COOLING WITH LESS WARMING: IMPROVING AIR CONDITIONERS IN INDIA

Addressing accelerating cooling demands with energy efficient and low-GWP ACs

Urbanization, rising temperatures, and more frequent heat waves due to climate change are intensifying cooling demand across the globe. Paired with increasing electricity access and the growing middle class, especially in rapidly developing nations like India, these factors are driving up the use of air conditioners (ACs). Today's AC units contribute to the further warming of our planet because of their significant energy consumption as well as the climate-forcing effects of the refrigerants used.

As nations phase out ozone-depleting refrigerants to comply with the Montreal Protocol, the AC industry faces the challenge – and opportunity – of switching to refrigerants that have lower global warming potential (GWP). GWP is a measure of how much heat a greenhouse gas traps in the atmosphere relative to a similar mass of carbon dioxide. This transition to climate-friendly refrigerants also provides the opportunity to develop more energy efficient AC designs that will simultaneously help reduce growing energy demand and combat climate change.

Several companies are already stepping up to the challenge, leapfrogging past transitional high-GWP refrigerants by using lower-GWP alternatives while at the same time pursuing energy efficiency.

This factsheet provides an overview of the growing Indian AC market, strategies to advance climate-friendly ACs, and market opportunities under the Montreal Protocol. The factsheet also profiles two climate-friendly refrigerants with growing use in the AC market, both in India and worldwide.

STRATEGIES TO IMPROVE ACS IN INDIA

Based on extensive research and discussions with stakeholders, the following strategies can improve ACs in the Indian market:

1. **Opportunities under the Montreal Protocol**: AC manufacturers phasing out HCFC-22 should continue leapfrogging traditional high-GWP HFCs in favor of lower-GWP alternatives with funding support from the Montreal Protocol, while also working with UN agencies to facilitate co-funding and/or financing for energy efficiency upgrades.
2. **Energy Efficiency and Low-GWP Standards & Labels**: Accelerating performance standards under India's efficiency labeling program and including the labeling of low-GWP refrigerants will foster competition and help consumers identify the most climate-friendly room ACs.
3. **Bulk Procurement Programs**: Bulk procurement programs pioneered by Energy Efficiency Services Limited (EESL) are revolutionizing the landscape for high efficiency products. Building on EESL's success, incorporating strategies to advance efficiency and encourage lower-GWP refrigerants as part of the procurement process can address both the direct refrigerant-related and indirect electricity-related climate impacts of room ACs. Bulk procurement could also be applied to purchase super-efficient AC components to lower costs to small- and medium-sized enterprises (SMSE).
4. **Raising Consumer Awareness**: Improving efficiency labelling and raising awareness of the benefits of cooling-friendly architecture, better cooling behaviors, distribution company incentive programs, and proper room AC sizing would help reduce the environmental impact of cooling. The Indian government's move to set thermostats to sensible temperatures (24-26°C) and inform consumers of the high cost of excessively cold air is a step in the right direction.
5. **Local Supply Chains and Research & Development**: Leveraging programs such as "Make in India," the AC industry can work with the Indian government to increase the production and financial incentives for domestic manufacturing of high-efficiency components used in room ACs. This promotes in-house engineering, greater design flexibility, and lower costs, encouraging the adoption of climate-friendly ACs.
6. **National Cooling Action Plan**: Strong national planning, such as the upcoming National Cooling Action Plan in India, can promote synergies between different types of AC policies to support the use of low-GWP refrigerants and energy efficient designs so that they are integrated, effective, and provide design flexibility to manufacturers.

More information on these strategies is available in the joint NRDC, TERI, and IGSD issue brief, *Cooling India with Less Warming: Improving Air Conditioners in India*.

INDIA'S RAPID AC EXPANSION

India is one of the fastest growing major economies in the world. Given its rising middle class, the expansion of its electricity grid, and increasing temperatures in an already hot and humid climate, the use of room AC units in India has been rising exponentially. The stock of room ACs has skyrocketed from four million units in 2014 to approximately 30 million in 2017, with 2017 AC sales at around 5.5 million units.[1] Room AC sales are projected to continue their rapid rise, with an installed stock of between 55 and 124 million units by 2030.

Further, less than 10% of India's population currently own ACs, but AC use is already the largest component of overall residential power consumption and the largest source of peak electricity demand in many cities.[2] With the rapidly expanding market, India's AC use is expected to become the world's largest contributor to new electricity demand through 2040 and add between 80-145 gigawatts to the country's peak power demand in a business-as-usual scenario by 2030.[3]

POTENTIAL CLIMATE IMPACTS

This rapid expansion of AC use can potentially warm the planet through both the indirect electricity-related and direct refrigerant-related emissions of climate pollutants. ACs stress electricity grids with greater peak power demand, leading to higher fossil fuel consumption and increasingly poor air quality. The increase in power generation exacerbates climate change through the emissions of carbon dioxide.

ACs also harm the climate through the direct release of refrigerants such as hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). These gases can be thousands of times more potent than carbon dioxide in heating the planet. Though accounting for only 1-2 percent of total warming now, HFCs are the fastest growing climate pollutants because of the skyrocketing demand for ACs in developing markets.[4]

OPPORTUNITY FOR CHANGE

In 2017, 70% of ACs sold in India used HCFC-22 as refrigerants.[5] As HCFCs are phased out under the Montreal Protocol for their ozone-depleting properties, the AC industry is undergoing a massive shift as it switches from HCFC-22 to alternative refrigerants. The longer established replacement refrigerant, HFC-410A, while not ozone depleting, is even more planet warming than its predecessor. This high-GWP refrigerant, along with all HFCs, will also eventually be phased down worldwide under the 2016 Kigali Amendment to the Montreal Protocol. However, better refrigerant options – that are both climate-friendly and market-proven – are available, and more are being developed. For example, HFC-32 and hydrocarbon 290 (HC-290) are refrigerants with significantly lower GWP that already have been effective in the AC market. (See Figure 1 below)

HFC-32 has a third of the GWP of HFC-410A and far lower flammability than HC-290.[6] HFC-32 is still 677 times more potent than carbon dioxide at heating our planet, so efforts are underway to further increase energy efficiency to offset this climate impact.[7,8] As an HFC, it is subject to eventual phasedown under the Kigali Amendment, and is currently one of the climate-friendly refrigerants on the market. HC-290 has a GWP of less than three, exponentially lower than those of HCFCs and HFCs, and is not subject to the Kigali Amendment. Unlike HCFC or HFC refrigerants, HC-290 – more commonly known as propane – has high flammability, but is sold following international safety standards.[9]

Room AC Refrigerants

Refrigerant	GWP	2017 AC Sales in India	India Market Status
HCFC-22	1,760	70%	India is phasing out HCFC-22 under the Montreal Protocol because of its ozone depletion impact. HCFC-22 is used in older, lower efficiency room ACs and has a high GWP.
HFC-410A	1,924	11%	HFC-410A has been commercialized worldwide, including in higher energy efficiency room ACs. However, it has high GWP, performs with poor energy efficiency at high ambient temperatures, and will be phased down under the Kigali Amendment.
HFC-32	677	17%	HFC-32 is replacing HCFC-22 in most of the global market. Over 1 million ACs with HFC-32 have been sold in India, including the highest efficiency room ACs, but it has a moderate GWP and will be subject to the Kigali Amendment.
HC-290	<3	2%	HC-290 is a low-GWP refrigerant replacing HCFC-22. Hundreds of thousands of room ACs using HC-290 have been sold in India, including the highest efficiency room ACs.

Figure 1: Refrigerants used in Indian room ACs. *Source: NRDC (2018).*

CLIMATE AND ENERGY BENEFITS

The benefits of switching to low-GWP refrigerants are huge. Scientists estimate that phasing down high-GWP HFCs globally under the Kigali Amendment will avoid up to 0.5°C of warming by 2100.[8] In India alone, fulfilling the Kigali Amendment is expected to avoid the use of HFCs equivalent to between 2 and 6 billion tons of carbon dioxide through 2050 – about 20 to 25% of which is likely to come from reductions in HFCs used for room ACs.[9]

Increasing energy efficiency can avoid an additional 0.5°C of warming, with even greater benefits when considering the impact of high ambient temperatures on the time-of-day carbon intensity of electricity.[10] In India, efficiency improvements can provide substantial reductions in greenhouse gas emissions – perhaps up to 10% of India's Paris Agreement targets in 2030.[11]

Improved efficiency reduces burden on the electricity grid and conserves power to meet growing energy demands. Energy efficiency also saves consumers money on energy bills and supports local economies.

PROGRESS ON IMPROVING ACS IN INDIA

The Indian government and stakeholders have recently moved forward with several programs and initiatives to promote the manufacture and use of improved ACs. These programs include:

Efficiency labeling: The Bureau of Energy Efficiency's (BEE) innovative five-star labeling program develops a metric to measure and compare the efficiencies of AC units. The program helps consumers make smart purchasing decisions and save money on energy bills, while driving competition and innovation in the industry.

Efficiency standards: India's minimum energy performance standards (MEPS), represented by the lowest efficiency threshold of the one-star level in the broader five-star program, has been steadily increasing efficiency requirements over time. The program has succeeded in strengthening AC efficiency standards by about 35% since 2006, representing major savings in energy and electricity cost to consumers and the nation.

Efficiency ratings of Indian ACs

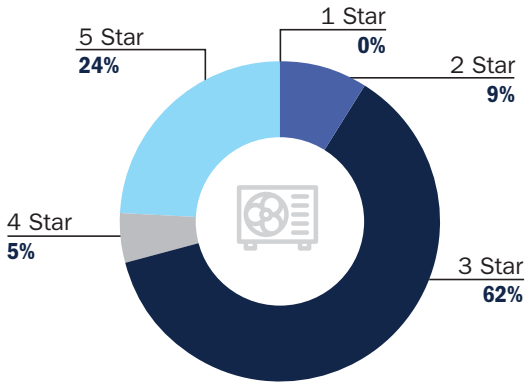


Figure 2: Room AC sales in India (as percent of total sales) by star rating for 2017.
Source: Bureau of Energy Efficiency (2017).

Bulk procurement: EESL's debut bulk procurement program secured the production of 100,000 ACs with a minimum efficiency above that of the most efficient unit on the market in its size class at the time it was introduced. Production included 40,000 highly efficient Godrej ACs using low-GWP refrigerant HC-290 at prices comparable to three-star (average efficiency) units.

National Cooling Action Plan: India's upcoming plan looks comprehensively at making ACs more climate-friendly, while also exploring measures to reduce cooling demand through passive cooling solutions.

Refrigerants used in Indian ACs

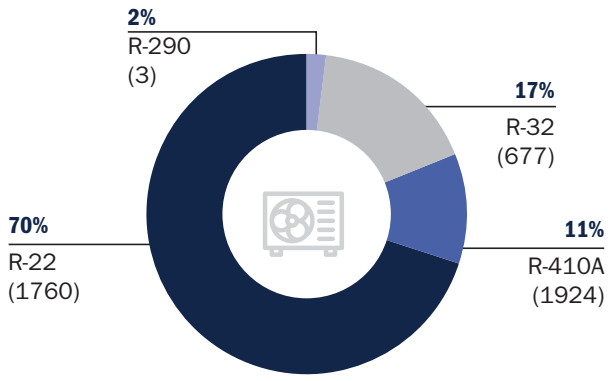


Figure 3: Room AC sales in India (as percent of total sales) by refrigerant for 2017. GWP in parentheses.
Source: Industry Information and Estimate (2018).

Top AC providers in India

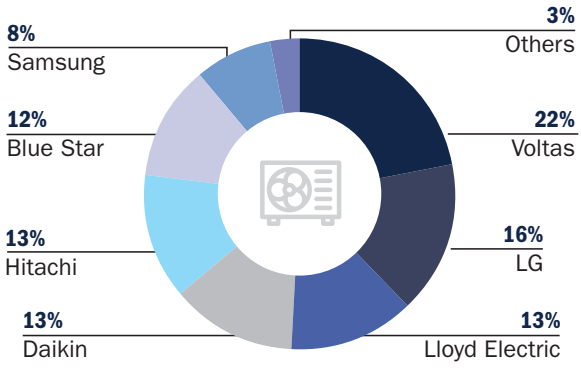


Figure 4: Market share of room AC manufacturers in India (as percent of total sales) for 2017.
Source: Motilal Oswal Research (2017).

INNOVATIVE PROGRAMS: PULLING THE MARKET FORWARD

Bulk procurement programs are revolutionizing the landscape for high efficiency products. Bulk procurements aggregate demand for a specific product and secure their production through a reverse-bidding process. In India, EESL has piloted new procurement programs that issue large production contracts for highly efficient products which manufacturers place low bids to fulfill. The resulting contracts allow companies to confidently manufacture products at scale that would otherwise see smaller market shares, reducing manufacturing cost and ultimately purchase price.

Tata Power, the largest power generation company in India, has introduced its own program to promote energy efficient ACs. Under this program, residents can trade in inefficient room ACs for highly efficient five-star units from a number of top AC manufacturers. Tata Power subsidizes this trade-in with warranties and rebates that can represent savings to consumers of up to 45% of the ACs' suggested retail price. Using more efficient ACs also lowers electricity bills, providing further savings to consumers.

Unlike MEPS, which provide an energy efficiency floor that "pushes" the market forward, these programs "pull" the market forward by introducing top-performing products at lower costs.

MARKET BENEFITS

Both in terms of refrigerant gases and energy efficiency, improving ACs offers the industry major benefits. Leapfrogging to lower-GWP alternatives from HCFC-22 provides an opportunity to avoid future transition costs and get ahead of the curve in markets moving away from high-GWP HFCs, while potentially receiving international financial support.

Leading AC manufacturers recognize the tremendous business opportunity of leapfrogging transitional high-GWP HFCs. Although India's cap on HFCs under the Kigali Amendment does not begin until 2028, some companies have already completely leapfrogged high-GWP HFC-410A to more climate-friendly refrigerants, while others have introduced AC lines using low-GWP refrigerants. Currently, half a dozen additional AC manufacturers are leapfrogging HFC-410A as a part of India's HCFC Phaseout Management Plan process, through which companies receive funding from the Montreal Protocol's Multilateral Fund (MLF) to convert away from ozone-depleting HCFC-22 by 2023. In addition, most major AC companies in India now offer inverter models, which are generally more efficient than traditional fixed-speed ACs, playing a significant role in transitioning the market to higher efficiency levels.

AC Companies Leapfrogging to Climate-Friendly Refrigerants

AC Manufacturer	Production lines to be converted / total lines	New Refrigerant	Phase out (GWP tons)	MLF Funding Received (USD)
Blue Star	2/3	HFC-32	143,941	1,785,917
E-Vision	2/4	HFC-32	122,281	1,574,300
Lloyd	3/5	HFC-32	153,195	1,868,372
Voltas	1/1	HFC-32	573,596	4,303,695
Videocon	1/1	HFC-32	177,021	1,817,975
Zamil Air Conditioners	1/2	HFC-32	64,980	1,161,200
Total	**10/16**		**1,235,014**	**12,511,459**

Figure 5: Companies that have committed to leapfrogging from high-GWP HFC-410A to HFC-32 with international financial support as a part of India's HCFC Phaseout Management Plan.
Source: MOEFCC (2017).

FINANCING EFFICIENCY UNDER THE MONTREAL PROTOCOL

Switching refrigerants presents an opportunity to simultaneously upgrade designs and components to make ACs more energy efficient. To finance energy efficiency advancements, a decision accompanying the Kigali Amendment supports funding factory-level investments in businesses as part of the HFC transition. The question before the Montreal Protocol parties now is how to use the MLF to finance the costs of improved energy efficiency above and beyond the traditional agreed incremental costs of switching refrigerants.

The MLF is exploring potential strategies to coordinate funding and incentive programs for energy efficiency improvements, including working with other financial institutions (such as the Global Environment Facility, the Green Climate Fund, and the World Bank) and tapping into market mechanisms (such as bulk procurement programs). These discussions are a key topic of negotiation at the Montreal Protocol meetings and will continue through the HFC phasedown. If the entire transition is done at scale, such arrangements would represent a breakthrough in finance for energy efficiency.

MARKET PROFILE: HFC-32 ROOM ACS

Sales: Daikin was the first company to introduce ACs with refrigerant HFC-32 in 2012. Mitsubishi, Fujitsu General, Hitachi, Panasonic, Toshiba, Sharp and others now also sell room ACs with this refrigerant. Since 2012, 43 million HFC-32 ACs have been sold by companies around the world.

Climate benefits: To date, the HFC-32 ACs deployed worldwide have achieved emissions reductions equivalent to more than 75 million tons of carbon dioxide. Daikin estimates that up to 800 million more tons could be reduced compared to business-as-usual scenarios if all presently used HFC-410A refrigerants were replaced by HFC-32.

Performance: The potential refrigerating effect of HFC-32 is 1.5 times that of HCFC-22 or HFC-410A. HFC-32 has higher cooling capacity and coefficient of performance – thermodynamic measures of efficiency – than the high-GWP HFC-410A.

Energy efficiency: Due to its greater cooling capacity, HFC-32 ACs provide significant energy savings. Switching to HFC-32 ACs with efficiency improvements from HFC-410A in a business-as-usual scenario will reduce energy-related greenhouse gas emissions from residential ACs in India by 31% by 2050. At temperatures of 35°C (95°F) and above, HFC-32 units also demonstrate better efficiency than HFC-410A. HFC-32's peak power consumption is also lower, helping alleviate burdens to the electricity grid during periods of high demand.

Affordability and patents: Global and free access to HFC-32 patents are offered by Daikin, which holds 93 patents for the refrigerants' use in ACs. This patent availability guarantees competitive pricing and facilitates wider adoption of HFC-32 in developing countries. Several global AC component suppliers are also developing compressors and components for use with HFC-32. Given the expansion of HFC-32–oriented production, the cost of appliances using this refrigerant are expected to continue declining in the future.[13,14]

Sources: Daikin. R-32: The Most Balanced Refrigerant for Stationary Air Conditioners and Heat Pumps. http://www.daikin.com/csr/information/influence/hfc32.html; NRDC, CEEW. Efficient Air Conditioning for the Next Decade (2014).

MARKET PROFILE: HC-290 ROOM ACS

Sales: In 2012, Godrej launched the first HC-290 AC in India. Since then, they have sold half a million units in India, and have also recently launched the ACs in the Maldives. Chinese manufacturers are also moving to HC-290 ACs with the support of the Chinese government, and German agency GIZ is introducing a pilot HC-290 program in Indonesia.

Energy efficiency: Godrej's HC-290 AC is among the most efficient in the market, with an Indian Seasonal Energy Efficiency Ratio of 6.15 – well above the five-star performance standard minimum of 4.5. A study analyzing HFC transition alternatives in China estimated that HC-290 ACs could save more than five times as much energy as HFC-410A ACs.

Climate benefits: By 2050, a switch to HC-290 could reduce greenhouse gas emissions from room ACs in India's residential sector by 38%, of which 15% would result from the reduction in fossil fuels burned to generate electricity due to energy efficiency, and 23% from reduced global warming caused by the direct emissions of the refrigerant into the atmosphere.

Performance: The benefit of HC-290 in high ambient temperatures appears to be higher than the high-GWP HFC-410A. A GIZ/Godrej study found that HC-290 is better suited for use in regions with high ambient temperatures, with its higher cooling capacity and coefficient of performance.

Affordability and patents: The HC-290 models are price competitive with other ACs of similar efficiency. Under EESL's bulk procurement program in 2017, Godrej won a contract to produce HC-290 ACs at the same price per unit as HFC-410A ACs. HC-290 is already used extensively in domestic refrigerators, and production is not limited by patents. Refrigerant-grade HC-290 can be affordably produced by domestic chemical and petroleum producers in India, promoting competitive pricing.

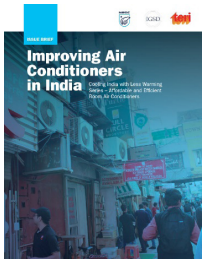
Safety: HC-290 is a flammable substance, but application of this refrigerant in residential and commercial refrigeration is safe if it meets international safety standards. Flammability concerns are addressed by designing HC-290 ACs to minimize risks, limiting the quantity of refrigerant charged in the AC, installing units using certified technicians, and offering product warranties. HC-290 ACs are manufactured with blast-proof components and system designs to ensure that the amount of charged refrigerant is not enough to cause a flammability hazard in the event of a leakage.[15,16]

Sources: D. Rajadhyaksha, B.J. Wadia, Abhijit A. Acharekar, D. Colbourne. The first 100,000 HC-290 split air conditioners in India. International Journal of Refrigeration 60 (2015) 289–296; Yoshimoto, Devin. Hydrocarbons 21; NRDC, CEEW. Air Conditioners with Hydrocarbon Refrigerant – Saving Energy while Saving Money.

MOVING FORWARD

As the room AC industry phases out high-GWP and ozone-depleting HCFCs under the Montreal Protocol, choices in AC design will determine whether India can turn the challenge posed by rapid growth in room AC use into a business and environmental opportunity. Companies' experiences with low-GWP refrigerants and energy efficiency suggest that improved ACs could deliver a win-win-win for business, energy resources, and the planet. As negotiations continue on the HFC transition, key decisions made under the Montreal Protocol on energy efficiency and financing can promote the accelerated adoption of climate-friendly ACs in India and worldwide.

Highlighted Resources



Improving Air Conditioners in India

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

(April 2018)

Cooling India Resource Guide

https://assets.nrdc.org/sites/default/files/cooling-india-highlighted-hfc-resources-fs.pdf

(October 2016)

The Business Case for Phasing Down HFCs

https://assets.nrdc.org/sites/default/files/air-conditioner-efficiency-IPpdf

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About the Authors

The Energy and Resources Institute (TERI) develops solutions to global problems in the fields of energy, environment and current patterns of development not only by identifying and articulating intellectual challenges straddling many disciplines of knowledge but also by mounting research, training, and demonstration projects leading to development of specific problem-based advanced technologies that help carry benefits to society at large. www.teriin.org

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ENDNOTES

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