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SHAKTI SUSTAINABLE ENERGY FOUNDATION

POLICY BRIEF 1 GREEN COOLING

Technology landscape for cooling: Status update

Introduction

The use of cooling technologies for thermal comfort, food storage, and vaccine delivery systems is rapidly increasing in developing countries. These are refrigerant-based technologies that are able to provide consistent cooling at temperatures well below that of the ambient environment. In India as with several developing countries, this proliferation in cooling demand is accompanied by a refrigerant transition programme.

The refrigerant transition was mandated under the Montreal Protocol on substances that deplete the ozone layer (here after Montreal Protocol), in order to phase out refrigerant gases with an ozone depleting potential (ODP). While the phase out of chlorofluorocarbons (CFC) is complete, the hydrochlorofluorocarbons (HCFC) are expected to be phased out in India by 2030. Simultaneously, with a freeze in 2028, under the Kigali Amendment to the Montreal Protocol, hydrofluorocarbons (HFC) with no ODP but with large global warming potentials (GWP) are set for a phase-down in India. What this means is that the cooling industry in India is simultaneously grappling with an increase in demand for cooling, while obligated to satisfy refrigerant reduction targets and transition to alternate refrigerants.

A common theme that runs through these refrigerant transitions is the goal to reduce their adverse impact on the environment. This impact of cooling equipment during its lifetime is measured in two ways, namely, direct and indirect greenhouse gas (GHG) emissions. Under direct emissions are emissions of refrigerant gases – CFCs, HCFCs and HFCs – with adverse impacts ranging from the ozone hole to global warming. Additionally, refrigerant-based cooling systems are well-recognised as energy guzzlers – this is the cause for indirect emissions. About 80% of the GHG emissions from refrigerant-based cooling can be attributed to its energy use during its lifetime. The indirect emissions from various applications of cooling thus constitutes a significant share of India's GHG emissions. Thus, there is a need for an integrated approach, one that addresses both the direct and indirect emissions from cooling.

With increasing affluence, in addition to increasing warming due to climate change, cooling demand for comfort, food security and health will see an exponential increase. Simultaneously, the cooling industry will undergo refrigerant transition from HCFC and HFC to emerging alternatives. While this transition is already underway in other developed countries, thereby providing technology options for India, through this policy brief series we aim to explore how India can mobilise a leap-frog transition to climate-friendly and sustainable cooling. We will explore existing alternative cooling technologies and the need to operationalise the India Cooling Action Plan (ICAP) to facilitate this leap-frog transition.

In this introductory policy brief, we examine the current landscape for cooling in terms of available technologies, refrigerant usage and energy efficiency.

Current space-cooling technologies

The aggregated nationwide cooling demand (in tonnes of refrigeration or TR) is expected to increase by eight times the 2017-18 levels by 2037-38. Simultaneously, by 2037-38, space cooling is expected to grow by eleven times the 2017-18 levels - the most significant growth among cooling sectors.[1]

Space cooling requirement in India today are predominantly met by fans and coolers. However, room ACs for residences and chillers and VRF units in commercial spaces are increasingly being preferred for space cooling.[2] Possession of air coolers and ACs in urban households has been captured in India's National Survey (2011-12) as having increased from 10.9% in 1999-'00 to 23.4% in 2011-12.[3] Electric fans were estimated to be present in 92.7% of urban households in 2011-12.[4] There is currently no individual estimate for ACs under the National Survey, however, current penetration of room ACs as per the ICAP is estimated at 10% of households in India.[5]

While current estimates based on a National Survey are awaited, there is sufficient evidence of growth in room AC use among Indian households. According to an estimate the CAGR of Indian room AC industry was projected at 15% for the year 2020 with an expected increase in sales to 7.2 million units.[6] Among room ACs, there was a further prediction of proliferation towards inverter ACs from fixed-speed ACs, with about 50% of the market in 2020 being captured by the former.[7] In general, among AC-based space cooling applications, room ACs constitute 50% of the segment, while other large cooling equipment like chillers, VRF etc constitute the remaining.[8]

About 94% of the room ACs in India use synthetic refrigerants (HCFC 22, HFC 410a, HFC 32 and HFC 407a) while a small fraction of ACs are Hydrocarbon (HC) 290 based. In terms of star-labelling, 3-star ACs have been found to be the preferred type by households, while the next most commonly bought ACs are 5-star labelled.[9, 10]

Refrigerant demand

Refrigerant demand in India is expected to increase by 5 to 8 times by 2037-38.[11] The ICAP's proposed interventions, grounded in passive cooling technologies and improved cooling efficiency are expected to decrease refrigerant consumption by 25–30% by 2037-38.

One analysis predicts that by 2030 HFCs will provide 50 percent of cooling in India (measured as equipment TR), while natural refrigerants will remain at the fringes estimated at ~11 percent of equipment TR, across sectors.[12] A subsequent analysis on room ACs, while predicting an increase in HFCs due to the HCFC phaseout in 2030, predicted natural refrigerants (HC, specifically) to constitute less than 1% of total refrigerant demand by 2030 under a business as usual (BAU) scenario.[13] The BAU scenario's baseline assumed HCFC, HFC and low-GWP refrigerant consumption at 64.5%, 35% and 0.5% respectively, in 2017.[14] This analysis further showed that even under an ambitious scenario of realising ICAP's target of reducing refrigerant demand by 25% by 2030 (deduced from 30% reduction in demand by 2038), HFCs continue to be the dominant refrigerant in the market, albeit in medium- and low-GWP versions.[15] Another BAU analysis predicts natural refrigerant based room ACs to occupy 25 percent of total sales by 2030.[16] It is important to note that at the moment both the ICAP and India's domestic policy on refrigerants remain refrigerant agnostic. That is, while natural refrigerants are not promoted, use of HFCs is not being curtailed owing to mainstream manufacturers.

A 2016 assessment stated 77% of the room AC sector can be converted to natural refrigerant-based systems with the existing technology. It further stated that taking this path and prioritising natural refrigerants can result in emission saving of 50 million tonnes of CO_2 per year between 2025 and 2030.[17] Key areas identified to achieve this were safety standards for hydrocarbons in room air-conditioners, supportive energy efficiency regulations, and promotion of natural refrigerants by the government of India. As noted earlier, the BIS has adopted key safety standards for natural refrigerants. However, we are severely lacking on the latter two. The following sections will explore where India stands in terms of natural refrigerant use, replaceability and barriers.

Despite relative advantages, natural refrigerants have not garnered a mainstream presence, often attributed to their inherent toxicity and/or flammability. Further, while the operational costs of these natural refrigerant-based systems are significantly lower than HFC systems, in the absence of a conducive market their capital costs remain steep.[18] As a result, in countries like India, HFCs that emerged as a stop-gap solution for HCFCs (to be phased out by 2030) are quickly becoming a long-term alternative.

Energy efficiency and Minimum Energy Performance Standards (MEPS)

The Bureau of Energy Efficiency (BEE) under the aegis of Ministry of Power (MoP) established the standards and labelling (S&L) programme in 2007. The S&L programme was established to provide consumers with information on energy efficiency performance of various appliances. The way that this is done is by providing a star label value ranging from 1 to 5, each higher value denoting an increasing value of energy efficiency in the AC unit. These star label values are defined based on a minimum energy performance standard (MEPS), defined in India in terms of the Indian Season Energy Efficiency Ratio (ISEER). This standard is periodically revised to improve the energy efficiency performance of appliances. The different cooling appliances pertaining to space cooling brought under the BEE's S&L programmes both on a voluntary and mandatory basis are listed in Table 1. The current ISEER ranges for the highest efficiency product of each of these appliances and the validity of this rating is also defined in Table 1 to further benchmark the current status of MEPS in India.

In addition to these, in the 13th Technical Committee Meeting for Room air conditioners held in January 2020, a proposal to bring packaged air conditioners and air coolers was floated. As per this meeting, a market analysis of both these technologies was proposed and a labelling program was to be launched by the end of 2020.[23]

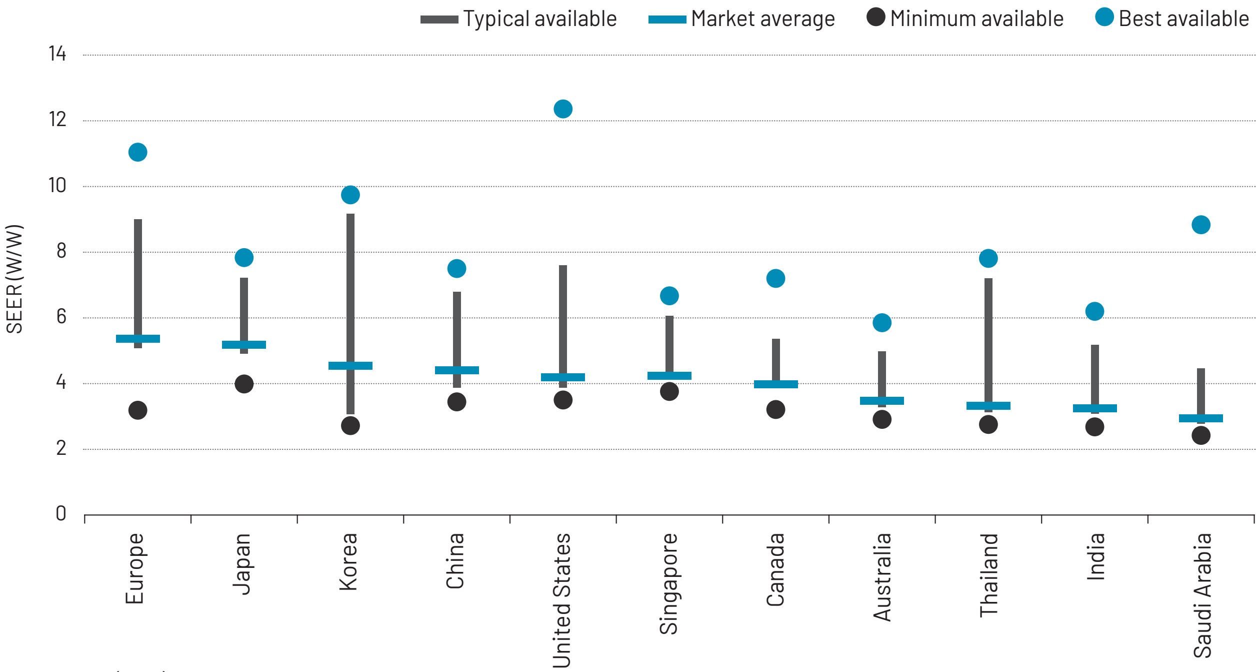
IEA's 'The Future of Cooling' stated that global best available ACs is up to five times more efficient than the least efficient equipment currently available.[24] Figure 1 depicts the SEER for residential ACs in terms of a typical range, market average, minimum available and best available.

Table 1: Status of S&L programme for space cooling appliances and equipment in India

	Equipment	ISEER ranges for most efficient product	Validity
Voluntary	Ceiling fans[19]	5 star ≥5.1 (sweep size < 1200 mm) 5 star ≥ 6.0 (sweep size ≥ 1200 mm)	1st September 2019 – 30th June 2022
	Light Commercial ACs[20]	5 star ≥ 4.0	2nd March 2020 – 31st December 2021
	Chillers[21]	5 star ranges from 4.40 to 9 depending on kW of cooling of the chiller ranging from <260 to ≥1580 kW.	1st January 2019 – 31st December 2021
Mandatory	Room ACs (Based on the 12th Technical Committee Meeting)[22]	5star ≥ 3.50 (Unitary) 5 star ≥ 5.00 (Split) 5 star ≥ 5.50 (Split)	2021 to 2026 (Unitary) 2021 to 2023 (Split) 2024 to 2026 (Split)
	Cassette, Floor standing tower, ceiling corner AC etc.	5 star ≥ 3.50	Not updated since 2017

Author analysis (2021)

Figure 1: SEERs of available residential ACs in selected countries/ regions, 2018



Source: IEA. (2018)

Note: SEER = the ratio of output cooling capacity to electrical input, adjusted for the overall performance of the device for the weather over a typical cooling season in each given country; as the test conditions differ across countries, the average ratios are not strictly comparable; W/W = watt per watt

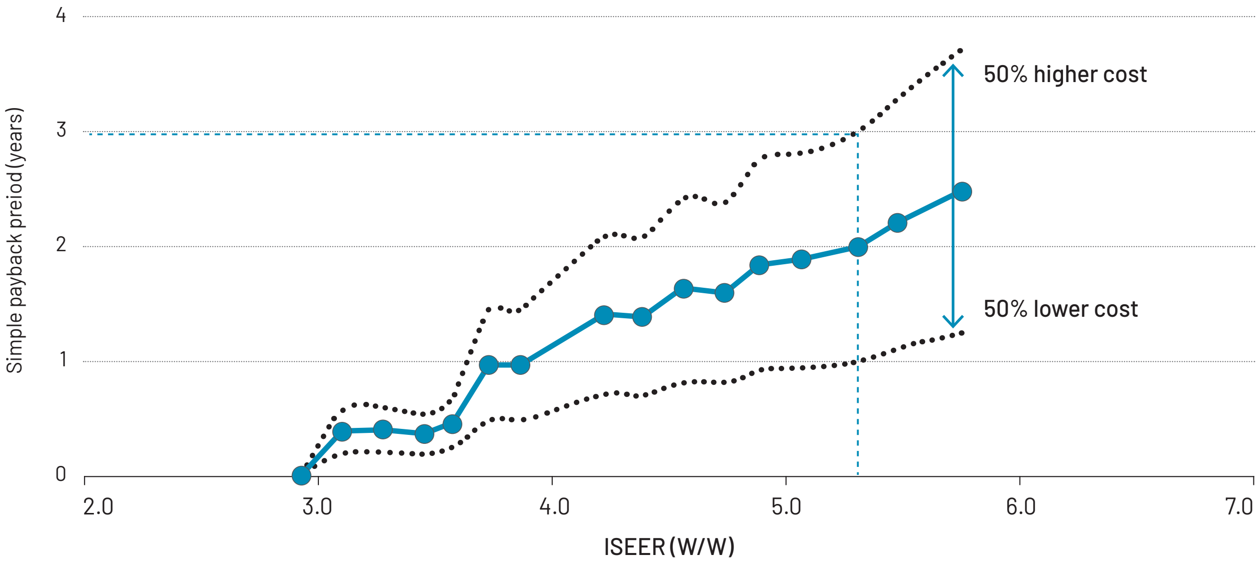
It is evident that the typical SEER range as well as the best available room AC in terms of efficiency in India is among the lowest, relative to most developed countries.[25] Further, the market average in India is closer to the least efficient AC in the market.[26] To this end, the 2018 Chilling Prospects Report stated that the growing middle class in developing countries will purchase the most affordable and thus least efficient ACs in the market.[27] All of these trends point to the need for India to improve it energy efficiency standards.

The ICAP proposed ~6% annual increase in energy efficiency in order to achieve 25 – 40% reduction in cooling energy demand by 2037-38.[28] The MEPS for room ACs (unitary and split), one of the steepest growth markets of cooling appliances, was due for an update in March 2019. While the BEE proposed a revision to the star rating system that placed annual energy efficiency improvement in order of ~5% (for split ACs), there has been considerable industry push back on this proposal.[29] This has in turn derailed any efforts to augment energy efficiency and energy savings for room ACs in India at the moment. However, it important that the government follows its commitments in ICAP and enhances ISEER as the benefits outweighs cost by a long margin.

The cost-benefit rationale behind enhancing the ISEER was investigated in 2016 to find that significant improvement in efficiency can be cost effective from a consumer perspective.[30] For an ISEER improvement from 2.8 to 3.5, the average payback period was estimated at less than one year and a retail price increase of INR 4900 (~15% increase over baseline) to cover the cost of efficiency improvement. A similar increase to ISEER 2.8 to 4, almost doubles the payback period and the retail price increase. Payback period for different levels of ISEER are represented in Figure 2.

Price increase on room air conditioners in response to increasing efficiency was estimated to have a payback period of up to three years, even for an increase in ISEER to 5.2 (see Figure 2). For this analysis payback periods were estimated assuming the average electricity price of INR 7/kWh. However, even for a range of electricity tariffs (INR 5-10/kWh), the payback period increase or decrease was limited to one year (depending on whether the tariff was higher or lower range). Of course, consumer benefits were the least when low tariffs for electricity were combined with small hours of usage of the air conditioners. However, even in such worst case scenarios, with an average air conditioner lifetime of 7-10 years, the payback period was estimated to extend to less than half the life of the equipment.

Figure 2: Payback period for increasing levels of efficiency in room air conditioners



Source: Shah et al. (2016)

Increase in price for efficiency has been addressed by EESL's super-efficient room air conditioner programme, that has been selling ISEER 5.2 room air conditioners at half the market price. Such procurement programmes can help provide access to efficient air conditioners at affordable prices. However, there needs to be a further analysis on whom these procurement programmes are reaching and the extent of success of these programmes. As increasing the energy efficiency is the way forward for India, it is imperative that long-term commitments are made that promote leapfrogging efficiency standards.

Key observations and way forward

Space cooling needs in India are largely met by fans, however, increasingly, air conditioners are finding a place in urban households. With increasing penetration of air conditioners, GHG emissions both in the form of high-GWP refrigerants as well as high energy use of these appliances are expected. To this end, affordable air conditioners in the market today are both reliant on medium to high-GWP HFCs and are among the least energy efficient options in the world. Addressing this regressive trend, the ICAP targets a reduction in both cooling energy demand and refrigerant demand substantially in the span of the next two decades by focusing on sustainable and climate-friendly cooling technologies. However, this is not likely to happen without deliberate action on-ground. We propose the following objectives as the basis of India's Green Cooling Agenda.

- **Cooling is an equity issue:** It is important to identify cooling as an equity issue which promotes access and affordability as a central objective. While demand for room air conditioners is rapidly rising, at the moment, fans are the most commonly used cooling appliance in India. By looking at cooling as an equity issue there is a possibility of creating opportunities for alternative cooling technologies, instead of the current bulldozing for room air conditioners by manufacturers. It is important to recognise that air conditioners are aspirational whereas access to thermal comfort is a developmental priority. By recognising cooling as an equity issue, there is a fundamental recognition to not disrupt the existing access or use of cooling technology, rather, augment the quality of these to gain on climate, sustainability and equity fronts.

- **Energy cost and refrigerant use of cooling need to be visible:** The energy cost of cooling, especially from the perspective of refrigerant-based air conditioners has been long recognised as a substantial part of cooling based GHG emissions. While energy efficiency standards in India need to be ratcheted up regularly, energy needs to become visible both at the air conditioner level and building levels. At the core of these efforts lies the endeavour to enhance the energy efficiency in cooling. In addition to making energy use visible, there are various allied approaches that can be adopted ranging from behaviour change experiments, incentive models, procurement of energy efficient appliances to exploring cooling as a service model.

In a similar manner, refrigerant-specific awareness is critical. Awareness among residential end-users on environmental impact of refrigerants should be supplemented with name of the refrigerant used in the appliances both through using labels on appliances and introducing these in brochures. It may also be beneficial to replace the 'R' for refrigerants with chemical-specific abbreviations of the refrigerants such as 'HFC-134a', HFC-410a' instead of 'R-134a' and 'R-410a'. This in turn can make refrigerants a visible and tangible aspect of air conditioners for end-users.

- **Cooling beyond lived-spaces:** There is a need to look at cooling beyond its use in affluent lived spaces – residential buildings, offices, commercial buildings, and as a basic requirement in community spaces and public infrastructure. Bus stands, railway stations, government schools, and courthouses, to name a few, are all public infrastructure and community spaces that are currently not conducive for air conditioners. There are several lucrative options in the form of not-in-kind technologies or passive cooling methods that offer access to affordable cooling in these spaces.

ANNEXURE 1

List of experts consulted for the survey and interviews

Survey

Name	Affiliation
Ms. Shikha Bhasin	CEEW
Mr. S P Garnaik	EESL
Dr. M.P.Maiya	IIT-M
Ms. Ritika Jain	Shakti Sustainable Energy Foundation
Dr. Bijan Kumar Mandal	IIEST, Shibpur
Mr. Aswani Kumar Sharma	WIPRO
Dr. M V Rane	IIT-B
Dr. Neeraj Agrawal	DBATU
Mr. Ashish Rakheja	AEON
Ms. Nisha Menon	DESL
Mr. Rajmohan Rangaraj	DESL, Veolia Environment Ingineering Council
Mr. Piyush Patel	Paharpur Cooling Technologies
Dr. Prasanna Rao Dontula	A.T.E Group
Mr. Shubhashis Dey	Shakti Sustainable Energy Foundation
Mr. Mohanlal Basantwani	Shankar Refrigeration & Engineering
Mr. Rajendra Bhavsar	Refcon Technologies & Sysetms Pvt ltd
Mr. Nikhil Raj	Neptune Refrigeration Co P Ltd
Mr. Shatrughan Kumar	Trans ACNR Solutions Private Limited
Mr. Ramesh Kumar Gupta	EVAPOLER ECO COOLING SOLUTIONS
Mr. Madhusudhan Rapole	Oorja Energy Engineering Services Pvt Ltd
Mr. Sudharshan Rapolu	TechnoDyne RS

Interviews

Mr. Tanmay Tatagath	Green Building Analyst, Executive Director Environmental Design Solutions
Ms. Sumedha Malaviya	Manager Energy Program, WRI India
Mr. Madhusudhan Rapole	Oorja Energy Engineering Services Pvt Ltd
Ms. Smita Chandiwala	Energe-se
Dr. Satish Kumar	AEEE
Mr. Vivek Ghilani	cBalance
Mr. Krishna Nagahari	Danfoss

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