

# REDUCING STRESS ON INDIA'S ENERGY GRID

The Power Sector Benefits of Transitioning to Lower Global Warming Potential and Energy Efficient Refrigerants in Room Air Conditioners



# Executive Summary

India is one of the fastest growing major economies in the world. Given the rising middle class and increasing temperatures, the commercial and residential sectors are expanding the use of room air conditioning (AC) units. This expansion stresses the electricity grid and power sector, often, during peak hours for electricity demand, causing power outages. Increasing the efficiency of air conditioning units is an immediate opportunity to strengthen the power sector and tackle climate change. Energy efficiency is also the low hanging fruit to achieve the Modi Government's goals to increase access to energy and grow the Indian economy.

One key means for increasing the energy efficiency of air conditioning units is through changing the refrigerant used as coolants in AC units along with improving the energy efficiency components. A 2014 analysis by Council on Energy, Environment and Water (CEEW) found that a switch to lower-global warming potential (GWP) room ACs with energy efficiency improvements could offer a 15% energy savings over a business-as-usual scenario, contributing to reductions of 31-38% in the global warming footprint of the residential AC sector in India.<sup>1</sup> India has an opportunity to not only mitigate climate change, but also to reap the energy benefits of commercially viable options already available.

Markets around the world are shifting away from potent heat-trapping hydrofluorocarbon (HFCs) with high GWP toward more climate-friendly alternatives. Two refrigerant alternatives, in particular, R-290 and R-32 have received significant attention and are increasingly being used in India and internationally. Several other refrigerant blends are being developed and are on the AC market horizon. In India, AC units using both R-290 and R-32 are being sold by leading AC companies, such as Godrej & Boyce and Daikin. A newly launched 2015 Godrej model using R-290 is sold as the "Diet-AC" since it exceeds India's 5-star AC efficiency program.<sup>2</sup>

In March 2015, the U.S. Environmental Protection Agency approved both R-32 and R-290 as safe refrigerants for room ACs in the United States.<sup>3</sup> Several other markets, including China, Japan, Indonesia, Thailand and the European Union are seeing rapid adoption of alternative refrigerants that are more efficient and cause less global warming. This shows a global shift away from antiquated, inefficient chemicals to sustainable ones that will benefit the power sector and move India forward.

*This paper explores the energy efficiency and power sector benefits of air conditioning companies in India to "leapfrog" and phase down unsustainable technologies based on chemicals with high GWP and move to a future based on climate-friendly and energy-efficient refrigerants.*

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# The Energy Impact of Air Conditioner Use in India

## India's Current Use of Air Conditioning

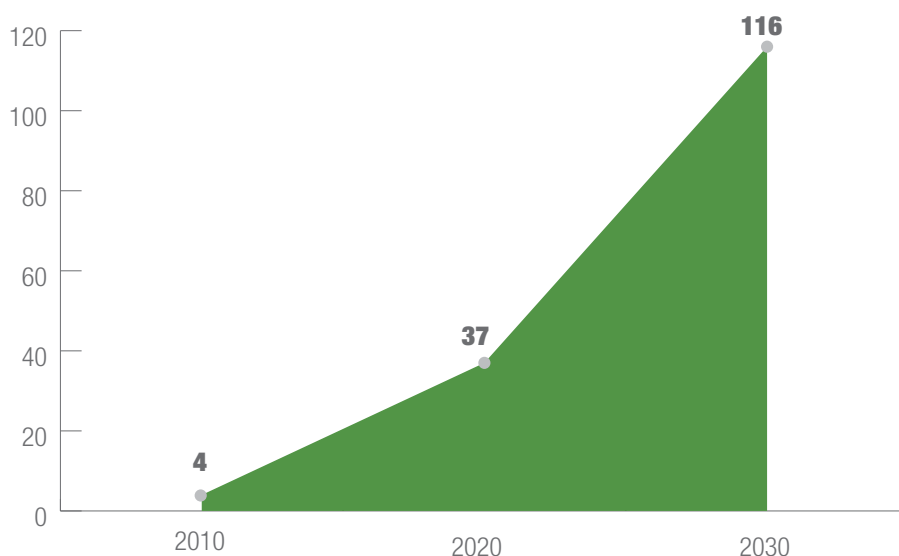
India faces tremendous energy demands, with AC use already playing a major role. Use of ACs is expected to be a significant driver of energy consumption.<sup>4</sup> According to the World Bank, in 2011, there were roughly 5 million room ACs in India, while other estimates show higher levels up to 9.7 million ACs in 2010 for residential use alone.<sup>5</sup>

Room ACs dominate the AC market, making up nearly 99% of annual sales. Room ACs run for about 8 hours a day at least half the year.<sup>6</sup> Studies show that AC use already accounts for up to 40% and 60% of energy use in the cities of Mumbai and New Delhi, respectively.<sup>7</sup> More than 75% of the energy load in these two cities comes from residential and commercial uses.<sup>8</sup>

## India's Air Conditioning Energy Consumption

As the Indian economy grows, energy consumption is also projected to increase.<sup>9</sup> This projection, coupled with India's ambient temperatures, which frequently exceed 40°C (104°F) during hot months, means people are increasingly turning to AC systems to stay cool during summers. Room AC market penetration in urban households stood at only 3% in 2010.<sup>10</sup> Compared to other countries with 100% saturation, the Indian market is poised for explosive growth in AC energy demands, especially as the economy grows. As an example, AC market penetration in major cities in China went from nearly zero to about 100% in a 15-year period, between 1992 and 2007.<sup>11</sup> In India, room AC sales have been growing at 20% on average over the last 10 years. With higher incomes and rising temperatures due to climate change, that growth is only likely to accelerate.

**China, Japan, Indonesia, Thailand and the European Union are seeing rapid adoption of alternative refrigerants that are more efficient and cause less global warming.**



Source: NRDC-CEEW (2015) based on data from "Avoiding 100 New Power Plants by Increasing Efficiency of Room Air Conditioners in India: Opportunities and Challenges" (2014).

Energy requirements for cooling buildings will grow faster than any other energy demand in the Indian building sector, according to CEEW experts.<sup>12</sup> The number of installed room ACs will grow from 4 million to 116 million with an increased electricity consumption from 8 terawatt hours (TWh) in 2010 to 239 TWh by 2030, according to research from the Lawrence Berkeley National Labs. This growth could put a huge additional burden on India's energy grid and "require unprecedented construction of new power plants."<sup>13</sup> Earlier 2008 estimates from the World Bank predict a ten-fold increase in the AC stock between 2011 and 2031, projecting increases from 4.7 million to 48 million ACs.<sup>14</sup>

## Burden on India's Energy Grid

Economic growth and human development are dependent upon energy.<sup>15</sup> The challenge for India is to increase energy consumption efficiently, without affecting the overall energy intensity of the economy.<sup>16</sup> AC use is highly coincident with peak electricity demand. This means that AC use overlaps considerably with the times of day that the electricity grid is highly stressed, thus increasing the risk of power outages. It is estimated that ACs will account for 46 gigawatts (GW) of peak energy demand by 2020 and 143 GW by 2030.<sup>17</sup> Power cuts currently are a daily occurrence during peak summer seasons in many Indian regions. In 2014, Power Minister Piyush Goyal announced a goal of uninterrupted access to energy for all homes, commercial buildings, and industry within the next five years. To meet this goal, India must take advantage of every energy-saving opportunity.

## HFCs and Climate Change

As one of the six greenhouse gases, HFCs are very potent contributors to global warming.<sup>23</sup> HFCs have a GWP that is hundreds to thousands of times greater than carbon dioxide.<sup>24</sup> HFCs are some of the fastest growing greenhouse gases in the world. Scientists estimate that unless HFCs are rapidly phased down, HFC use and emissions will grow exponentially. If we do not address HFCs now, then on a global basis they could raise the temperature by 0.5°C by 2100, all by themselves.

Most developed markets are phasing down HFCs because of their lower global warming potential and efficiency benefits. The European Union finalized a new and stronger regulation that goes into effect January 1, 2015 to reduce F-gas emissions by two-thirds over 2014 levels and bans other uses.<sup>25</sup> Japan, China, the United States and other countries are also shifting away from HFCs.

The 1987 Montreal Protocol is the treaty that saved the ozone layer by phasing out chlorofluorocarbons (CFCs), HCFCs, and other ozone-depleting chemicals.

HFCs fall within the jurisdiction of the Montreal Protocol and its parent agreement (the 1985 Vienna Convention) because the ambit of those treaties includes assuring the safety of replacement chemicals.<sup>26</sup> HFCs were invented as replacements for CFCs and HCFCs, and their rapid growth is directly attributable to the phase-out of those chemicals under the Montreal Protocol.

The current refrigerant used in India's room ACs is HCFC-22 and scheduled for phase out under the Montreal Protocol with India having a freeze in consumption by 2013 and phase out plan of 10% by 2015, 35% by 2020, 67.5% by 2025, and 97.5% by 2030. The current default in India for phasing out HCFC-22 is HFC-410a. Unfortunately, HFC-410a has a very low energy efficiency rating, which means it is not cost effective for the power sector. HFC-410a also has a GWP of 2088, which is significant and will accelerate climate change. If HFC-410a remains the default refrigerant, it will contribute to 32% of the total global warming impact in India by 2050 from room ACs.<sup>27</sup> Fortunately, HFC-410a is not yet widely used in India. If India switches to HFC-410a, it will be trading a highly energy efficient product with one that is not energy efficient.



Energy efficiency is a tremendous energy-saving opportunity for India's growing economy. The Ministry of Power's Bureau of Energy Efficiency emphasizes that "efficient use of energy and its conservation is the least-cost option to meet the increasing energy demand."<sup>18</sup> A leading estimate by McKinsey projects that 80 percent of the infrastructure – the roads, buildings and appliances – that will exist by 2030 have yet to be built, representing a huge opportunity to build efficiency into the design from the start.<sup>19</sup> Another report by Lawrence Berkeley National Laboratory estimates that energy consumption by ACs in emerging economies, such as India, could be significantly and cost effectively improved by up to 40% by enhancing efficiency.<sup>20</sup> This equals energy savings in the amount 60 GW at peak demand by 2030, and an estimate avoiding the construction of 100 mid-sized coal-fired power plants.<sup>21</sup> Additional benefits of improving energy efficiency in the Indian economy include "higher energy security, reduction in local air pollutants, reduction in capital investment requirement for electricity and reduction in marginal abatement cost," according to researchers at the Indian Institute of Management, Ahmedabad.<sup>22</sup>

## Climate Change and Air Conditioning Use

Air conditioning units impact the climate system through direct, indirect, and embodied emissions of greenhouse gases. Direct HFC emissions come from leaking room and vehicle air conditioners during their working lives and when they are eventually retired. Indirect emissions come from the combustion of fuel to power the equipment and embodied emissions come from production, transportation, service, and disposal over the product life-cycle.<sup>28</sup>

India is prone to the adverse effects of climate change, including the threat of drought and floods. Specifically, India has already experienced a national increase temperature of 0.4°C, variable regional monsoons, and sea level rise of 1.06-1.75 mm per year.<sup>29</sup> The Intergovernmental Panel on Climate Change (IPCC) has predicted with virtual certainty that frequent hot temperature extremes will be one of the many impacts of increased global temperature.<sup>30</sup> This means India very likely will experience amplified and extended heat waves. This increase in temperature will only exacerbate use of room ACs,<sup>31</sup> causing a continual feedback loop of increased temperature, increased AC use, and so forth. In addition, not only will extended heat waves have adverse health effects on India's most vulnerable population, but they will also affect food security and potentially displace large numbers of people living along India's vulnerable riverfronts and coastline.



Hydrocarbon AC in use at a commercial establishment in Gujarat

# Commercially Viable Options Already in the Market

## Energy Efficient Benefits

India's National Action Plan on Climate Change outlines energy efficiency as a national mission.<sup>32</sup> Energy efficiency reduces peak energy demand, which has many co-benefits such as reduced burden on the energy grid, increased energy security, fewer blackouts, and reduced demand for more expensive power plants. These energy efficiency improvements are also likely to have air quality benefits and to provide savings for equipment owners.

A key option for reducing energy demand is to increase the energy efficiency of room ACs. Room air conditioners are commercially available with cooling capacity up to 7 kilowatts, which makes up more than 80% of sales in India.<sup>33</sup> Room ACs that use lower-GWP refrigerants can provide greater energy efficiency while providing a thermodynamic advantage by improving performance at high ambient temperatures.<sup>34</sup> Combined with design improvements, lower-GWP refrigerants can deliver even greater energy savings with a higher cooling capacity and coefficient of performance over the high-GWP HFC-410a.<sup>35</sup>

Several alternative blends are emerging in the market as well as the leading alternatives – R-290 and R-32. Both R-290 and R-32 models have higher energy efficiency ratings available and perform better at high ambient temperatures common in India. Initial 2014 research from the European Union finds that at high ambient temperatures, R-290 and R-32-based room ACs are more energy efficient than those that use R-410A.<sup>36</sup> An accompanying study found that in “developing countries, approximately 90% of HCFCs and high-GWP HFCs can be replaced by substances with low or moderate GWP” in the short or medium term.<sup>37</sup> Presently, for these smaller room ACs, hydrocarbons like the low-GWP refrigerant R-290 and mid-GWP refrigerant R-32 are viable options. Both of these refrigerants are already being deployed in high energy-efficiency room ACs and being sold widely in India and internationally.

## Hydrocarbons R-290

Hydrocarbon refrigerants R-290, commonly known as propane, are naturally occurring and not subject to patents. R-290 has a global warming potential of <5 and received superior LCCP compared to HFC-410a. According to the EU study, given projected unitary AC sales for 2015 and high ambient temperature conditions, R-290-based room ACs could save 11.9 GW hours a month over room ACs using HFC-410a.<sup>38</sup>

R-290 has been seen as a good fit for Indian ACs because of high ambient temperatures. When compared to HFC-410a, R-290 is far more efficient.<sup>39</sup> While AC units using R-290 are limited to 1.5 tonne in size, the majority of systems sold in India are of 1 and 1.5 tonne capacity. Initial concerns about the flammability of these units have been investigated and resolved by manufacturers in India as sales continue to increase.

**Room ACs that use lower-GWP refrigerants can provide greater energy efficiency while providing a thermodynamic advantage by improving performance at high ambient temperatures.**

Godrej & Boyce's R-290 room AC model has a five star rating from India's Bureau of Energy Efficiency, the highest rating awarded. It achieves the five-star rating without the use of inverter technology, which would increase the efficiency by the equivalent of about two stars more.<sup>40</sup> Godrej reports sales of 100,000 units<sup>41</sup> and includes free installation from certified technicians to ensure safety. Godrej stated that even as a drop-in replacement, before further design improvements, R-290 saves energy.<sup>42</sup> Godrej also just unveiled the first "Diet AC" with a 7 star rating due to its superior energy efficiency. Switching to R-290 can help consumers save money in the long run, while being significantly more energy efficient and environment friendly.

## R-32

Another leading alternative, R-32, has a mid-GWP of 675, which is 2/3 lower than HFC-410a. Tests conducted in India comparing the performance of HFC-410a and R-32 systems concluded that at temperatures of 35°C and above, the R-32 system demonstrated superior energy efficiency.<sup>43</sup> R-32 is considered among one of the most efficient refrigerant option among the commercially available alternatives to HCFC-22 for AC units at high ambient temperatures.<sup>44</sup> It is estimated that R-32 would also reduce greenhouse gas emissions by 31 % by 2050. Half of this reduction would come from energy efficiency and the other half from direct emissions reductions.<sup>45</sup>

Daikin, Fujitsu General, Hitachi, Mitsubishi, Panasonic, Toshiba, and Sharp all sell room ACs produced with R-32. Daikin's R-32-based room AC earned the prestigious grand prize for excellence in energy efficiency and conservation in Japan as the most energy efficient device of its class on the market, with 15 million units globally.<sup>46</sup> Both Daikin and Fujitsu General reports sales of over 3 million units in Japan and 150,000 in India.<sup>47</sup> Daikin will allow companies in India and other developing countries to use basic patents at no charge through "nonassertion contracts" and will allow these companies using their patents to sell in both Indian and export markets. Daikin has a large facility in India to manufacture R-32 for its own use and plans to produce one million units per year.<sup>48</sup> Recent leapfrog test cases in Thailand determined that the cost to transition from HCFCs to R-32 (leapfrogging over HFC-410a) was feasible with a total estimated cost of Rs.367 million (\$5.84 million). In fact, the compressors are similar to the HFC-410a compressors and therefore, will not cost any more than HFC-410a.<sup>49</sup>

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## Market Benefits of Phasing Down HFCs

The co-benefits of leapfrogging over HFC-410a to low-GWP chemicals such as R-290 and R-32 are numerous. Transition projects can revive enterprises in the commercial refrigeration sector and increase employment for India's young population.<sup>50</sup> Specifically, the new AC units will require skill training for installation and servicing of the units, which supports the Modi Government's skill training focus.

The air conditioning market is global with international companies competing for market share to achieve economies of scale. Many countries are making the transition to low-GWP air conditioning. Many companies are designing products that satisfy the most stringent energy efficiency, safety, and environmental standards so they can be marketed worldwide. International markets that have already begun phasing down HFCs are the United States, Japan, and Europe. For example, in December 2013, the European Union passed legislation requiring a reduction in HFC use to 1/5 of today's levels by 2030. Additionally, some large developing countries, such as China, are already moving toward more climate friendly alternatives. Room ACs produced with R-32 are already on sale in 30 countries.<sup>51</sup>

These market trends and regulatory measures could affect India's major export markets and provide an early commercial driver for change in India among export oriented companies. Even if India has not yet penetrated these markets or felt the impact from the global market, by using a product that cannot be used in many countries due to regulatory measures, India would essentially be foreclosing global markets.

Indian policy-makers, industry and stakeholders can draw on their experience in successfully phasing-out CFCs. India was the second largest producer of CFCs in the world.<sup>52</sup> By successfully phasing out CFCs, India is viewed as a leader in restoring the stratospheric ozone layer.<sup>53</sup> India has an opportunity to leapfrog over HFC-410a and gain access to financing from the Montreal Protocol Multilateral Fund, which finances phase down projects in developing countries with grace period timeframes. For example, Indian industry received Rs.547 million (\$87.47 million) to phase out CFCs.<sup>54</sup> In addition, India would gain access to the expertise of implementing agencies to help establish the infrastructure to make the transition along with training, and insight on the best technologies available.

Indian companies have an opportunity to start adopting more energy efficient and climate friendly refrigerant alternatives with financing from the Montreal Protocol Multilateral Fund, avoid higher costs of transitioning later and gain greater access to domestic and foreign markets that are moving away from HFCs. Indian companies are among the leaders in next-generation room air conditioning that uses safer refrigerants and achieves higher energy efficiency. By adopting alternatives, India can take advantage of an emerging market, prevent a major share of future climate-changing emissions before they even occur, and help India meet its energy needs.

**Room ACs produced with R-32 are already on sale in 30 countries.**



## Endnotes

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## ABOUT THE PROJECT TEAM

**The Council on Energy, Environment and Water (CEEW)** is an independent, not-for-profit policy research institution. CEEW addresses pressing global challenges through an integrated and internationally focused approach. It does so through high-quality research, partnerships with public and private institutions, and engagement with and outreach to the wider public. [www.ceew.in](http://www.ceew.in).

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<http://ceew.in/pdf/ceew-nrdc-a-profile-of-air-conditioners-using-r290-30nov14.pdf>

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