CBALANCE
carbon ▸ cost ▸ community ▸ climate

Critical Review of the India Cooling Action Plan (2018)

Note: the critical review presented below must be read alongside the specific critical remarks made to the report (appended herewith in Appendix A)

Section : *Executive Summary*

➔

- **In response to:** Cooling is linked with economic growth
- **Comment:** Cooling's multiple linkages with many other social and environmental phenomena (eg. its disproportionate energy consumption and impact on energy access for those without basic energy access for other vital life functions and comfort systems, its impact on heat island and heat stress for persons inhabiting spaces where heat is rejected from cooling technologies) are not mentioned. This is a unidimensional representation of a multidimensional issue. The multiplicity of the linkages must be mentioned right at the outset, to recognize their enmeshed nature.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Increasingly, cooling has become a developmental need which is linked with the achieving sustainable development goals.
- **Comment:** The linkage of cooling with sustainable development goals is tenuous. Whether it is a broadly accepted and articulated need, by all sections of Indian society, is a contentious statement.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** That being said, Fig. 1 shows that India has one of the lowest access to cooling across the world, which is reflected in its low per-capita levels of energy consumption for space cooling, at 69 kilowatt hours (kWh), as compared to the world-average of 272 kWh.

- **Comment:** Space cooling energy per capita is a function of built space per capita. Given the lower built-up area per capita in India relative to high-income economies, the comparison of absolute energy per capita can be misleading. Comparing the energy consumption per unit of built space area is more appropriate and possibly very revealing in terms of deconstructing a core issue with cooling in India; its relatively poor energy and GHG emissions efficiency which must be addressed by the NCAP.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** As part of demand side management of energy use, Minimum Energy performance standards (MEPS) and star rating scheme for room air conditioners are in place in the country.
- **Comment:** However, customers tend to purchase oversize AC tonnage. To curb oversizing of AC tonnage by potential Room AC users, the BEE could develop and formally endorse a Room AC tonnage calculator that incorporates a broad spectrum of parameters such as room and window size, surface exposure to direct sunlight, annual demand etc.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** The domestic actions on energy efficiency of room air conditioners by ratcheting up of Energy Efficiency standards
- **Comment:** The report must provide verified energy conservation performance information to substantiate its assertion that the BEE's energy conservation efforts are adequate (i.e. commensurate with INDCs, or with similar programs in other developed countries etc.) and that they have accomplished significant energy conservation. For instance, the report writers can provide data to underscore their claim that the BEE's efforts with respect to Chillers and VRFs have led to net reduction of energy (not merely increase in efficiency) by end-users of these machines.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** The development of the NCAP had been multi-stakeholder exercise in order to synergize actions for

addressing cooling demand across all areas: technology, manufacturing...

- **Comment:** Technology and manufacturing are 'means', and energy efficiency and environment (the main focus of the MoEF) ought to be the 'ends'. The report inadvertently or deliberately treats them as equal considerations. It is recommended that the Policy's orientation be towards ensuring energy efficiency and environmental conservation as primary end goals and its ramifications for technology and manufacturing be treated as secondary by-products of the Policy's intended outcomes; in short the Policy drivers must be the Ministry's end-goals and not the 'means'.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Building energy code (ECBC for both commercial and residential buildings) implementation should be made a national priority with Bureau of Energy Efficiency under the MoP, Ministry of Housing and Urban Affairs along with the municipal corporations and urban and local bodies and MoEF & CC's Environmental Impact Assessment working together to bring most newly constructed buildings under the ECBC purview within the next 12 months. All new construction in the public sector should be 100% ECBC compliant.
- **Comment:** To avoid the adverse effects of the rebound effect of unequivocal endorsement of energy efficiency, a telescopic energy-efficiency benchmarking system (which disincentivizes large homes or offices per capita) or a per-capita energy efficiency criteria for achieving a mandatory ECBC rating must be established. This would cut net energy consumption rather than merely achieve relative energy reductions (on a per-unit area basis for instance).
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** The labeling program should also require the addition of equipment operational cost on the product labels in order to address the market behavior of gravitating towards low first-cost.
- **Comment:** Instead of merely 'statically' labelling the ACs (since customers might still be sceptical of the validity of these labels in real-world operational situations), the program can mandate that all new ACs be outfitted with sensor/display technologies which accurately measures and dynamically depicts the amount of money spent during every hour of

operation. Through such real-time displays, the performance benefits of higher-star-rated ACs, properly serviced/maintained ACs, and operating them at higher set-point temperatures etc. can be translated and conveyed as direct cost benefits to the consumer to justify any higher up-front costs for super-efficient equipment and annual maintenance contracts etc.

- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** The environmental footprint of cooling equipment in terms of GWP (or ODP), GHG emissions, should be factored in combination with safety, performance, and energy efficiency, under a single eco/environmental label; add cooling appliances under MoEF&CC, Government of India's 'Ecomark' scheme on labelling of environment friendly products.
- **Comment:** This eco-labelling programme must be a Total Equivalent Warming Impact (TEWI) based rating programme that is based on life-cycle GHG emissions from energy and non-energy (refrigerant leakage) sources.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Government is the single largest buyer of goods and services in the country and framing guidelines for public procurement shall help in the market transformation towards an energy-efficient economy. Issue public procurement guidelines for Energy-efficient cooling equipment and requirement of services of certified and Trained service technicians/professionals for annual maintenance contracts.
- **Comment:** Bulk-deployment schemes such as EESL can be bundled with renewable energy policies. Specifically, subsidy rates for rooftop solar PV in India must be linked with demand-side measures adopted by buildings to reduce air conditioning demand and proven performance-based energy efficiency of the constructed building.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** D. Allocate government funding and support towards targeted programs to enable cooling for the economically weaker segment.
- **Comment:**
- **Edits/Omissions:**
- **Additions:** 2) The Fairconditioning Program's Retractable Radiant-Barrier for tin and asbestos sheet roofs, piloted in slum dwellings in Mumbai and Pune - should be publicized and emulated.

  ● Work with architectural professional capacity buildings programs that already have government support (eg. Micro Homes Solutions, and Fairconditioning Program) to build passive design capacity (for achieving solar heat gain reduction and improved cross-ventilation) of builders/contractors in the informal housing economy in urban and pre-urban areas of Indian cities and towns. Existing capacity building programs for this sector are addressing other aspects of resilience (earthquake, structural and fire safety for instance) and the existing institutional training apparatus can be re-purposed to include Thermal Comfort as well.

Section : ***Chapter 1 INTRODUCTION: A synergistic approach to cooling***

1.1 Background

➔

- **In response to:** The cooling demand in these and other sectors will grow in future due to current low penetration of air conditioners, rise in per capita incomes
- **Comment:**
- **Edits/Omissions:**
- **Additions:** HVAC industry-sponsored and media-induced aspiration for artificial cooling as an entitlement synonymous with urbanization, and the expected economic growth of the country. The impact of rising cooling demand is compounded by the paradox that fulfilling the demand for cooling using business-as-usual energy intensive technologies leads to further cooling demand amongst erstwhile thermally-adapted and resilient communities. This is due to local (heat island) and global warming effects of the heat rejection from cooled spaces, waste heat generation from compressors, and radiative forcing effect of fugitive emissions of refrigerants.

➔

- **In response to:** Cooling is also intimately associated with human health, well-being and productivity. The need to ensure thermal comfort for all and access to cooling across

income groups is even more important considering the tropical climate of India. Multiple studies across the globe have underscored the importance of cooling.

- **Comment:**
- **Edits/Omissions:**
- **Additions:** These studies have also highlighted the detrimental health, well-being and productivity effects of an aggressive, hegemonic artificial cooling strategy for residents and employees living and working in artificially cooled buildings. These populations have shown to become less resilient and less adapted to local climatic conditions overtime and also suffer measurably from new-age ailments such as sick building syndrome etc. Furthermore, the disproportionate energy use of inefficient vapor-compression based technologies (which defines most of the cooling equipment stock in India currently, wherein the power used for operating a 1 ton AC uses the same power as 25 ceiling fans) exacerbates energy access for the less-privileged in India and deprives them of energy required for other basic technologies to keep them healthy and enhance the dignity of their lives.

  In essence, while artificial cooling is certainly a requirement in most regions of India, the NCAP is also a response to the undeniable fact that the current cooling practices followed under a business-as-usual scenario in India are not 'fair'; artificial cooling of a fraction of India's built space is achieved at the cost of undermining thermal comfort for a vast number of less privileged persons who endure the escalated global effects from a warmer atmosphere, and local effects of intensified urban heat island effects stemming from heat rejection from air conditioned buildings; this effect hampers the ability to non airconditioned to naturally cool down during the night time amongst other undesirable impacts . The asymmetry of consequences borne by economic sections of Indian society causing summertime power-cuts (through unregulated use of air-conditioning) and those endured by populations that are its victims (without being the cause due to their relatively frugal use of refrigeration and air-conditioning technologies) further compounds the inequities enmeshed with this issue. Finally, the populations responsible for the causes of punishing summertime power-cuts are least vulnerable to its consequences as they often possess means to continue consuming energy and maintain comfort through uninterrupted power supply; this correlation between cause and vulnerability is reversed for the victims of power outages who do not possess the resources for continuing energy

consumption and thermal comfort through power backups.

➔

- **In response to:** There is a separate National Mission on Enhancing Energy Efficiency under the National Action Plan on Climate Change. Substantial work has been undertaken with respect to demand side management of power; there is a standard and labelling programme for appliances, the energy efficiency building code has been brought out and an energy-efficiency driven market transformation is being effected through the bulk procurement of energy efficient appliances.
- **Comment:** While the BEE's Split/Window AC Labelling Programme is a commendable program that represents a meaningful effort towards stimulating conscious consumption of artificial cooling technologies and products, the program's standards are significantly less demanding of Industry than similar programs in other countries. For instance, the average EER value for Room ACs (equating to approximately 2 Star rating according to the BEE's Standards and Labelling Program) in India is 2.9 W/W while that of the Japanese Standards and Labelling Program is 4.1 W/W (LBNL, 2014). This represents a significant un-fulfilled opportunity for reducing energy use from about 24 GW of peak power consumption, and consequent GHG emissions from India's dramatically rising stock of Room ACs, which are expected to be approximately 68 Million TR by 2020.
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to: "**The cooling demand in these and other sectors will grow in future due to current low penetration of air conditioners, rise in per capita incomes"
- **Comment:**
- **Edits/Omissions:**
- **Additions:** The cooling demand in these and other sectors will grow in future due to current low penetration of air conditioners, rise in per capita incomes HVAC industry-sponsored and media-induced aspiration for artificial cooling as an entitlement synonymous with urbanization, and the expected economic growth of the country. The impact of rising cooling demand is compounded by the paradox that fulfilling the demand for cooling using business-as-usual energy intensive technologies leads to further cooling demand amongst erstwhile thermally-adapted and resilient

communities. This is due to local (heat island) and global warming effects of the heat rejection from cooled spaces, waste heat generation from compressors, and radiative forcing effect of fugitive emissions of refrigerants.

➔

- **In response to: "**Multiple studies across the globe have underscored the importance of cooling."
- **Comment:**
- **Edits/Omissions:**
- **Additions:** Multiple studies across the globe have underscored the importance of cooling. These studies have also highlighted the detrimental health, well-being and productivity effects of an aggressive, hegemonic artificial cooling strategy for residents and employees living and working in artificially cooled buildings. These populations have shown to become less resilient and less adapted to local climatic conditions overtime and also suffer measurably from new-age ailments such as sick building syndrome etc. Furthermore, the disproportionate energy use of inefficient vapor-compression based technologies (which defines most of the cooling equipment stock in India currently, wherein the power used for operating a 1 ton AC uses the same power as 25 ceiling fans) exacerbates energy access for the less-privileged in India and deprives them of energy required for other basic technologies to keep them healthy and enhance the dignity of their lives.

  In essence, while artificial cooling is certainly a requirement in most regions of India, the NCAP is also a response to the undeniable fact that the current cooling practices followed under a business-as-usual scenario in India are not 'fair'; artificial cooling of a fraction of India's built space is achieved at the cost of undermining thermal comfort for a vast number of less privileged persons who endure the escalated global effects from a warmer atmosphere, and local effects of intensified urban heat island effects stemming from heat rejection from air conditioned buildings; this effect hampers the ability to non airconditioned to naturally cool down during the night time amongst other undesirable impacts . The asymmetry of consequences borne by economic sections of Indian society causing summertime power-cuts (through unregulated use of air-conditioning) and those endured by populations that are its victims (without being the cause due to their relatively frugal use of refrigeration and air-conditioning technologies) further compounds the inequities enmeshed with this issue. Finally, the populations responsible

for the causes of punishing summertime power-cuts are least vulnerable to its consequences as they often possess means to continue consuming energy and maintain comfort through uninterrupted power supply; this correlation between cause and vulnerability is reversed for the victims of power outages who do not possess the resources for continuing energy consumption and thermal comfort through power backups.

➔

- **In response to:** There is a separate National Mission on Enhancing Energy Efficiency under the National Action Plan on Climate Change. Substantial work has been undertaken with respect to demand side management of power; there is a standard and **labelling** programme for appliances, the energy efficiency building code has been brought out and an energy-efficiency driven market transformation is being effected through the bulk procurement of energy efficient appliances.
- **Comment:** While the BEE's Split/Window AC Labelling Programme is a commendable program that represents a meaningful effort towards stimulating conscious consumption of artificial cooling technologies and products, the program's standards are significantly less demanding of Industry than similar programs in other countries. For instance, the average EER value for Room ACs (equating to approximately 2 Star rating according to the BEE's Standards and Labelling Program) in India is 2.9 W/W while that of the Japanese Standards and Labelling Program is 4.1 W/W (LBNL, 2014). This represents a significant un-fulfilled opportunity for reducing energy use from about 24 GW of peak power consumption, and consequent GHG emissions from India's dramatically rising stock of Room ACs, which are expected to be approximately 68 Million TR by 2020.
- **Edits/Omissions:**
- **Additions:**

Section :

1.2 Recommendations

Short term recommendation

➔

- **In response to:** "Closely monitor the global best practices in terms of policies and technology pathways."
- **Comment:** India AC appliance standards can be upgraded to require inclusion of motion sensor-based 'sleep support

function' as a standard feature in all Room ACs manufactured beyond a date (arrived at by consensus through dialog with RAMA etc.). This feature tracks human movement in a dark room to automatically detect periods during which users are sleeping to alter temperature setting in response to the altered physiological state of low metabolic activity.

- **Edits/Omissions:**
- **Additions:**

Section : ***Chapter 2 SPACE COOLING IN BUILDINGS***

2.2.2 Commercial building Sector

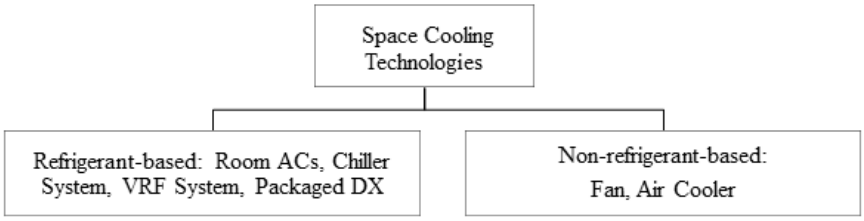
➔

- **In response to:** The range of air conditioning systems utilised in commercial buildings includes chillers, packaged DX units, VRFs, and Room Air-Conditioners.
- **Comment:**
- **Edits/Omissions:** There is a missing narrative on the adoption of sustainable cooling technologies adopted in the commercial sector.
- **Additions:**

2.3 Prevalent Space Cooling Technologies

➔

- **In response to:** The prevalent technologies for providing thermal cooling in buildings fall within two broad categories: refrigerant based, and non-refrigerant based.



- **Comment:** The flow-chart must include the state-of-the-shelf sustainable cooling technologies like structure cooling, radiant cooling, solar VAM and indirect-direct evaporative cooling systems in respective categories.
- **Edits/Omissions:**
- **Additions:**

2.3.1 Overview of Refrigerant-based Cooling Technologies

➔

- **In response to:** Overview of Refrigerant-based cooling technologies
- **Comment:** The section must include the state-of-the-shelf sustainable cooling technologies like radiant cooling and solar VAM systems.
- **Edits/Omissions:**
- **Additions:**

1. **Radiant Cooling System**

Installed/Sold Capacity: As per data received by four manufacturers of Radiant Cooling systems from 2008 till March 2016 and projections till March 2017, an aggregate of approximately 3.95 million sq. ft. built-up area in India is cooled using Radiant Cooling, replacing approximately 17,524 TR of conventional air conditioning in 73 large commercial buildings.

GHG, Power and Energy Savings Until March 2017, power savings from installed Radiant Cooling systems is estimated to be 8,034 kW, energy savings are 17,931 MWh/year, and a total of approximately 29,992 MT CO2e/year of GHG emissions are estimated to be avoided.

2. **Solar VAM System**

Installed/Sold Capacity: As per data received by manufacturers from 2007 till March 2015 and projections till March 2017, an aggregate of 0.71 million TR of Solar VAM air conditioning (replacing an equivalent amount of conventional air conditioning) is installed in India.

GHG, Power and Energy Savings Until March 2017, power savings from installed VAM systems is estimated to be 3,95,223 kW, energy savings are 8,82,140 MWh/year, and a total of approximately 15,01,711 MT CO2e/year of GHG emissions are estimated to be avoided.

➔

- **In response to:** ***Room Air-Conditioner:*** Currently, the fixed speed systems are developed to meet up-to BEE 3-Star standards
- **Comment:** The report erroneously states that 3-star is the upper limit for fixed speed AC systems, whereas these units are also available in 4 star and 5 star rating system categories

- **Edits/Omissions:**
- **Additions:**

2.3.2 Overview of Non-Refrigerant-based Cooling Technologies

➔

- **In response to:** Overview of Non-Refrigerant-based cooling technologies
- **Comment:** The section must include the state-of-the-shelf sustainable cooling technologies like Indirect - Direct Evaporative Cooling and Structure cooling systems.
- **Edits/Omissions:**
- **Additions:**

1. **Indirect Direct Evaporative Cooling System**

Installed/Sold Capacity: As per data received from four manufacturers of IDEC systems from 2008 till March 2015 and projections until March 2017, an aggregate capacity of approximately 42.8 million cubic feet per minute (air flow) has been installed in India. This equates to replacement of approximately 1,06,773 TR or conventional air conditioning in more than 800 buildings.

GHG, Power and Energy Savings Until March 2017, power savings from installed IDEC systems is estimated to be 48,048 kW, energy savings are 1,07,147 MWh/year, and a total of approximately 1,27,505 MT CO2e/year of GHG emissions are estimated to be avoided.

2. **Structure Cooling System**

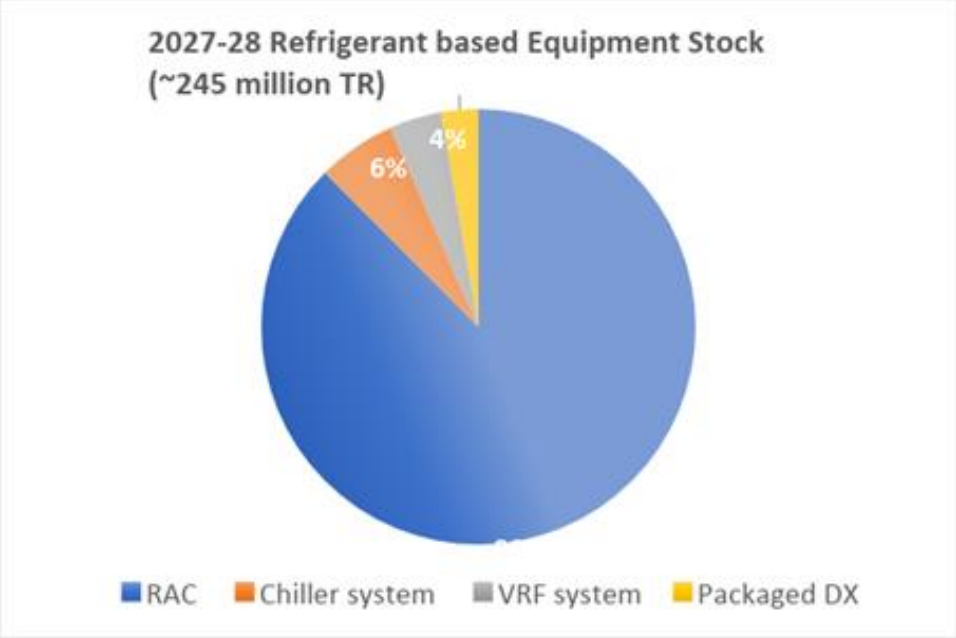
Installed/Sold Capacity As per data shared by manufacturers from 2005 till March 2014 and projections upto March 2017, an aggregate of approximately 0.55 million sq. ft. built-up area in India uses Structure Cooling Technology, replacing approximately 4,598 TR of conventional air conditioning in 28 large commercial buildings.

GHG, Power and Energy Savings Until March 2017, power savings from installed Structure Cooling systems is estimated to be 2,914 kW, energy savings are 6,505 MWh/year, and a total of approximately 8,438 MT CO2e/year of GHG emissions are estimated to be avoided.

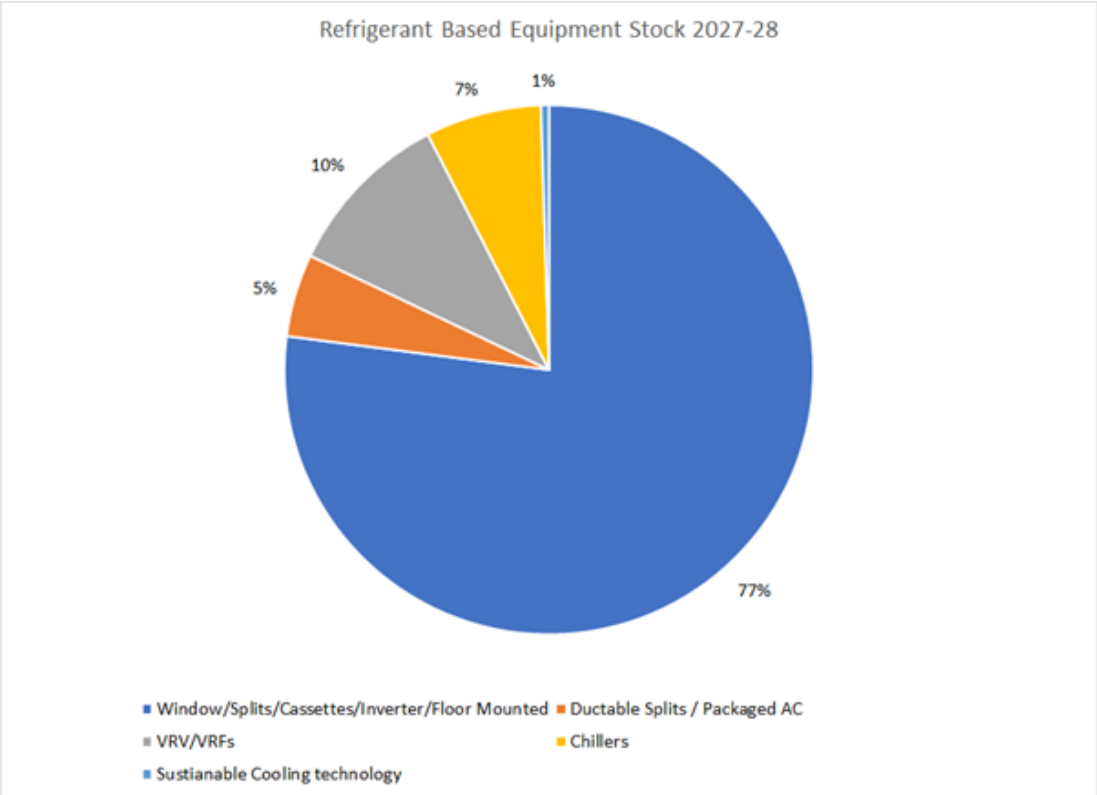
2.3.3 Stock and Growth of Prevalent Space Cooling Technologies: Key Results

➔

- **In response to:** Figure 2.7 : 2027-28 Refrigerant based Equipment Stock



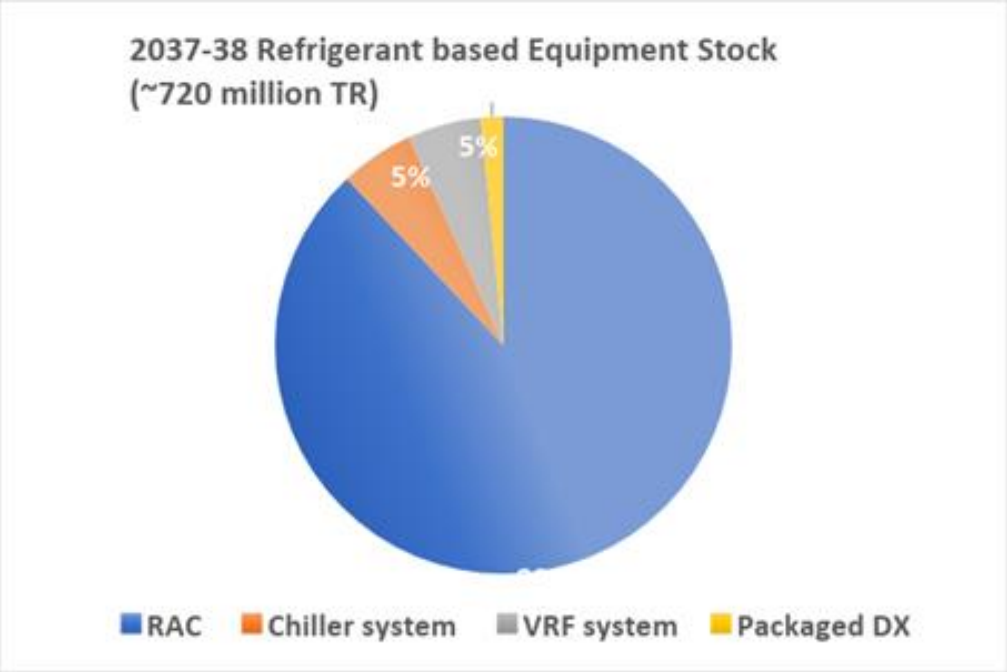
- **Comment: Edits/Omissions:** The refrigerant based equipment stock analysis must include the state-of-the-shelf sustainable cooling technologies.
- **Additions:**



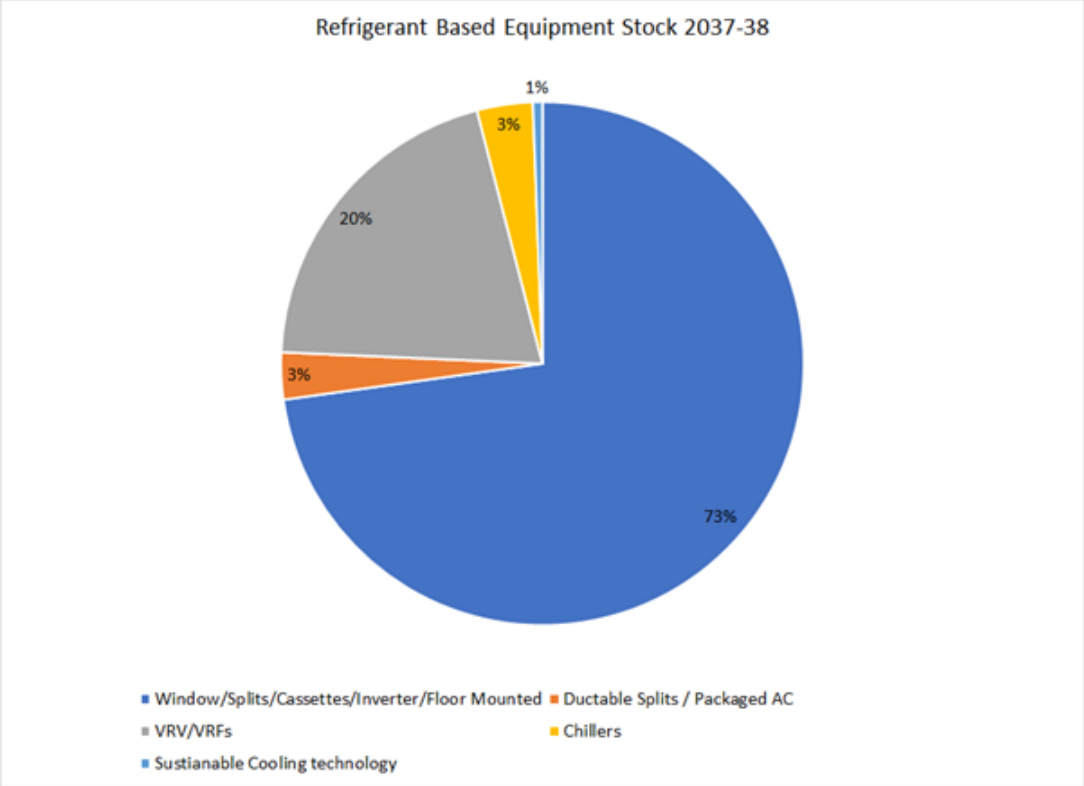
(**Source**: Research cBalance Solutions Pvt Ltd)

➔

- **In response to:** Figure 2.8: 2037-38 Refrigerant based Equipment Stock



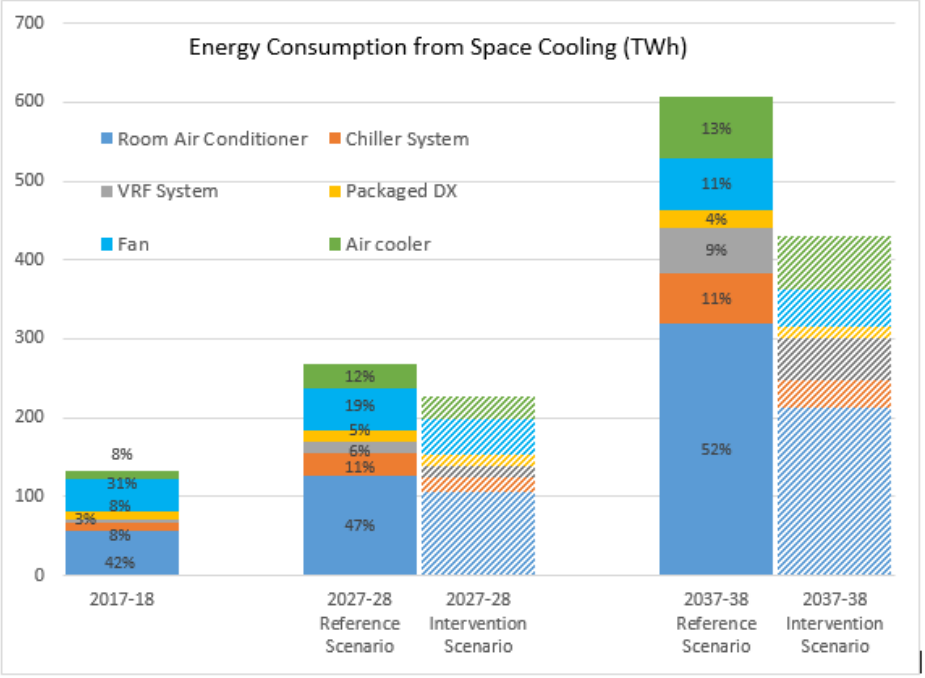
- **Comment:** The refrigerant based equipment stock analysis must include the state-of-the-shelf sustainable cooling technologies. The sustainable cooling technologies will contribute to 1% with BAU scenario
- **Edits/Omissions:**
- **Additions:**



(**Source**: Research cBalance Solutions Pvt Ltd)

➔

- **In response to: Figure 2.10: Sub-sector wise Annual Energy Consumption (TWh)**



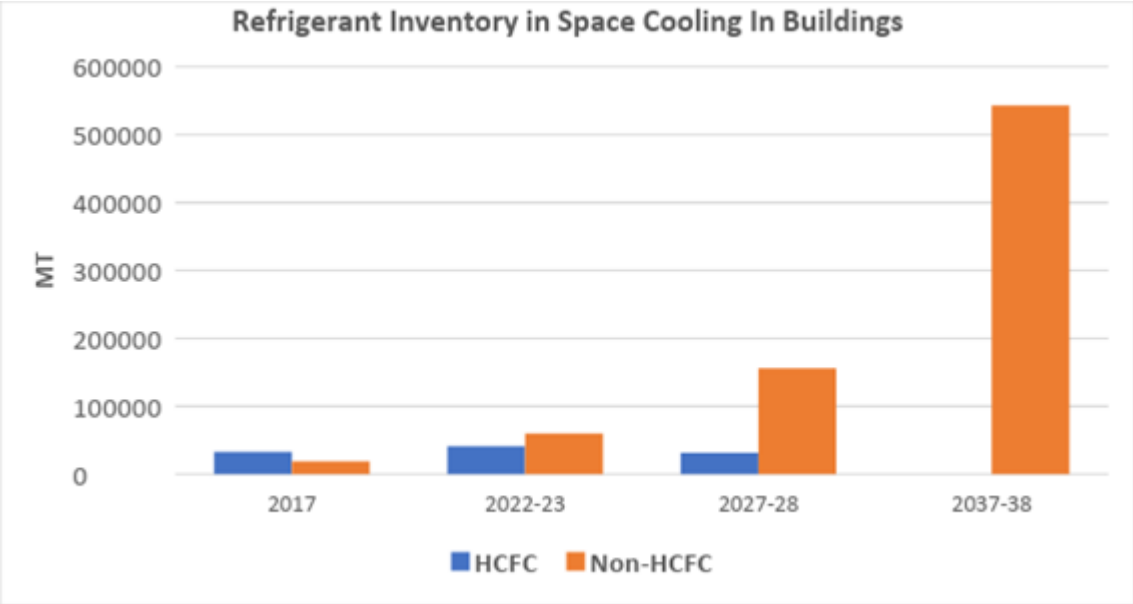
- **Comment:** This is a misleading analysis that either deliberately or inadvertently conveys the sense that

sustainable cooling technologies are still not available in the 'mainstream' HVAC industry. However, these not-in-kind cooling technologies like structure cooling, radiant cooling and indirect-direct cooling systems are installed at sizeable scales at commercial locations already.

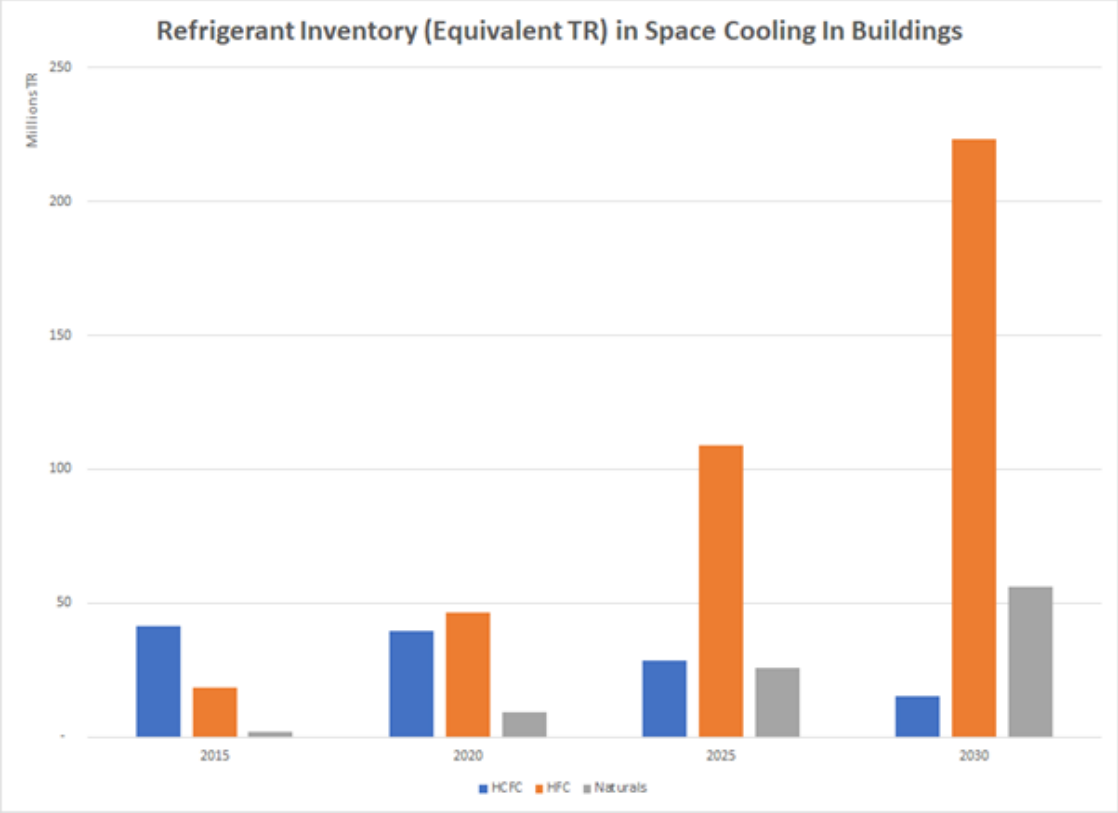
- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Figure 2.11: Total refrigerant inventory in use (without servicing) (in metric tonnes)



- **Comment:** This is a misleading analysis that either deliberately or inadvertently conveys the sense that natural refrigerants like R290, Ammonia are still not available in the 'mainstream' HVAC industry. However R290, Ammonia are already being used in space cooling applications
- **Edits/Omissions:**
- **Additions:**



(**Source**: Research cBalance Solutions Pvt Ltd)

2.4.2 Inputs and Assumptions behind the Analysis

➔

- **In response to:** "BEE revises the MEPS of Room Air-Conditioner every 3 years. If these revisions in Room Air-Conditioners efficiency levels is annualised, a steady growth of 3% p.a. in Room Air-Conditioners MEPS can be observed."
- **Comment:** An exemplary accelerated energy efficiency model that can be replicated in India, with adequate alterations to suit specific national and regional contexts, is the Japanese and South Korean Standards and Labelling programs. These programs have achieved annual energy efficiency gains of approximately 7% per year for the past 10 years (LBNL, 2016) . Contrastingly, the Indian Standard is designed to achieve annual energy efficiency of 3% upto 2030. Adopting a more ambitious (i.e. approximately doubling annual efficiency improvement of MEPS and ratcheting up of Star Rating 'bands') could shave-off nearly 40 GW of peak power demand and reduce energy consumption by 64 TWh/year by 2030 (LBNL, 2016).
- **Edits/Omissions:**
- **Additions:**

2.5.1 Energy Efficiency as a Foundational Building Strategy

➔

- **In response to:** Bureau of Energy Efficiency has issued guidelines to all consumers of commercial buildings are suggested to maintain the internal temperature between 24-25°C with appropriate humidity and airflow to conserve energy and for the health benefits of occupants, subject to operational and functional requirement on voluntary basis.
- **Comment:**
- **Edits/Omissions:**
- **Additions:** To encourage corporate offices to establish thermostat settings around 24°C, the and dress codes in corporate India must change to become more climate appropriate so as to enable occupants to work at higher indoor temperatures without any negative impact on comfort and productivity. It has been found out that raising the set point temperature to 26°C (as compared to 24°C) could lead to 13% reduction of annual energy consumption of commercial buildings where employees follow a more casual, climate appropriate dress code.

2.5.2 Technology Improvements and Interventions

- **In response to:** The not-in kind technologies have scattered examples in India but are yet to be adopted at large scale
- **Comment:** This is a misleading statement that either deliberately or inadvertently conveys the sense that sustainable cooling technologies are still not available in the 'mainstream' HVAC industry. However, these not-in-kind cooling technologies like structure cooling, radiant cooling and indirect-direct cooling systems are installed at sizeable scales at commercial locations already.
- **Edits/Omissions:**
- **Additions:**

2.6 Recommendations

➔

- **In response to:** Short-term Recommendations
  (a) Passive design and envelope improvements in all new construction to inherently reduce the need for active space cooling.

- **Comment:**

- **Edits/Omissions:**
- **Additions:** ● Only 100 out of India's 427 architecture colleges offer even a single course that addresses energy efficiency. Of those, only 3 to 4 out of the 72 courses over the bachelor's degree course encompass the environment. Thus, even if ECBC becomes mandatory today for all new buildings, presently, there isn't enough workforce that will be able to adequately handle its implementation. It is therefore recommended, sustainable cooling be integrated into undergraduate academic curricula of Indian engineering and architecture universities through educational policy change promulgated by Ministry of Human Resource Development/Ministry of Urban Development. Furthermore, it is imperative that sustainable cooling pedagogy skill development programs be launched and executed for the benefit of architecture and engineering professors and its formal integration in professional development requirements determined by All India Council of Technical Education (AICTE) and Council of Architecture (COA)
  ● To ensure adequate professional capacity for implementing the sustainable cooling related objectives of the NCAP, it is recommended that sustainable cooling related skills be integrated into professional licensing requirements for Indian Architects (COA) and HVAC Engineers (Indian Society of Heating Refrigeration and Air Conditioning Engineers), into formal training of green building consultants aligned with major certification systems (LEED, IGBC, GRIHA), and made mandatory for in-house architects and MEP/HVAC consultants of all real-estate builders/developers associated with industry bodies such as CREDAI etc.

➔

- **In response to:** Institutionalizing DSM programs with DISCOMs to replace inefficient Room Air-Conditioners or Fans with BEE 5 Star rated equipment .
- **Comment:** Replacement must consider sustainable cooling technologies, wherever it can be applicable. In hot and dry climatic zone lower efficiency air-conditioning units should be replaced by indirect-direct evaporative cooling units.

  The 'replacement' program must integrate a robust strategy for mitigating the influences of the material and psychological rebound effects. These well-known behavioral traits and biases are known to provoke higher total energy, material /resource (EMR) consumption, because the user of more efficient technologies is under the impression that he/she has economized on EMR use and that there is thus no harm in using the concerned device a bit more. Thus, the replacement ACs must include sensor/display technologies which

accurately measures and dynamically depicts the net amount of emissions (contextualized in terms of equivalent 'trees' or 'energy consumed by an average Indian' and other communication devices) to evoke strong emotional responses from users. The goal should be to trigger actions to reduce total energy consumption and invoke a 'sufficiency' based response that achieves net energy and GHG emission reductions as opposed to efficiency-based actions.

- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Closely monitor the global best practices in terms of policies and technology pathways.
- **Comment:** India AC appliance standards can be upgraded to require inclusion of motion sensor-based 'sleep support function' as a standard feature in all Room ACs manufactured beyond a date (arrived at by consensus through dialog with RAMA etc.). This feature tracks human movement in a dark room to automatically detect periods during which users are sleeping to alter temperature setting in response to the altered physiological state of low metabolic activity.

- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Instituting Eco-labelling programme for cooling appliances in India
- **Comment:** This eco-labelling programme must be a Total Equivalent Warming Impact (TEWI) based rating programme that is based on life-cycle GHG emissions from energy and non-energy (refrigerant leakage) sources.
- **Edits/Omissions:**
- **Additions:**

3.2.4 Recommendations

➔

- **In response to:** This can be achieved through appropriate product labelling, and the government and industry's collaboration on awareness campaigns.
- **Comment:** Instead of merely 'statically' labelling the ACs (since customers might still be sceptical of the validity of these labels in real-world operational situations), the program

can mandate that all new ACs be outfitted with sensor/display technologies which accurately measures and dynamically depicts the amount of money spent during every hour of operation. Through such real-time displays, the performance benefits of higher-star-rated ACs, properly serviced/maintained ACs, and operating them at higher set-point temperatures etc. can be translated and conveyed as direct cost benefits to the consumer to justify any higher up-front costs for super-efficient equipment and annual maintenance contracts etc.

- **Edits/Omissions:**
- **Additions:**

➔

- **In response to:** Proven market transformation mechanisms, such as EESL's retrofitting initiative for Room Air-Conditioners, or government-supported refrigerator retrofit/upcycle programmes in other countries, can be emulated and adapted to eliminate inefficiencies due to obsolete refrigeration equipment.
- **Comment:** Bulk-deployment schemes such as EESL can be bundled with renewable energy policies. Specifically, subsidy rates for rooftop solar PV in India must be linked with demand-side measures adopted by buildings to reduce air conditioning demand and proven performance-based energy efficiency of the constructed building.
- **Edits/Omissions:**
- **Additions:**

Section 4.4.1 Refrigerant Technologies and Future trends

➔

- **In response to:** HFO-1234yf systems are able to achieve the same system performance and fuel efficiency as HFC-134a system if they use either an internal heat exchanger (IHX) or a condenser in which the sub cooling area is enlarged by about 10% while keeping the same total exchange area.
- **Comment:** A synthesis research study conducted by the Swiss Environmental non-profit organization Noe21, and corroborated by other technical literature, indicates that HFOs decomposes to TFA (trifluoro acetic acid), which is persistent and accumulates in nature infinitum without decomposing. Since its ecotoxicology is still highly uncertain and its release could trigger serious ecological problem similar to the past catastrophes caused by persistent pollutants (DDT, PCB, CFC, SF6), the 'Precautionary Principle' forbids the mass production of HFO-1234yf until detailed environmental impact of this

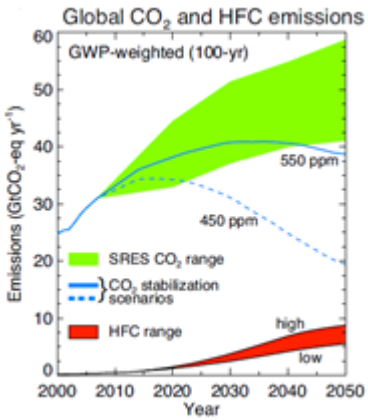
substance is available. Instead of HFCs and HFC-HFO it is recommended that the industry leap-frog to natural refrigerants along with “not-in-kind” alternatives that do not involve refrigerants.

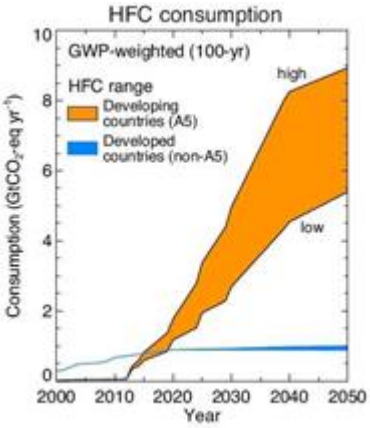
- **Edits/Omissions:**
- **Additions:**

Section 6.1 Background

➔

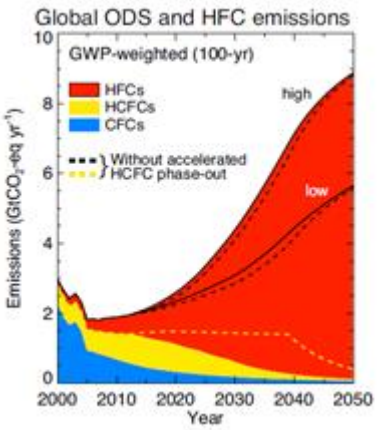
- **In response to:** The phase-out of production and consumption of Hydrochlorofluorocarbons (HCFCs) is presently underway as per the control measures set out for HCFCs under the Protocol.Hydrofluorocarbons (HFCs) being non-Ozone Depleting Substances (ODSs) have emerged as the alternative refrigerants to HCFCs. HFCs have high Global Warming Potential (GWP) but much lower than the ODSs. The world community, recognizing the impact of growing global production and consumption of HFCs, decided to phase-down HFCs. The Parties to the Montreal Protocol adopted an amendment to the Montreal Protocol at its 28th Meeting in October 2016 at Kigali, Rwanda for phase-down of HFCs.
- **Comment:** HFCs are still a stop gap solution. While it may be 'comparatively lower' in terms of GWP to HCFCs, it is still significantly high enough to surpass CFC and HCFC emissions by 2025
- **Edits/Omissions:**
- **Additions:** In an attempt to replace HCFCs, focus has already shifted towards the third generation of f-gases. HydroFluoroCarbons (HFCs), a stop-gap solution to the issue, are again powerful GHGs developed to avoid ozone depletion. HFCs are already being used as substitutes and if their growth is unchecked, they are likely to overtake emissions from CFCs and HCFCs by as early as 2025 and further intensify by 2050 (See Figure 1). Moreover, the demand for HFCs in developing countries or refrigerants has seen a steady growth of 20% between 1989 and 2007. This growth is only expected to grow further (Velders et al, 2009). It is estimated that, under business-as-usual scenarios, the consumption of HFCs in developing nations would be 8 times greater than in developed countries by 2050, translating into a global consumption of 3.5 times higher than peak consumption of CFCs and HCFCs in 1989 (Velders et al, 2009) (See Figure 3).





Source: Velders et al, 2009

Figure 1 | Global ODS and HFC Emissions Figure 2 | HFC vs CO2 Emissions Figure 3 | Growing HFC Market



Additionally, according to recent peer reviewed reports, global HFC emissions in 2050 would be 9% to 19% of the total projected CO2 emissions globally in BAU scenario i.e. under no adoption of CO2 Stabilization scenario. This would give rise to GWP weighted HFC emission to increase from 5.5-8.8 GtCO2e per year by 2050. But this percentage would increase from 28% to 45% of projected global CO2 emission in 450 ppm CO2 Stabilization scenario. (Velders et al, 2009). In fact, ever since the implementation of UNFCCC's Kyoto Protocol, HFC emissions have increased by 15% every year (UNEP, 2009).

The world is currently at a crossroad, wherein we could either opt for HFCs and let its growth go unchecked to a point of no return and cause catastrophic climate change or leapfrog from HCFCs directly to tried and tested, environmentally safe natural refrigerants. Natural refrigerants not only have the potential to meet present needs, but can easily fulfil our future ones. Leapfrogging to natural refrigerants is of utmost importance especially since developing countries are already transitioning from HCFCs to HFCs, it is crucial that this scenario is avoided.

Section 6.4 Proposed Refrigerant Pathways

- **In response to:** Increased proportion of low GWP HFCs such as HFC-32[1] (India has already embarked on this path)
- **Comment:** As per UNEP Technology and Economic Assessment Panel (TEAP) of Montreal Protocol,2017, low-GWP

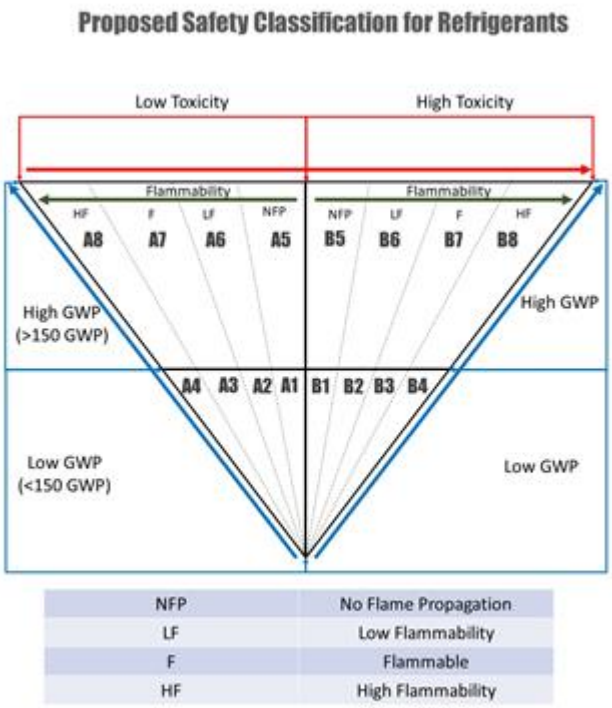
refers to refrigerants with GWP of < 300 and medium-GWP refers to refrigerants with GWP of 1000 or lower. None of the commonly proposed/used HFCs that are designed to substitute HCFCs eg. R410a, R134a, and R32, have GWP less than 300 and can therefore not be classified as low-GWP refrigerants.

- **Edits/Omissions:**
- **Additions:**

Section 6.5 Recommendations

- **In response to:** Licensing system for import and export of HFCs.
- **Comment:** Considering that HFCs are a dead-end technology with a limited future, investing in setting up a bureaucratic apparatus to promote the export and import of these gasses which are being phased out, is not a tenable strategy from even a conventional economic standpoint.
- **Edits/Omissions:** Restructuring safety classification for refrigerants to highlight their GWP (refer snippet of information
- **Additions:** While we dwell into the potential of future refrigerants, it's important to also take a look at refrigerant safety classification. Currently, as per ASHRAE Standard 34 the refrigerants are classified based on their toxicity and flammability aspects as depicted in the diagram below.

  Prima facie, while it does cover 'human and environmental' safety , it fails to illuminate 'climate-safety' standards of the refrigerants. The obscurity of Global Warming Potential (GWP) as part of safety standards only flatters the HCFCs and HFCs (and other high GWP) refrigerants to be perceived as A1 class 'safe' refrigerants and diverts the narrative of 'natural refrigerants' like R-290, R-600 etc as being 'unsafe' for their flammability characteristics.
  (Hesitation relative to the flammable characteristics of 'natural refrigerants' like R-290, R-600 are further cleared in the section below.)
  Thus, it becomes vital to introduce GWP in the safety classification category to understand hazards and false safety representation of HCFCs, HFCs and other high GWP refrigerants. The following figure is proposed for the safety classification of refrigerants with inclusion of GWP as the selection category.



The diagram represents a ternary plot, whereby the two sides of inverted triangle represents the GWP axis while the base represents Toxicity axis. Vertical division, divides the plot into low and high toxicity groups and the horizontal division divides the plot into low and high GWP groups. The dotted lines scale in ascending order of flammability starting from the vertical division on till the vertices on either side of division.
This setup above creates a 2-dimensional version of 3-dimensional grid with 16 cells, helping us more accurately assert and classify refrigerants.

For e.g. R-22, we know, has no flame propagation and low toxicity but high GWP thereby categorizing it under A5 group . Comparatively, R-290 has high flammability and low toxicity but low GWP, thus, it falls under A4 group. This comparison demystifies the A1 safety classification of R-22 from prior safety nomenclature to the proposed one.

Section 6.4 Proposed Refrigerant Pathways

- **In response to:** Most of the low GWP alternative refrigerants are heavily patented by MNCs and are very costly
- **Comment:** This is an inaccurate generalization. Hydrocarbon refrigerants and other refrigerants such as ammonia, CO2, air

etc. do not have any controlling patents that constrain their use by imposing economic obstacles.

- **Edits/Omissions:**
- **Additions:**

Section Refrigerants Development

- **In response to:** Bureau of Indian Standards (BIS) is working on developing refrigerant safety standards for room air conditioners especially for the natural refrigerants, which generally are toxic and flammable.
- **Comment:** This is a sweeping generalization to make, most hydrocarbon refrigerants are non-toxic and there are many natural refrigerants that are non-flammable (eg. water, air, CO2, ammonia). Hence it is advised that his statement be removed.
- **Edits/Omissions:** Relevant modifications to BIS's Hydrocarbon-Refrigerant based Appliance Safety Standards (currently based on ISO 5149), which regulate the maximum allowable charge in Room ACs as a function of room volume, should consider the risk analysis approach towards accommodating flammability risk mitigation in Room AC design. Specifically, the formulae for determining the charge limits should account for improved tightness, airflow and reduced released mass. These revised formulae (relative to those currently recognized by ISO 5149) developed by Daniel Colbourne, accounting for research conducted as part of two Japanese studies by JARECO and JSRAE, provide emphatic support for increasing charge-size limits without hampering vital safety concerns surrounding flammability of hydrocarbon refrigerants. The proposed formulae are provided in the Table below:

Sr. No.	Parameters	Formula
1	**Basic**	**m_{max} = 0.25 x h x LFL x A_{room}**
2	Improved tightness	m_{max} = 0.40 x h x LFL x A_{room}
3	With airflow	m_{max} = 0.80 x LFL x V_{room}
4	Reduced released mass	m_{max} = {any of 1), 2A) or 2C) } + retained mass
5	Proof by test	According to test when C_{max} < 90% LFL

Where m_{max} = allowable charge size in a room, h = installation height of appliance
LFL = Lower Flammability limit, A= Room Area

- **Additions:**

Section: 5.1.1.2 ● HVAC Technology Development

Scope of R&D and Potential Areas of Technological Interventions

➔

- **In response to: "**Production of refrigerants to meet the growing requirements of cooling while minimizing impact on climate as envisaged under the Kigali Amendment to the Montreal Protocol is a challenging task. It would require a comprehensive R&D programme in the country to minimise economic burden on the users."
- **Comment:** NCAP must underscore the enormous socio, ecological, and economic impetus offered by adopting a strategy that galvanizes a shift to energy efficient Room ACs. Lawrence Berkeley National Laboratory estimated that India would have to construct 300 coal-based power plants of 500 GW each to meet 239 TWh/yr electricity demand from ACs in 2030. The energy efficient ACs would avoid building 100 new coal-based power plants of 500 each. Additionally, if the 2030 stock of room ACs in India are assumed to use low GWP refrigerants and high energy efficient systems, peak load reduction of 31 – 71 GW can be achieved and savings of GHG emissions of over 0.32 GT/year annually, which is around two times the savings expected from installing 100 GW during National Solar Mission. Therefore, it is imperative to simultaneously improve the energy efficiency of Room ACs while looking for a paradigm shift of high GWP refrigerant to low GWP refrigerants.

  It is important to understand that transforming regulations, and investing in R&D, to reduce energy demand from Room ACs is resounding more cost and environmental effective strategy than building 100s of coal-based power plants to meet the electricity demand from energy-intensive ACs.

- **Edits/Omissions:**
- **Additions:**

Section: 5.1.1.2 ● HVAC Technology Development

Scope of R&D and Potential Areas of Technological Interventions

➔

- **In response to:** "Table 7.1: Proposed Plan of R&D activities - HVAC/ Not-in-kind technology development/Service Sector"
- **Comment:**
- **Edits/Omissions:**
- **Additions:** Research to include the motion sensor-based 'sleep support function' as a standard feature in all Room ACs manufactured beyond a date (arrived at by consensus through dialog with RAMA etc.). This feature tracks human movement in a dark room to automatically detect periods during which users are sleeping to alter temperature setting in response to the altered physiological state of low metabolic activity.

Section: Chapter 7 Cross Cutting Policy Regulations

➔

- **In response to:** "it is recognized that affordability of energy efficient RAC equipment and high upfront cost to consumer is a stumbling block to higher penetration on energy efficient RAC equipment, globally. The life cycle costs of efficient RAC equipment and pay back of investment has not been able to increase the penetration substantially."
- **Comment:** From the customers' perspective, more energy efficient Room ACs make them cheaper to run and their life-cycle cost benefits make them a more financially prudent choice as they yield a finite payback period (often in the range of 3 to 5 years) whereas business-as-usual technologies offer a payback period that is mathematically equivalent to infinity (i.e. zero cost savings per year). Considering 2018 Room AC cost data, a 5-star ACs costs approximately INR 3, 828 more than a typical 3-star AC. Based on average electricity tariffs and annual usage conditions of Indian Urban households, it is estimated that electricity cost when using a more efficient AC will be INR 1,500 lesser per year; thereby yielding a simple payback period of 2-3 years.
- **Edits/Omissions:**
- **Additions:**

Section: Chapter 7 Cross Cutting Policy Regulations

➔

- **In response to:** "A move towards low GWP energy efficient RAC equipment essentially requires to address the issue of affordability to have climate benefits and reduced energy consumption. "
- **Comment:** The point on affordability is incongruent while looking for a move towards low GWP energy efficient RAC equipment. Innumerable examples abound in other spheres of technology wherein environmental and performance improvements are deployed in the market at a rate this is widely disparate with respect to equipment lifespan or cost. For instance, in the automobile industry in India, the Bharat Stage regulations, established to reduce emissions from vehicles, are upgraded at an accelerated rate relative to the long equipment lifespans of vehicles affected by these regulations. The current fuel efficiency of a typical passenger vehicle, the Maruti Suzuki, under BS III norms is 16 km/L and the fuel efficiency will be required to increase to 22km/L under BS VI; this can serve as an exemplary policy to emulate in the RAC industry as the Automobile Industry has been compelled by progressive government regulations to leapfrog from BS III to BS VI to achieve accelerated reductions in emissions, commensurate with the alarming and toxic rise in air pollution levels in Indian cities. Analogous experiences with significant specifications changes are witnessed regularly in the IT industry as well. The lifespan of a typical computer is approximately 5 years and within these 5 years, substantial changes in performance specification and cost of a computer takes place. Nevertheless, customers usually do not immediately discard the equipment they possess; they use the existing products till the end of life of the product.
- **Edits/Omissions:**
- **Additions:**

Section 7.4 Cross Cutting Policy Regulations

➔

- **In response to:** Institutionalise Demand Side Management programmes with DISCOMS to replace inefficient ACs with energy efficient equipment.
- **Comment:** The 'replacement' program must integtate a robust strategy for mitigating the influences of the material and psychological rebound effects. These well-known behavioral traits and biases are known to provoke higher total energy, material /resource (EMR) consumption, because the user of more efficient technologies is under the impression that he/she has economized on EMR use and that there is thus no harm in using the concerned device a bit more. Thus, the replacement ACs must include sensor/display

technologies which accurately measures and dynamically depicts the net amount of emissions (contextualized in terms of equivalent 'trees' or 'energy consumed by an average Indian' and other communication devices) to evoke strong emotional responses from users. The goal should be to trigger actions to reduce total energy consumption and invoke a 'sufficiency' based response that achieves net energy and GHG emission reductions as opposed to efficiency-based actions.

- **Edits/Omissions:**
- **Additions:**
