Energy Efficiency Gains with Lower Global Warming Impact

A Profile of Air Conditioners Using R-290

As living standards rise for tens of millions in India, use of room air conditioners (ACs) is rapidly growing, straining India's electric grid.[1] Because of their significant energy use as well the climate-forcing effects of the refrigerants used, today's air conditioning units also contribute to increasing greenhouse gas pollution.[2] Choices made by Indian consumers, companies, and government authorities will determine whether India can turn the challenge posed by rapid growth in use of room air conditioners into a business and environmental opportunity. As India phases out ozone-depleting hydrochlorofluorocarbons (HCFCs) to comply with the international Montreal Protocol treaty, could replace high global warming potential (GWP) refrigerants with climate-friendly refrigerants which can contribute to reductions in India's increasing energy demand and combat climate change.

Commercially Viable Technology

One innovative approach that is rising to the challenge is using a commonly available hydrocarbon – propane (hydrocarbon 290, HC-290, or R-290) – as the refrigerant. The standard-bearer for this approach in India is Godrej & Boyce Manufacturing Co. Ltd, the Indian appliance manufacturer which developed the R-290 AC for India. The R-290 AC makes the case that ACs in the Indian market can be built using climate friendly refrigerant alternatives that protect the ozone layer, and at the same time make air conditioning more energy efficient and less costly to operate.

The R-290 models are price competitive with other ACs of similar efficiency whether they use R-410A or R-32, which are the two other refrigerants that are scheduled to replace the ozone-depleting R-22 refrigerant being phased-out in India. Company representatives report that since the 1- and 1.5-tonne R-290 based air conditioners were launched in the Indian market, Godrej has sold over 100,000 units of this AC. The company also reports

Figure 1: Godrej R-290 Hydrocarbon Air Conditioner

that its manufacturing facility near Pune in India can produce 180,000 R-290 based ACs per year.[3]

Meanwhile, Chinese manufacturers are also moving to R-290 based air-conditioners with the support of the Chinese government.[4]

There is a strong case for other AC companies to follow Godrej's lead and adopt R-290. R-290 is not protected by patents. In addition, hydrocarbons are already used extensively in domestic refrigerators and have reached a penetration of 55% in industrialized countries. India's domestic chemical manufacturers should be able to produce R-290. Liquid petroleum gas (LPG) producers and refineries are often capable of supplying refrigerant-grade R-290.[5]

Using Flammable Refrigerants Safely

R-290 is a flammable substance, but application of this refrigerant in residential and commercial refrigeration is safe if it meets European and international safety standards for 1 to 1.5 ton capacity for use in small rooms. The Godrej R-290 AC, developed in collaboration with German development agency GIZ, and India's Ministry of Environment and Forests' Ozone Cell, addressed flammability of R-290 in four ways: 1) designing the appliance and manufacturing facility to minimize risks; 2) limiting the quantity of refrigerant charge in the AC according to international safety standards; 3) installing the A/C using factory-trained technicians, and 4) safety procedures and training of service personnel.[6]

To ensure safety, Godrej upgraded their manufacturing facility to incorporate additional safety alarms and procedures for dealing with the flammable refrigerant. The R-290 AC uses blast-proof components and system design to ensure that the amount of R-290 charged in an AC is so small that it never causes a flammability hazard in the event of refrigerant leakage.

Key Facts

- Number of R-290 ACs sold in India: about 100,000
- Number of production lines switching in China: 18-22
- Estimated energy savings in Indian residential sector from switch to R-290 room ACs with energy efficiency improvements over business-as-usual with HFC-410A: 15%
- Energy efficiency rating for Godrej's R-290 AC: five stars from India's Bureau of Energy Efficiency
- Godrej R-290 AC launched in: 2013
- Patents on manufacture and use of R-290 in room ACs: none
- Safety of R-290 use in room AC: in compliance with international safety standards, safe to use in ACs smaller than 1.5 tons cooling capacity

High Energy Efficiency

Room AC's using R-290 can provide significant energy savings. The Godrej R-290 AC model received a five star energy efficiency rating – the highest available rating awarded by India's Bureau of Energy Efficiency (BEE). The Godrej R-290 room A/C achieves the five-star rating without the use of inverter technology, which would increase the efficiency by the equivalent of about two stars more.[7] A study analyzing HFC transition alternatives in China estimated that HC-290 air conditioners would save more than five times as much energy as a HFC-410A air conditioner.[8] Reduction of peak energy demand is likely to be even more significant, as AC use is highly coincident with peak demand in India.[9] A recent analysis by CEEW indicates that a switch to HC-290 air conditioners with energy efficiency improvements could offer energy savings over a business-as-usual scenario with HFC-410A. By 2050, a switch could reduce greenhouse gas emissions from room ACs in India's residential sector by 38%, of which 15% would result from energy efficiency induced reduction in fossil fuels burned to generate electricity, and the remainder from reduced global warming caused by the direct emissions of the refrigerant into the atmosphere.[10]

The benefit in high ambient temperatures also appears to be higher. India is hot, with ambient temperatures in most of the country exceeding 40°C (104°F) during the months between April and September. A recent GIZ/Godrej study showed R-290 to be better suited for use in regions with high ambient temperatures. R-290 has higher cooling capacity and coefficient of performance – thermodynamic measures of efficiency – than the high-GWP HFC-410A also being considered as a replacement for the R-22 refrigerant currently dominating use.[11] This means that it will save Indian consumers and the economy money in the long run, and help India better meet its growing energy demands, to which air conditioners contribute significantly.

Climate Change Benefits

Last but not least, the climate benefits of R-290 over other currently available alternatives cannot be understated. Most developed country AC manufacturers are in a multiple-step transition. Already having phased out ozone depleting CFCs under the Montreal Protocol, developed countries currently use dangerous HFCs (e.g. HFC 410A) – gases with a high global warming potential. This is because when companies manufacturing ACs in the developed world switched to ozone friendly gases a decade ago, HFCs were the best alternative available to them. But this is not the case any more. By switching to climate-friendly HFC alternatives such as R-290, companies in India and other developing economies have an opportunity to jump ahead and adopt climate-friendly refrigerants.

The 100-year GWP of HC-290 is less than five, compared to 1760 for R-22, 2088 for R-

410A, and between 350 and 700 for a host of other HFC/HFO refrigerants candidates for replacing R-22.[12] International markets are moving toward climate-friendly alternative refrigerants to HFCs. Globally, companies and government leaders are making progress on phasing down HFCs. In December 2013, the European Union officially passed legislation to reduce HFC use to one-fifth of today's levels by 2030.[13] The United States, through President Obama's Climate Action Plan, directs policies to phase down HFCs as well.[14] Chinese companies are already responding by switching production to R-290 based ACs. By adopting R-290 based ACs, India can demonstrate global leadership on climate change while making a transition that is good for the environment, good for business, and good for the consumer and India's energy grid.

The development of the R-290 room air conditioner shows that air conditioners can be built much more sustainably than they are today. Godrej's experience shows that it is possible to bring a product to market keeping costs down in the near and long-term, while customers and the energy grid reap energy efficiency benefits.

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[2] Chaturvedi V and Sharma M. 2014. *Modelling Long Term HFC Emissions from India's Residential Air-Conditioning Sector.* CEEW Working Paper 2014/7, http://ceew.in/publication_detail.php?id=200 (last accessed Oct. 23, 2014).

[3] Interview with Godrej & Boyce Manufacturing Co. Ltd expert, Dilip Rajadhyaksha.

[4] United Nations Industrial Development Organization, *Montreal Protocol: Demonstration Sub-Project for Conversion From HCFC-22 to Propane at Midea Room Air-Conditioner Manufacturing Company and Demonstration Sub-Project for Conversion Of Room Air-Conditioner Compressor Manufacturing From HCFC-22 to Propane at Guangdong Meizhi Company*, http://www.unido.org/fileadmin/user_media_upgrade/Worldwide/Projects/MPB_China.pdf; Hydrocarbons21.com, "Chinese Ministry of Environmental Protection Offers Subsidy for R290 Air Conditioner Production," July 30, 2014, http://www.hydrocarbons21.com/articles/chinese_ministry_of_environmental_protection_offers_subsidy_for_r290_air_conditioner_production; U.S. EPA, *Benefits of Addressing HFCs under the Montreal Protocol July 2014*, at 16, http://www.epa.gov/ozone/downloads/Benefits_of_Addressing_HFCs_under_the_Montreal_Protocol-July2014MASTER_REV4.pdf.

[5] GIZ, *Production conversion of domestic refrigerators from halogenated to hydrocarbon refrigerants, A Guideline*, 2011, http://www.thai-german-cooperation.info/download/2011_production_conversion.pdf

[6] *See* Dilip Rajadhyaksha, Godrej & Boyce Manufacturing Co. Ltd, *Development and Handling of Hydrocarbon Air-Conditioners – The Godrej Experience*, presentation at Bangkok Technology Conference, 29 June 2013 held in conjunction with the Montreal Protocol Open-Ended Working Group (OEWG), http://www.unep.fr/bangkoktechconference/docs/IIIA-1%20Dilip%20Rajadhyaksha%20Godrej%20Presentation.pdf.

[7] *See id.*

[8] Tingting Wan, *et al.*, *Environmental Benefits for Phase-Out HCFC-22 in the Residential Air-Conditioner Sector in China*, Advances in Climate Change Research 2(2): 86-92, 2011, www.climatechange.cn, DOI: 10.3724/SP.J.1248.2011.00086.

[9] Phadke, et al., at 18.

[10] Chaturvedi V and Sharma M. 2014. *Modelling Long Term HFC Emissions from India's Residential Air-Conditioning Sector.* CEEW Working Paper 2014/7, http://ceew.in/publication_detail.php?id=200 (last accessed Oct. 23, 2014).

[11] *See* Daniel Colbourne, GIZ Proklima, *HC-290 as an Alternative Refrigerant for Split Air Conditioning Systems in High Ambient Temperatures*, presentation at UNIDO ATMOsphere Technology Summit, 3 June 2013, http://www.atmo.org/media.presentation.php?id=222.

[12] The latest official GWP are estimated by the Intergovernmental Panel on Climate Change (IPCC) Assessment Report Number 5, Chapter 8, Table 8.A.4, https://www.ipcc.ch/report/ar5/wg1/; NRDC, CEEW, TERI, IGSD, *Cooling India with Less Warming*, Tbl. 4, http://www.nrdc.org/international/india/files/air-conditioner-efficiency-IP.pdf.

[13] European Commission, "Council endorses agreement on Commission's proposal to limit F-gases," Dec. 12, 2013, http://ec.europa.eu/clima/news/articles/news_2013122001_en.htm.

[14] *See* US EPA, *Benefits of Addressing HFCs under the Montreal Protocol July 2014*, http://www.epa.gov/ozone/downloads/Benefits_of_Addressing_HFCs_under_the_Montreal_Protocol-July2014MASTER_REV4.pdf.

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The Institute for Governance & Sustainable Development (IGSD)'s mission is to promote just and sustainable societies and to protect the environment by advancing the understanding, development, and implementation of effective, accountable, and democratic systems of governance for sustainable development. Beginning in 2005, IGSD embarked on a "fast-action" climate mitigation campaign that will result in significant reductions of greenhouse gas emissions and will limit temperature increase and other climate impacts in the near term. The focus is primarily on strategies to reduce non-CO2 climate pollutants, to complement cuts in CO2, which is responsible for more than half of all warming. It is essential to reduce both non-CO2 pollutants and CO2. Neither alone is sufficient to limit the increase in global temperature to a safe level. IGSD's fast-action strategies include reducing emissions of short-lived climate pollutants—black carbon, methane, tropospheric ozone, and hydrofluorocarbons. They also include measures to capture, reuse, and store CO2 after it is emitted, including biosequestration and strategies to turn biomass into more stable forms of carbon for long-term storage.