



COOLING WITH LESS WARMING SCENARIOS FOR PHASING DOWN HYDROFLUOROCARBONS IN INDIA

MAXIMIZING THE BENEFITS OF IMPLEMENTING THE KIGALI AMENDMENT TO THE MONTREAL PROTOCOL

India's cooling sector is in the midst of a major transformation. In September 2021, the government ratified the Kigali Amendment to the Montreal Protocol, the 2016 global phasedown of hydrofluorocarbons (HFCs). HFCs are widely used as refrigerant gases to produce the cooling effect inside cooling appliances and as foam blowing agents. But HFCs have high global warming potentials (GWPs) hundreds to thousands of times that of CO₂ on a kilogram-for-kilogram basis. Rapid replacement of HFCs with climate-friendlier alternatives that can serve the same function – without unduly imperiling the climate – is of paramount importance and a key priority for the cooling sector in India.

Under the Kigali Amendment, India is an Article 5 Group II party, which obligates it to freeze HFC consumption and production in 2028 and phase down HFCs in a graduated manner to 15% of the baseline by 2047 (Figure 1). But that's not the only task at hand: alongside phasing down HFCs, India will aim to scale up its cooling industries to better serve what today is the largest unmet cooling need in the world. For example, just 8% of Indian households currently

Recommended Strategies to Maximize Kigali Implementation Gains

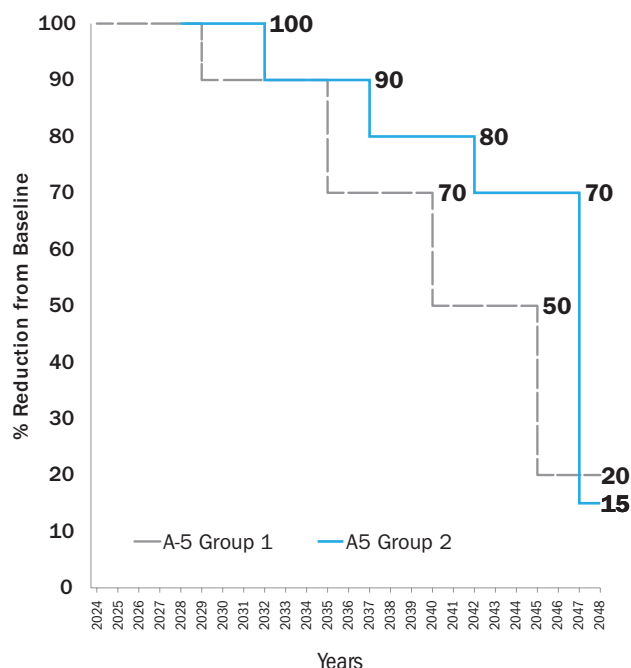
MAC sector could be the first to transition: HFO-1234yf is technologically and economically feasible and in use widely globally. India has domestic production of HFO-1234yf and its adoption starting in 2025 can align with patents expiration timelines. Feasibility of HFC-152a based secondary loop MAC has also been demonstrated in India. India has a globalized motor vehicle industry and is already exporting vehicles with HFO-1234yf MAC systems. This and other global market forces may encourage the sector to move even faster than required.

Move to low-GWP alternatives in space conditioning: The biggest contributor to India's overall HFC demand is the sectors of room air conditioners (RAC), packaged direct expansion systems (DX), and variable refrigerant flow systems (VRF), together constituting 'space conditioning.' The Indian RAC industry has leapfrogged to climate-friendlier refrigerant HFC-32 (90% of the market) over the last few years – a major achievement. However, with India's low HFC baseline and high growth potential, HFC-32 and other mid-GWP alternatives are unlikely to be a tenable long-term solution. Rather, identification and adoption of a suitable low-GWP alternative (such as R-290 or others) is likely to be needed by 2030. Identifying and deploying a low-GWP alternative even faster – by 2025 – is the best way to speed up the phasedown.

Effective Leakage Prevention & Reclamation: Reducing refrigerant leakage through effective installation, servicing and reclamation is a major opportunity to reduce need for virgin HFCs in India. Establishing a reclamation program for all refrigerants would decrease costs and environmental harm.

has air conditioning.¹ In the future, as more and more people can afford to purchase air conditioning, the associated demand for HFCs is expected to grow rapidly alongside the large-and-still-growing need for cooling, particularly considering increases in extreme heat events due to global warming.

FIGURE 1: HFC Phasedown Schedule for Article 5 Parties



India therefore has a dual task, to scale up cooling while phasing down HFCs. A recent research study published in the *Environmental Research Letters (ERL)* models' pathways for India to phase down HFCs without infringing on the nation's effort to scale up access to cooling for millions. The study, led by a diverse group of experts, assessed multiple scenarios for the adoption of alternatives to HFCs and projected the associated HFC use trajectory for India in each scenario (Figure 2). It presents a possible sector-by-sector schedule for adopting climate-friendlier alternatives over the coming decades. These HFCs demand scenarios are then compared to the trajectory with HFC phasedown obligations required to comply with the Kigali Amendment. The study demonstrates that Kigali implementation in India will likely avoid use of HFCs equivalent to 2.2 billion metric tons of CO₂ through 2050 compared to current market trends, which is equivalent to a full year of India's total greenhouse gas emissions in 2018.

¹ (Khosla R, Agarwal A, Sircar N and Chatterjee D 2021. *The what, why, and how of changing cooling energy consumption in India's urban households*. *Environ. Res. Lett.* 16 (2021) 044035)

Move refrigeration out of R-404A and shift smaller refrigeration units to hydrocarbons within a few years:

Refrigeration units manufactured with R-404A can easily be transitioned to available HFC-HFO blends R-448A or R-449. Remote condensing units also have the potential to use HFC-134a in lieu of R-404A, while smaller refrigeration units may adopt hydrocarbon refrigerants with superior energy efficiency. The retail food sector is small today but may need to consider decentralized units with low-GWP refrigerants if it is to grow large. There are challenges of refrigerant choice, leak management, and energy efficiency when dealing with large, distributed supermarket style-compressor rack systems.

Starting early can lead to lower costs and greater emissions:

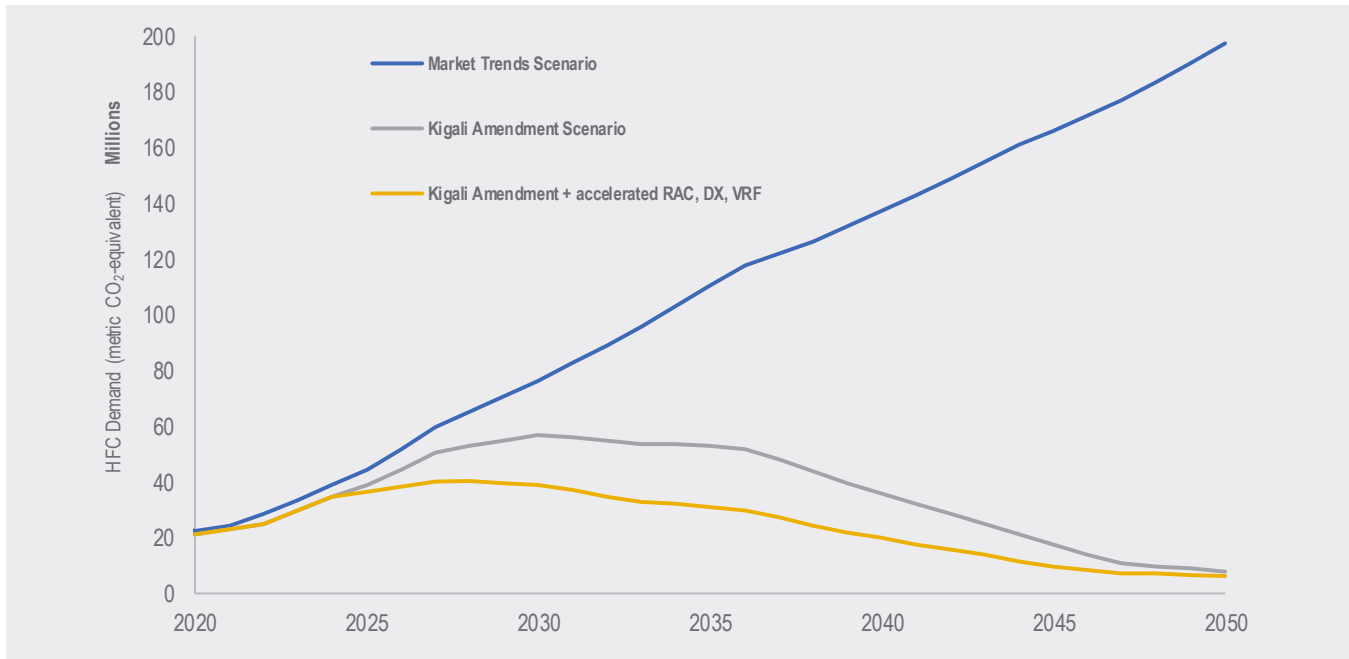
In general, there are technologically and economically feasible HFC alternatives available in most sectors. Beginning the phasedown before required in 2028 brings major benefits, avoiding buildup of a large installed base of HFC-based units that would require stronger and more aggressive transition efforts to reduce as the phasedown progresses. A typical approach is to start with the readiest sector and give time to sectors needing greater innovation, research, development, and deployment.

Source: Alex Hillbrand et al 2022 *Environ. Res. Lett.* 17 074019

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Indian industry's recent progress of adopting climate-friendlier HFC-32 in the air conditioning sector has already placed it among the leading countries in the world adopting better alternatives to mainstream HFCs. India's biggest HFC-using sector, room air conditioning, has over the last few years transitioned more than 90 percent of the manufacturing of room air conditioners to using climate-friendlier alternative HFC-32, with roughly one-quarter the climate potency of the globally ubiquitous, high climate impact HFC called R-410A. The study points to this kind of early action that will make implementing the Kigali Amendment easier, cheaper, and more environmentally beneficial. However, there's a lot of work ahead to plan and start a complete HFC phasedown. And with strategic, timely action, India can set its industries up for long-term, sustainable success (Box 1). A key finding from the study is that early action on Kigali Amendment implementation could provide multiple benefits. Early action – i.e., beginning

Figure 2: India's HFC demand trajectory among the three scenarios



Source: Alex Hillbrand et al 2022 *Environ. Res. Lett.* 17 074019

phasedown steps prior to them being required in 2028 and beyond – makes it possible for India to maintain a steady pace of converting manufacturing industries to using HFC alternatives. This approach benefits from leaving enough time to transition sectors at a reasonable speed, which is like the pace followed in prior fluorocarbon transitions, and leaves time for industries to recoup their investments along the way. It also increases the benefits to climate and reduces costs by avoiding multiple refrigerant transitions along the way.

The study also points to the likely need to transition by 2030 (for new manufacturing capacity) to low-GWP refrigerants in space conditioning, India's biggest current and projected future source of refrigerant demand. While, as noted, HFC-32 and other mid-GWP alternatives are far preferable to very high GWP HFCs commonly used today, India's low refrigerant consumption rate and high growth potential combine to drive a need for a truly low-GWP alternative in this sector. Furthermore, India can accelerate its phasedown to on par with most developing countries under the Kigali Amendment by accelerating that process by five years. Doing so, would deliver an additional reduction in India's HFC demand equivalent to 337 million metric tons CO₂e cumulatively between 2025 and 2050.

The Government of India, cognizant of the tasks ahead, announced a two-year HFC phasedown

planning process alongside its ratification of the Kigali Amendment announcement in 2021. India will complete a national strategy for phasing down HFCs in close consultation with the industry by 2023 and make amendments to the existing legislation framework, the Ozone Depleting substances (Regulation and Control) rules, by mid-2024 to allow appropriate control of the production and consumption of HFCs to ensure compliance. The new study in ERL should provide a solid basis for considerations of order, pace, and approaches to the phasedown under that process, ultimately helping India maintain its global leadership in the fluorocarbon transitions of the Montreal Protocol.

For further details, please read the full analysis available at: Alex Hillbrand et al 2022 *Environ. Res. Lett.* 17 074019. <https://doi.org/10.1088/1748-9326/ac7538>



HIGHLIGHTED RESOURCES



Frequently Asked Question (FAQs) Cool Roofs

May 2020

<https://www.nrdc.org/sites/default/files/india-cool-roofs-faq-20200527.pdf>



Towering Possibilities in India

September 2019

<https://www.nrdc.org/sites/default/files/towering-possibilities-in-india-20190910.pdf>



Cooling with Less Warming

November 2018

<https://www.nrdc.org/sites/default/files/cooling-india-air-conditioners-market-profile-2018-fs.pdf>



Improving Air Conditioners in India

April 2018

https://www.nrdc.org/sites/default/files/cooling-india-issue-brief-2018_0.pdf

HIGHLIGHTED BLOGS

- **Discussing Climate Friendly Cooling in India**, Prima Madan and Sameer Kwatra, July 2022
<https://www.nrdc.org/experts/sameer-kwatra/discussing-climate-friendly-cooling-india>
- **Countries Get Back to Work on HFCs at the Montreal Protocol, July 2022**
<https://www.nrdc.org/experts/alex-hillbrand/countries-get-back-work-hfcs-montreal-protocol>
- **Cooling with Less Warming in India**, Prima Madan and Anjali Jaiswal, October 2021
<https://www.nrdc.org/experts/anjali-jaiswal/guestblog-prima-madan-cooling-less-warming-india>
- **Cooling with Less Warming: Fighting Global Superpollutants**, Prima Madan and Anjali Jaiswal, October 2021
<https://www.nrdc.org/experts/anjali-jaiswal/cooling-less-warming-fighting-global-superpollutants>
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<https://www.nrdc.org/experts/sameer-kwatra/world-ozone-day-global-effort-save-planet>
- **India to Ratify the Kigali Amendment, Develop HFC Strategy**, Sameer Kwatra, Alex Hillbrand and Prima Madan, August 2021
<https://www.nrdc.org/experts/sameer-kwatra/india-ratify-kigali-amendment-develop-hfc-strategy>
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<https://www.nrdc.org/experts/sameer-kwatra/all-eyes-indias-plan-kigali-amendment>
- **India Can Help Cement Global Commitment on HFCs, April 2021**
<https://www.nrdc.org/experts/sameer-kwatra/global-progress-hfcs-why-india-should-ratify>
- **Cooling With Less Warming: Updates from US, India and China, Nov 2020**
<https://www.nrdc.org/experts/anjali-jaiswal/cooling-less-warming-updates-us-india-and-china>



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