iFOREST INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

SHAKTI SUSTAINABLE ENERGY FOUNDATION

POLICY BRIEF 1 GREEN COOLING

India's Room Air Conditioners (RAC): Technology Landscape

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 demand for cooling and refrigeration is expected increase by eight-times between 2017 and 2037.[1] This is expected to increase both the demand for refrigerants and electricity substantially.

Proliferation in cooling demand, in India as in the case for several developing countries, 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 from climate change, cooling demand for comfort, food security and health will see an exponential increase. However, increasing use of HFC refrigerant-based cooling will contribute to global warming. These aspects of India's cooling paradox have been addressed by the India Cooling Action Plan (ICAP) under the overall objective of providing 'sustainable cooling for all'. Successful implementation of ICAP's recommendations can reduce refrigerant demand by up to 30%, decrease cooling energy use by up to 40% while simultaneously addressing human well-being by increasing access to thermal comfort and refrigeration.

In this policy brief series, we aim to explore existing alternative cooling technologies for the room air-conditioning (RAC) sector and the ways to make this transition under ICAP's implementation plan. Key alternatives here are available in the form of natural refrigerant and not-in-kind cooling and refrigeration technologies. In this introductory policy brief, we examine the current RAC landscape - available technologies, refrigerant usage and energy efficiency.

RAC technology landscape

The aggregated nationwide space cooling demand by 2037-38 is expected to grow by eleven times the 2017-18 levels - the most significant growth among cooling sectors in India.[2]

Space cooling requirement in India today are predominantly met by fans and coolers. 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] However, RACs for residences and chillers and VRF units in commercial spaces are increasingly being preferred for space cooling.[6]

According to an estimate the CAGR of Indian RAC industry was projected at 15% for the year 2020 with an expected increase in sales to 7.2 million units.[7] 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.[8] In general, among AC-based space cooling applications, RACs constitute 50% of the segment, while other large cooling equipment like chillers, VRF etc constitute the remaining 50%.[9]

Refrigerant demand

Refrigerant demand in India is expected to increase by 5 to 8 times by 2037-38.[10] 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.

Refrigerants used in air-conditioners can either be synthetic derivatives like HCFCs, HFCs and Hydrofluoroolefin (HFOs) or natural refrigerants like hydrocarbons (HC), ammonia (R-717), carbon dioxide (R-744) and water (R-718). About 94% of the RACs 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.[11] Two key distinctions between synthetic and natural refrigerants is the latter class of refrigerants' relatively low impact on the environment and patent-free status.

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 RACs, 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.

A 2016 assessment stated 77% of the RAC 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 HCs in RAC, supportive energy efficiency regulations, and promotion of natural refrigerants by the Government of India. In 2020, the BIS adopted key safety standards for HC 290 and a code of practices for ammonia.

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. Table 1 summarises the current ISEER ranges for the highest efficiency cooling appliances used for thermal comfort in India.

In the 13th Technical Committee Meeting for Room air conditioners held in January 2020, a proposal to add 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.[19]

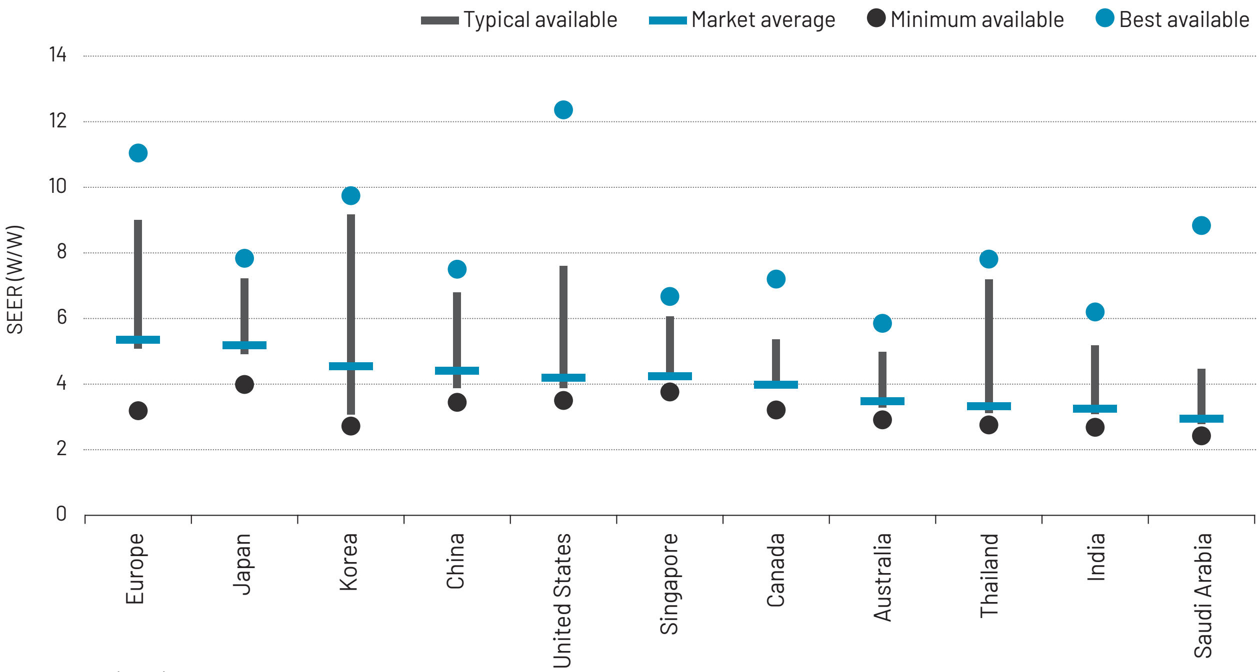
IEA's 'The Future of Cooling' stated that global best available ACs is up to five times more efficient than the least efficient equipment currently available.[20] Figure 1 depicts the SEER for RACs in terms of a typical range, market average, minimum available and best available.

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[21]	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[22]	5 star ≥ 4.0	2nd March 2020 – 31st December 2021
	Chillers[23]	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)[24]	5 star ≥ 3.50 (Unitary) 5 stsr ≥ 5.00 (Split) 5 stsr ≥ 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

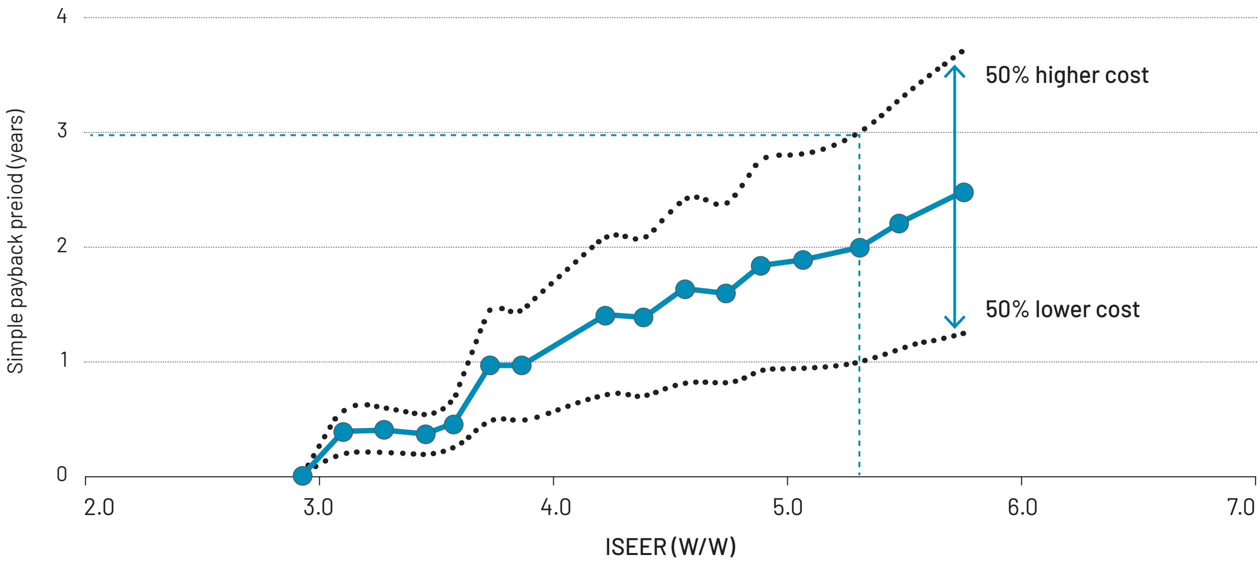
From Figure 1, it is evident that the typical SEER range as well as the best available RAC in terms of efficiency in India is among the lowest, relative to most developed countries.[25] Further, the market average in India is closer to the least efficient AC in the world.[26] To this end, the 2018 Chilling 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 while also address existing market barriers.

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 RACs (unitary and split), one of the steepest growth markets of cooling appliances, was due for an update in March 2019. The BEE proposed a revision of ~5% in energy efficiency (for split ACs) but was met with industry push back.[29] This has in turn derailed any efforts to augment energy efficiency and energy savings for RACs in India at the moment. It is important that the government enhances ISEER at least at the rate of 5% per annum as the benefits outweigh the 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 RACs 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 ACs. 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. Further, EESL's current procurement super-efficient AC programme promotes a medium-HFC based unit. This in turn can be detrimental in India's path to phasing down HFCs. 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 while simultaneously taking refrigerants into consideration.

Green Cooling in India: Objectives

Space cooling needs in India are currently met by fans, however, increasingly, RACs are finding a place in urban households. With increasing penetration of RACs, 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 India are both reliant on medium to high-GWP HFCs or HCFCs 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. Through this series of policy briefs we aim to understand the barriers and opportunities for offsetting conventional RACs and the role of ICAP in doing so. More specifically we aim to:

- Examine current technology and market preparedness of natural refrigerant and not-in-kind technologies.
- Examine barriers and propose interventions for greater adoption of natural refrigerant & not-in-kind technologies in India.
- Identify implementation challenges of the ICAP and suggest opportunities to augment its implementation efforts.

BOX: Principles for Green Cooling in India

The 'green' cooling agenda proposed in this series will encompass the following broad principles:

1. Access to thermal comfort as an equity issue

By addressing thermal comfort as an equity issue, the focus is on creating a diverse marketplace for affordable and climate-friendly cooling technologies while moving away from conventional RACs. There is a need to address the aspirational aspect of RAC purchase in India by increasing awareness on their detrimental impact on the environment and improving accessibility to sustainable methods of thermal comfort. Such an approach will simultaneously disrupt the existing RAC market and diversify the modes of thermal comfort (passive vs active, natural refrigerant vs synthetic refrigerant, vapour absorption vs vapour compression etc.).

There is also a need to look at cooling beyond its use in affluent lived spaces – residential buildings, offices, commercial buildings, to being 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 conventional refrigerant-based 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.

2. Need for synergies between energy efficiency and refrigerant transition

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. At the same time, the high-GWP values of HFCs (>1000) will be addressed under the upcoming refrigerant transition. India thus needs to quickly integrate its energy efficiency programmes with the refrigerant transition. The ICAP is a seminal policy document that takes a multi-sector and multi-stakeholder that addresses the need for policy and programmatic synergies. Some existing programmes identified by the ICAP are BEE's S&L programme, EESL's sustainable procurement, BIS's eco-mark/standards and Ozone Cell's refrigerant phase-down. However, currently, it is critical to operationalise ICAP's synergies by making them targeted and measurable.

In addition to the programmatic synergies, there are various allied approaches that can be adopted ranging from behaviour change experiments, incentive models, green procurement with consideration for both energy efficiency and refrigerants. Further, refrigerant-specific awareness is critical. Awareness among residential end-users on environmental impact of refrigerants could be supplemented with name of the refrigerant used in the appliances both through using labels on appliances and introducing these in brochures.

3. Localise implementation of policies and programmes on cooling

Many of the policies and programmes (under the Montreal Protocol) focusing on refrigerants have a been formulated and implemented at the national-level. While this has worked in the case of a focused refrigerant phaseout, it may be more challenging in the upcoming refrigerant phase-down. There is an increasing number of aspects to be looked into under refrigerant phase-down such as energy efficiency and climate impact etc, which may need the involvement of state departments. The ICAP too has been charted for implementation by the Central Government departments largely, with minimal participation of any state departments. In coming decades, this centralised approach may not be suitable considering rapid proliferation in demand for RACs (increasing energy and refrigerant demand) and the diverse climatic regions in the country.

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

ENDNOTES & REFERENCES

1 Ozone Cell. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change, Government of India: New Delhi. http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

2 Ibid

3 Singh, M., Gurumurthy, G., Shekhar, S. (March, 2019). Mapping the Refrigerant Trends in India: An Assessment of Room AC Sector. The Energy and Resources Institute: New Delhi. https://www.teriin.org/sites/default/files/2019-11/Mapping%20the%20Refrigerant%20Trends%20in%20India%20An%20Assessment%20of%20Room%20AC%20sector.pdf

4 NSSO. (2014). Household Consumption of Various Goods and Services in India 2011-12. NSS 68th Round 558. NSSO. New Delhi: National Sample Survey Office, Ministry of Statistics and Programme Implementation.

5 Ibid

6 Ozone Cell. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change, Government of India: New Delhi. http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

7 Sharma, A., and Shah, A. (2017). Room Air Conditioners. Thematic Report. Motilal Oswal. https://www.motilaloswal.com/site/rreports/html/636288151341015916/index.htm

8 Ibid

9 Singh, M., Gurumurthy, G., Shekhar, S. (March, 2019). Mapping the Refrigerant Trends in India: An Assessment of Room AC Sector. The Energy and Resources Institute: New Delhi. https://www.teriin.org/sites/default/files/2019-11/Mapping%20the%20Refrigerant%20Trends%20in%20India%20An%20Assessment%20of%20Room%20AC%20sector.pdf

10 Ozone Cell. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change, Government of India: New Delhi. http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

11 Sharma, A., and Shah, A. (2017). Room Air Conditioners. Thematic Report. Motilal Oswal. https://www.motilaloswal.com/site/rreports/html/636288151341015916/index.htm

12 Singh, M., Gurumurthy, G., Shekhar, S. (March, 2019). Mapping the Refrigerant Trends in India: An Assessment of Room AC Sector. The Energy and Resources Institute: New Delhi. https://www.teriin.org/sites/default/files/2019-11/Mapping%20the%20Refrigerant%20Trends%20in%20India%20An%20Assessment%20of%20Room%20AC%20sector.pdf

13 cBalance. (2016). Mapping Natural Refrigerant Technology Uptake in India—Current state future scenarios. CBalance. https://shaktifoundation.in/wp-content/uploads/2017/06/Mapping-Natural-Refrigerant-Technology-Uptake-in-India.pdf

14 Singh, M., Gurumurthy, G., Shekhar, S. (March, 2019). Mapping the Refrigerant Trends in India: An Assessment of Room AC Sector. The Energy and Resources Institute: New Delhi. https://www.teriin.org/sites/default/files/2019-11/Mapping%20the%20Refrigerant%20Trends%20in%20India%20An%20Assessment%20of%20Room%20AC%20sector.pdf

15 Ibid

16 Ibid

17 Bhushan, C. (2016). Prioritising Natural Refrigerants in India. Center for Science and Environment. https://www.cseindia.org/prioritizing-natural-refrigerants-in-india-7770

18 Ibid

19 12th Technical Committee Meeting – Minutes of the Meeting http://www.beestarlabel.com/home/viewminutesmeeting?eqpid=1 23 13th Technical Committee Meeting – Minutes of the Meeting http://www.beestarlabel.com/home/viewminutesmeeting?eqpid=1

20 IEA. (2018). The Future of Cooling: Opportunities for energy-efficient air conditioning. https://www.k-cep.org/wp-content/uploads/2020/03/The_Future_of_Cooling.pdf

21 cBalance. (2016). Mapping Natural Refrigerant Technology Uptake in India—Current state future scenarios. CBalance. https://shaktifoundation.in/wp-content/uploads/2017/06/Mapping-Natural-Refrigerant-Technology-Uptake-in-India.pdf

22 https://www.beestarlabel.com/Content/Files/Schedule8-CF.pdf

23 https://www.beestarlabel.com/Content/Files/Schedule_24_LCAC.pdf

24 https://www.beestarlabel.com/Content/Files/Chillers_schedule_21.pdf

25 IEA. (2018). The Future of Cooling: Opportunities for energy-efficient air conditioning. https://www.k-cep.org/wp-content/uploads/2020/03/The_Future_of_Cooling.pdf

26 IEA. (2018). The Future of Cooling: Opportunities for energy-efficient air conditioning. https://www.k-cep.org/wp-content/uploads/2020/03/The_Future_of_Cooling.pdf

27 SE4All. (2018). Chilling Prospects: Providing Sustainable Cooling for All. https://www.seforall.org/system/fi les/gather-content/SEforALL_CoolingForAll-Report.pdf

28 Ozone Cell. (2019). India Cooling Action Plan. Ministry of Environment, Forest & Climate Change, Government of India: New Delhi. http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

29 See Minutes of the Meeting for 11th, 12th and 13th Technical Meeting for full discourse, available at http://www.beestarlabel.com/home/viewminutesmeeting?eqpid=1

30 Shah, N., Abhyankar, N., Park, W., Phadke, A., Diddi, S., Ahuja., Mukherjee, P.K., and Walia, A. (2016). Cost-Benefi t of Improving the Effi ciency of Room Air Conditioners (Inverter and Fixed Speed) in India. LBNL, CLASP. https://www.clasp.ngo/research/all/cost-benefi t-of-improving-the-effi ciency-of-room-acs-in-india/#:~:text=The%20energy%20effi ciency%20of%20the,the%20payback%20period%20for%20consumers.

Acknowledegment

This policy brief is one of four in a series that presents research findings, analysis and policy recommendations on adopting green cooling in India. This brief was written by **Apurupa Gorthi** and conceptualised by **Chandra Bhushan**. Special thanks to all the experts (**See Annexure 1**) for their valuable inputs and insights on the subject during the survey and interviews. These policy briefs have been written as a part of a project funded by Shakti Sustainable Energy Foundation.

iFOREST | INTERNATIONAL FORUM FOR ENVIRONMENT, SUSTAINABILITY & TECHNOLOGY

SHAKTI SUSTAINABLE ENERGY FOUNDATION