a negligible impact on the ozone layer. We also discuss energy efficiency improvements to cooling equipment, which, because of the opportunity to simultaneously upgrade the energy efficiency of equipment, augments the climate change mitigation potential of the substance phasedowns and reduces related air pollutants by reducing indirect emissions from electricity generation. Phasing down HFCs has the potential to avoid up to 0.5°C of warming by 2100. Y. Xu et al., *The Role of HFCs in Mitigating 21st Century Climate Change*, 13 Atmos. Chem. Phys. 6083, 6087 (2013) [hereinafter *Role of HFCs*]. Improvements to the energy efficiency of cooling equipment could perhaps double this. Nihar Shah et al., Ernest Orlando Lawrence Berkeley National Laboratory (LBNL), LBNL-1003671, *Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning* (2015) [hereinafter *Benefits of Leapfrogging*].

Shifting to the role of one of the key parties to the Montreal Protocol and Kigali Amendment, we focus on China's status as the largest historical producer of HCFCs, the largest producer of HFCs, and the largest producer of refrigerant-using equipment, specifically room air conditioners (ACs). Further, we review China's efforts to manage the energy efficiency of cooling equipment as this relates to China's ability to help shape the future evolution of the Montreal Protocol.

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Kigali Amendment Background

The Kigali Amendment was agreed to on October 15, 2016, after intensive negotiations involving the Montreal Protocol's 197 parties. *See* Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, Oct. 15, 2016, U.N.T.C., C.N.827.2016.TREATIES.XXVII.2.f. The Kigali Amendment brings the power of universal adoption and compulsory party commitments under the Montreal Protocol to the problem of controlling HFCs.

HFCs are factory-made chemicals principally produced for use in refrigeration, air conditioning, insulating foams, aerosol propellants, and metered dose inhalers, with minor uses as solvents and for fire protection. HFCs were developed to rapidly replace CFCs and HCFCs under the Montreal Protocol. However, HFCs trap thousands of times more heat in the atmosphere per unit of mass than carbon dioxide (CO_2). HFCs are no longer needed because environmentally superior alternatives and substitutes have been commercialized and will continue to be commercialized as a result of the business opportunities of the HFC phasedown. Hence, the Kigali Amendment represents the expansion of the Montreal Protocol's scope from a focus on ozone-depleting substances to explicitly covering powerful climate pollutants. The Kigali Amendment is an important force in shifting to a new generation of ozone-safe and climate-friendly refrigerants.

Possible substitutions for high-GWP HFCs include natural refrigerants, hydrofluoroolefins (HFOs), and lower-GWP HFCs. Natural refrigerants include ammonia (GWP of 0), carbon dioxide (GWP of 1), and hydrocarbons (GWP of 3 to 6). There are numerous HFOs with a GWP less than 1, and lower GWP HFCs include HFC-32 (GWP of 677) and HFC-152a (GWP of 138). *See* Durwood Zaelke et al., *Primer on HFCs* table 3 (Institute for Governance & Sustainable Development (IGSD), Working Paper, 2018) [hereinafter *Primer on HFCs*].

A key to achieving universal support from the Kigali Amendment parties was the successful negotiation of differential phase-down commitments for developed and developing countries. *See* Durwood Zaelke, *Historic Kigali Amendment Eliminates Warming from One of Six Main Greenhouse Gases*, 48 Trends (2017). As has always been the case in Montreal Protocol phasedowns, developed countries (Non-Article 5 Parties) will go first, followed by a grace period, after which the developing countries (Article 5 Parties) must act. In this case, the developed country parties will lead the HFC phasedown, with reductions beginning on or before 2019 and continuing down to 15 percent of baseline levels by 2036. In an innovation under the Kigali Amendment, there are two separate groups

Published in *Natural Resources & Environment* Volume 33, Number 2, Fall 2018.

(rather than the traditional one group) of developing countries with different phase-down commitments for each group. As a Group I member, China will freeze HFC production and use on or before 2024 at agreed baseline levels and will phase down production and use, beginning with a 10 percent phase-down below freeze levels by 2029.

Kigali Amendment Ratification, Funding Replenishment, and Future Evolution

Ratifications of the Kigali Amendment have exceeded the minimum threshold of 20 to ensure entry into force on January 1, 2019. By the end of April 2018, 35 Kigali Amendment parties had deposited their instruments of ratification. The current status of ratifications may be found at Ozone Secretariat, *Status of Ratification*, http://ozone.unep.org/montreal-protocol-substances-deplete-ozone-layer/94561.

The parties have also replenished funding for Montreal Protocol and Article 5 compliance. At the Montreal Protocol's 30th anniversary Meeting of the Parties (MOP), held November 20–24, 2017, the parties agreed to a robust three-year replenishment of $540 million to fund the continuing phaseout of HCFCs and to enable initial activities for phasing down HFCs under the Kigali Amendment. Decision XXIX/1: Replenishment of the Multilateral Fund for the Implementation of the Montreal Protocol for the Triennium 2018–2020 (2017). This replenishment was particularly significant considering increasing international budgetary pressure on multilateral environmental activities. The prior replenishment budget (2015–2017) for the Montreal Protocol implementation was $507.5 million. Decision XXVI/10: 2015–2017 Replenishment of the Multilateral Fund (2014). In addition, a group of donor countries pledged $27 million and a group of philanthropists provided an additional $53 million to support fast implementation of the HFC Amendment and energy efficiency. Press Release, White House Office of the Press Secretary, Leaders from 100+ Countries Call for Ambitious Amendment to the Montreal Protocol to Phase Down HFCs and Donors Announce Intent to Provide $80 Million of Support (Sept. 22, 2016).

Additional efforts to promote energy efficiency of cooling equipment represent a further evolution of the Montreal Protocol and have the potential to provide even greater climate mitigation. As background to this trend, it is important to recall the Paris Agreement's ambitious goal of limiting global warming to "well below 2°C above pre-industrial levels," aiming for 1.5°C, and for net zero emissions in the second half of the century. United Nations Framework Convention on Climate Change, Adoption of the Paris Agreement, FCCC/CP/2015/L.9 (2015). Scientific research found that the highest number (11) of the tipping points in the climate system occur between Paris Agreement goals of 1.5°C to 2°C, including abrupt sea ice decrease/collapse in the Arctic and abrupt Tibetan snow melt. V. Ramanathan et al., *Well Under 2 Degrees Celsius: Fast Action Policies to Protect People and the Planet from Extreme Climate Change* 7–8 (2017); Sybren Drijfhout et al., *Catalogue of Abrupt Shifts in Intergovernmental Panel on Climate Change Climate Models*, 112 Proc. Nat'l Acad. Sci. E5777, E5784 (2015). Actions that can magnify climate benefits take on a particular urgency in light of research showing warming was already 1.1°C above the pre-industrial period in 2016. *See* World Meteorological Organization, WMO Statement on the State of the Global Climate in 2016 4 (2017).

Under the initial phase-down schedule, the Kigali Amendment will avoid up to 0.5°C of warming by 2100 and 80 billion metric tons of CO_2 equivalent (CO_2eq) by 2050. *Role of HFCs* at 6087. If the parties accelerate the schedule and leapfrog HFCs during the ongoing phaseout of HCFCs, the climate benefits would increase by 39 to 64 billion tons CO_2eq in 2050. G.J.M. Velders et al., *Growth of Climate Change Commitments from HFC Banks and Emissions*, 14 Atmos. Chem. Phys. Discuss. 4563, 4568 (2014). In addition, an HFC phasedown under the Montreal Protocol would, as in past phasedowns, catalyze significant energy efficiency gains in air conditioning and refrigeration systems, in the range of 30 to 60 percent, and significantly reduce CO_2 emissions. *Primer on HFCs* at 5. In the room AC sector alone, a modest 30 percent improvement in energy efficiency, in parallel with the transition to the use of low-GWP refrigerants, could double the climate benefits over an HFC phasedown alone. *Id.* Simultaneous transition also would reduce costs to manufacturers, which could accomplish HFC phasedown and energy efficiency improvement in one conversion of the design and manufacturing line, rather than separately. *Benefits of Leapfrogging* at 3.

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AC energy efficiency improvement is critical to curb global energy demand and mitigate climate change in the next three decades. With a growing population and increasing income that is expanding the middle class, global energy demand for air conditioning is projected to triple by 2050. When coupled with the current fossil fuel–heavy electricity generation, this will nearly double GHG emissions from this sector, from 1.25 billion tons of CO_2 in 2016 to 2.28 billion tons a year in 2050, further increasing the world's need for cooling in a dangerous feedback loop. International Energy Agency, *The Future of Cooling* 65 (2018) [hereinafter *Future of Cooling*]. The Intergovernmental Panel on Climate Change (IPCC) projects that global air conditioning energy demand will grow 33-fold from 300 terawatt hours (TWh) in 2000 to more than 10,000 TWh in 2100. Douglas J. Arent et al., Key Economic Sectors and Services, Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 665 (C.B. Field et al. eds., 2014). The growing use of ACs in homes and

offices worldwide is a critical blind spot in the energy discussions, as AC use alone will consume as much electricity as all of China today by 2050 absent additional policies to improve energy efficiency. *Future of Cooling* at 3.

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Efforts to combine HFC phasedown with energy efficiency improvements have advanced since the adoption of the Kigali Amendment. In the decisions related to the adoption of the Kigali Amendment, the parties agreed to request that:

> [T]he Executive Committee develop cost guidance associated with maintaining and/or enhancing the energy efficiency of low-GWP or zero-GWP replacement technologies and equipment, when phasing down [HFCs], while taking note of the role of other institutions addressing energy efficiency, when appropriate.

Decision XXVIII/2: Decision Related to the Amendment Phasing Down Hydrofluorocarbons, para. 22 (2016). At the November 2017 MOP to the Montreal Protocol, the parties also requested that the Technology and Economic Assessment Panel (TEAP) undertake a study on the simultaneous phasedown of HFCs and upgrade of energy efficiency in the refrigeration, air-conditioning, and heat-pump sectors in Article 5 countries. Decision XXIX/10: Issues Related to Energy Efficiency While Phasing Down Hydrofluorocarbons, para. 1 (2017). Specifically, the parties asked TEAP to assess the following aspects of enhancing energy efficiency technologies as part of the phasedown: (1) technology options and requirements, including (a) challenges to their uptake, (b) their long-term sustainable performance and viability, and (c) their environmental benefits in terms of CO_2 equivalents; (2) capacity-building and servicing sector requirements in the refrigeration and air-conditioning and heat-pump sectors; and (3) related costs including capital and operating costs. *Id.* Additionally, the parties mandated that TEAP prepare a final report from the study for consideration by the Open-ended Working Group (OEWG) of the Parties to the Montreal Protocol at its 40th Meeting on July 11–14, 2018, in Vienna, Austria.

Leading up to the 40th Meeting of the OEWG, the parties convened a workshop on July 9–10, 2018, which provided an opportunity for parties and other stakeholders to discuss in depth: (1) the types of technical opportunities that can be adopted to improve the energy efficiency of both new and existing refrigeration, air-conditioning, and heat-pump (RACHP) equipment, as well as improvements to building design; (2) the barriers to these opportunities and the ways in which barriers can be overcome through appropriate policy measures and investments; and (3) the connections between Montreal Protocol activities to phase down HFCs and other activities that are addressing energy efficiency issues in the RACHP sectors. UN Environment, Summary of the Workshop on Energy Efficiency Opportunities while Phasing Down Hydrofluorocarbons, (July 2018), http://conf.montreal-protocol.org/meeting/oewg/oewg-40/presession/English/OEWG40-6-Rev1.e.docx. TEAP will also prepare an updated final report taking into consideration the outcome of the workshop to be submitted to the 30th Montreal Protocol MOP planned for November 5–9, 2018, in Quito, Ecuador.

During the 40th Meeting of OEWG, parties also reaffirmed their commitment to the Montreal Protocol and its mechanisms for ensuring compliance by taking urgent action to respond to the recent detection of unexpected emissions of trichlorofluoromethane (CFC-11) (banned as of 2010). Ozone Secretariat, *Parties Take Up Urgent Response to CFC-11 Emissions*, http://ozone.unep.org/node/100367.

In the upcoming meetings, governments, industry, and other stakeholders will further explore opportunities to phase down HFCs and improve energy efficiency simultaneously within the capacities of the Montreal Protocol and its Multilateral Fund. Chinese government and industry involvement in these explorations will significantly influence this trend, as discussed further below.

China's Critical Role in Achieving the Ambition and Evolution of the Montreal Protocol

China filled a key role in bringing about the global consensus that resulted in the Kigali Amendment's adoption. U.S. and China agreements reflected this diplomatic leadership, initially during the meeting between President Obama and President Xi in Sunnylands, California. *See* Press Release, White House Office of the Press Secretary, United States and China Agree to Work Together on Phase Down of HFCs (June 8, 2013). The United States and China reaffirmed their leadership role through multiple statements and agreements, including President Obama's and President Xi's agreement to open formal negotiations on the amendment to phase down HFCs under the Montreal Protocol on the margins of the G20 Summit in St. Petersburg. *See* Press Release, White House Office of the Press Secretary, United States and China Reach Agreement on Phase Down of HFCs (Sept. 6, 2013). Following these commitments, China is currently completing domestic procedures necessary to ratify the Kigali Amendment.

China's central part in the Kigali Amendment negotiations reflects its historical and continuing importance to Montreal Protocol implementation and evolution. For instance, China

was the world's largest producer of HCFCs, a fact that made China's actions on HCFC phaseout critical to the Montreal Protocol's global success. Indeed, China's HCFC Phase-out Management Plan (HPMP) contributed to an ahead-of-schedule fulfillment of Montreal Protocol commitments, generating benefits equivalent to removing roughly 19.5 million cars from the roads. *See* Press Release, The World Bank, China Announces Major Reduction in Ozone Depleting Gases on International Ozone Day (Sept. 15, 2014).

The details of China's HPMP bear this out. On April 19, 2013, China agreed to phase out HCFCs completely over the subsequent 17 years, which is expected to cut the equivalent of 8 billion tons CO_2 at a total cost of $385 million. U.N. Env't Programme, Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol, Report of the Sixty-Ninth Meeting of the Executive Committee, Ozl.Pro/ExCom/69/40, 30 (2013). As part of the HPMP, China committed to low-GWP refrigerant R290 as the major substitute for the R22 refrigerant in the room AC sector. In the *Catalogue of Major Recommended Substitutes for HCFCs (First Batch)* (Draft for Comment), issued in August 2016, China listed low-GWP alternatives as the only substitutes it will support from Chinese industry for 10 refrigeration and air conditioning end-uses.

During Stage I of China's HPMP (covering the period 2011–2015), Montreal Protocol Multilateral Fund financial support was primarily used to upgrade 18 R290 room AC manufacturing lines and three R290 compressor manufacturing lines. Stage II of China's HPMP (covering the period 2016–2020), preferentially singles out natural refrigerants or low-GWP alternative refrigerants in sectors such as room AC and industrial and commercial refrigeration. Also, during Stage II, China plans to complete upgrades of at least 20 additional R290 room AC manufacturing lines and three additional R290 compressor manufacturing lines. Chinese stakeholders have actively promoted the amendment of international and domestic standards to facilitate market penetration for low-GWP substitutes and associated, high-efficiency ACs.

China's actions involving HFCs also appear to be following a similar path as those for HCFCs. Following the United States' and China's bilateral agreements on HFC phasedown in 2013, China's State Council announced in May 2014 that it would strengthen management of HFC emissions and accelerate the destruction and replacement of HFCs. *See* China State Council, 2014–2015 Energy Conservation, Emissions Reduction and Low Carbon Development Action Plan (2014). The plan set the target of reducing HFC emissions by 0.28 Gt CO_2eq by 2015. A key component of the plan addressed destruction of HFC-23. HFC-23 is a by-product of the manufacture of chlorodifluoromethane (HCFC-22). This destruction is funded through annual China National Development and Reform Commission (NDRC) financial subsidies through 2019. NDRC General Office, Circular on Organizing the Launch of HFCs Disposal Related Work (2015).

As the Montreal Protocol and Kigali Amendment address the way parties can best magnify climate benefits through combining HFC phasedown with cooling equipment energy-efficiency improvements, China again plays a key role. China has a long history of regulating and offering incentives for improvements in product energy efficiency. This history includes improving energy efficiency for room ACs, a very significant fact in light of China's position as the largest producer of room ACs and AC components in the world. China AC producers account for roughly 70 percent of global production of variable and fixed-speed ACs and an even greater percentage of the global supply of rotary compressors that form a critical component of room ACs.

The Montreal Protocol's evolutionary trend toward maximizing energy efficiency improvements during scheduled refrigerant replacements aligns with China's national strategies and policies. The initiatives include, but are not limited to: (1) national plans involving "Construction of an Ecological Civilization" to facilitate green, low-carbon, and circular development (State Council, Opinions on Accelerating Promoting the Construction of Ecological Civilization (2015)); (2) a "Made in China 2025" strategy promoting Chinese innovation and the "China brand" overseas (State Council, Made in China 2025 (2015)); and (3) the construction of a "Green Belt and Road," designed to seize opportunities presented by the revolution in energy technologies to achieve green and low-carbon development. Ministry of Environmental Protection, Ministry of Foreign Affairs (MFA), NDRC, Ministry of Commerce (MOC), Guiding Opinions on Promoting the Construction of Green "Belt and Road" (2017). Raised by Chinese President Xi Jinping in 2013, the Belt and Road Initiative includes jointly building the Silk Road Economic Belt and the 21st century Maritime Silk Road. *See* NDRC, MFA, and MOFCOM, with State Council authorization, Visions and Actions on Jointly Building Silk Road Economic Belt and 21st Century Maritime Silk Road (Mar. 28, 2015). In addition, maximizing energy efficiency improvements, which reduces electricity-production demand, will also significantly contribute to China's battle against air pollution.

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China's policy-making and law-making activities undergirding the Montreal Protocol's HFC-transition and energy-efficiency improvement evolutions, however, are far more specific than evidenced in these broad policy frameworks. For example, China has a well-established mandatory minimum energy performance standard (MEPS) system and energy efficiency labeling system. These are regulated under several updated national laws and regulations, such as the Energy Conservation Act (2016), Standardization Act (2017), Measures for the Administration of Energy Efficiency Labels (2016), and Regulation on Certification and Accreditation

(2016). National mandatory standards provide detailed technical requirements governing room AC energy efficiency. Such standards include "The Minimum Allowable Value of the Energy Efficiency and Energy Efficiency Grades for Room Air Conditioners" (GB 12021.3-2010) and "The Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grades for Variable Speed Room Air Conditioners" (GB 21455-2013). ACs manufactured and sold in China must meet these mandatory minimum energy performance standards and display mandated energy efficiency labels, among other requirements. China is currently in the process of amending and combining the energy performance standards for fixed-speed and variable-speed AC products, which has the potential to promote market penetration of higher-efficiency AC products significantly, as was recently accomplished in India. *See* Nihar Shah et al., Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-1005787, *Cost-Benefit of Improving the Efficiency of Room Air Conditioners (Inverter and Fixed Speed) in India* (2016).

If China elects to depart from "business as usual" and pursues a leadership path that promotes super-efficient and low-GWP AC in its export markets, as it is doing at home, we can thank China for doing its part to fulfill the Montreal Protocol's ambition and avoid global climate crises.

The Chinese government also established an array of mechanisms promoting the development, sale, and purchase of highly energy-efficient products such as room ACs. The Ministry of Industry and Information Technology (MIIT) launched the National Energy Star program in 2012 to recognize products demonstrating high energy-efficiency performance. Energy Star products include industrial equipment and other energy-consuming products. Similarly, China's Top Runner program, inspired by Japan's similar initiative, recognizes and promotes the most energy-efficient appliances available on the market through specialized labels. "Top runners" refer to the best energy-efficient products, companies, or entities. NDRC, Ministry of Finance, MIIT, Government Offices Administration of the State Council, National Energy Administration, General Administration of Quality Supervision, Inspection and Quarantine, and National Standardization Administration, Implementation Plan for the Energy Efficiency Top Runner Program (2014). The Chinese government prioritizes both Energy Star products and Energy Efficiency Top Runner products for government procurement and for government-funded energy-saving renovation projects.

Further Prospects for China's Role in Protocol Evolution

China's history of proactive industry transformation supporting HCFC phaseout and HFC phasedown responsibilities bodes well for the fulfillment of the Montreal Protocol's most recent evolution. It also bodes well for further strengthening of Montreal Protocol mechanisms affecting future Kigali Amendment compliance, as global analysis is ongoing regarding the potential sources for unexpected CFC-11 emissions. At a press conference in July 2018, China's Ministry of Ecology and the Environment pledged to resolutely crack down on the illegal production, sale, and use of CFC-11 by enterprises. Hou Liqiang, *Ministry Reiterates Zero-Tolerance toward Use of Banned Ozone-Depleting Substance*, China Daily, updated July 26, 2018, https://enapp.chinadaily.com.cn/a/201807/26/AP5b598e08a3100686eced8f5b.html.

Whether China also is able to help realize the ambition of the Kigali Amendment, fast-tracking HFC phasedown and magnifying climate benefits, remains to be seen. Positive signs of China's ability to move this evolution and ambition forward exist. However, a key factor will be whether the transformation encompasses production facilities and products that use refrigerants not only in China's domestic market, but also in China-originating facilities and products that use refrigerants in its export markets.

Underscoring this observation is the fact that China is also the world's biggest AC exporter. In 2017, China's residential AC exports amounted to 52.44 million units, including growing exports to countries in China's Belt and Road Initiative. China Industry Online, *Residential Air Conditioner Export: 2017 Reached Historical High* (Feb. 11, 2018). If China elects to depart from "business as usual" and pursues a leadership path that promotes super-efficient and low-GWP AC in its export markets, as it is doing at home, we can thank China for doing its part to fulfill the Montreal Protocol's ambition and avoid global climate crises. In return, this leadership guides China-based AC industry members in securing and expanding foreign market penetration and technological innovation.

China plays a critical role in the HCFC phaseout under the Montreal Protocol and HFC phasedown under the Kigali Amendment as the world's largest room AC manufacturer, consumer, and exporter. In line with China's policy priorities supporting domestic green development, fighting severe air pollution, strengthening ODS ban monitoring and compliance, and promoting an international "Green Belt and Road," China's promotion of innovations and market penetration of China-produced super-efficient and low-GWP room ACs will demonstrate China's commitment to being a global environmental leader and contribute significantly to the Montreal Protocol's evolving role in solving the global climate crisis.