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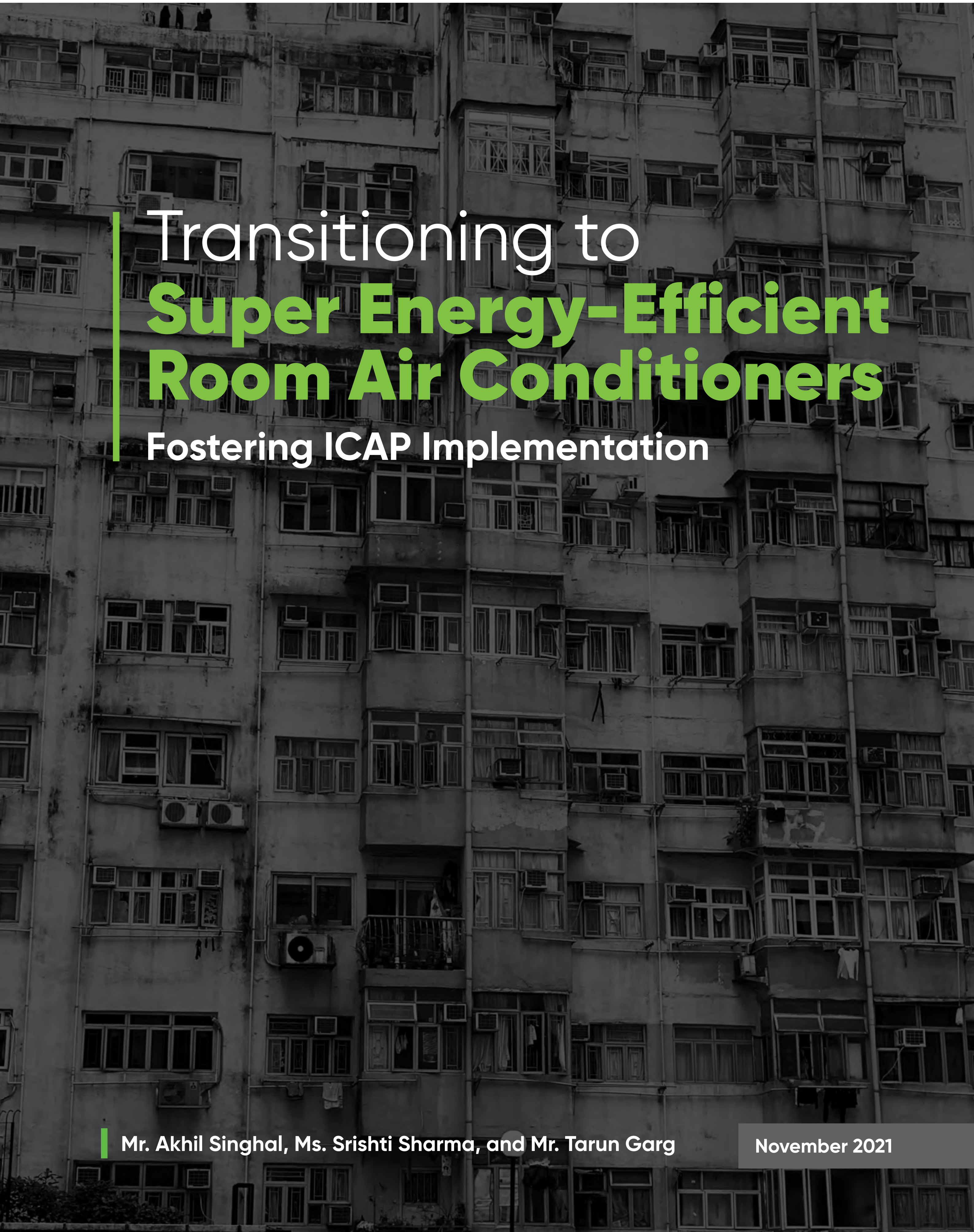

Transitioning to Super Energy-Efficient Room Air Conditioners

Fostering ICAP Implementation

Mr. Akhil Singhal, Ms. Srishti Sharma, and Mr. Tarun Garg

November 2021

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Project: Alliance for Sustainable Habitat, Energy Efficiency and Thermal Comfort

"The Alliance for Sustainable Habitat, Energy Efficiency and Thermal Comfort (SHEETAL) is a consortium of Civil society organisations led by The Energy and Resource Institute (TERI) with the Alliance for an Energy Efficient Economy (AEEE), and the Council on Energy, Environment and Water (CEEW) as partners.

Supported by CIFF, SHEETAL facilitates the roll out of India's sustainable cooling agenda enshrined in the India Cooling Action Plan. Engaging with national and international stakeholders, the consortium partners discuss, identify and test integrated approaches best suited to improve the development, access and use of energy-efficient cooling practices and technologies for R&D, space cooling, cold chain, transport air-conditioning, and the servicing sector. SHEETAL convene different line ministries and international and domestic cooling policy experts to collaborate and synergise actions to accelerate sustainable cooling in India".

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Children's Investment Fund Foundation (CIFF) is a philanthropy organisation working towards the upliftment of children's quality of life, in developing countries. There areas of work are inclusive of maternal and child health, adolescent sexual health, nutrition, education, and deworming, tackling child slavery and exploitation, and supporting smart ways to slow down and stop climate change. Their prime focus towards quality data and evidence-based approach to measure the impact.

Prepared by: Alliance for an Energy Efficient Economy

Alliance for an Energy Efficient Economy (AEEE) is a policy advocacy and energy efficiency market enabler with a not-for-profit motive. AEEE advocates energy efficiency as a resource and collaborates with industry and government to transform the market for energy-efficient products and services, thereby contributing towards meeting India's goals on energy security, clean energy and climate change. AEEE collaborates with diverse stakeholders such as policymakers, government officials, business and industry, consumers, researchers, and civil society organisations. We believe that our work speaks for itself and we hold Respect, Integrity and Synergy as central to our efforts.

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Contributors and Reviewers

National and international experts provided inputs and reviewed preliminary drafts of this report. Their comments and suggestions were of great value. Therefore, AEEE wants to extend its thanks and acknowledge the following peer reviewers for their valuable contribution to the report:

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Won Young Park, Lawrence Berkeley National Laboratory (LBNL)
Brian Holuj, United for Efficiency (U4E)

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Many sectoral experts and organisations have directly or indirectly contributed towards development of this report and their work has been cited within the report at regular instances wherever required and AEEE would also like to recognise their valuable contributions.

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Message from the Chairperson, AEEE

As the world is becoming increasingly serious about mitigating climate change and setting ambitious targets accordingly, India faces a unique opportunity but disguised as a challenge. Rising average temperatures due to global warming increase the demand for cooling solutions (which are also required by many regions to fulfil India's commitment to Sustainable Development Goal of 'Health & well Being', which, in turn, increases total energy consumption and further contributes to global warming. Households that were previously comfortable without even a ceiling fan are now installing room air conditioners. Coordinated & systematic efforts to increase the energy efficiency of cooling technologies and the penetration of these technologies on the market are much needed. The India Cooling Action Plan (ICAP) represented a crucial first step in this regard & now it is time to make that plan a reality. This will require the involvement and consensus of a wide range of stakeholders and various policies, incentives, and tools to make the achievement of the targets viable.

The Standards and Labelling Scheme was launched by the Bureau of Energy Efficiency back in 2006 and has continuously improved the Minimum Energy Performance (MEPS) of Appliances. The scheme has proven to be one of India's more successful efforts towards bringing market transformation and has led to saving 65 Billion Units of electricity during 2019-2020. Improving the energy efficiency of RACs (Room Air Conditioners) has been a critical step in the overall process, and continual enhancement of the MEPS supports in removing the least efficient products from the market & efforts continue to widen the scope of this program to include other commercial products as well. However, continual efforts and ecosystem-level enhancement propositions are required to overcome several barriers on different fronts, including market, financial, and enforcement barriers. These mechanisms become essential to support the transition to more energy-efficient products, achieve overall eco-system level efficiency gains, and lead to the larger goal of ICAP implementation and pathways to meet India's Climate Change Commitments.

Alliance for an Energy Efficient Economy is well-positioned to facilitate and inform these propositions through multi-stakeholder collaboration and the development of a knowledge base on energy efficiency efforts in the cooling sector, both domestic and international. The Alliance for Sustainable Habitat, Energy Efficiency and Thermal Comfort (SHEETAL), which AEEE is participating in, along with The Energy and Resources Institute and Council on Energy, Environment and Water, is filling a critical gap in this regard and working to establish the necessary synergies to accelerate India's transition to sustainable cooling. This report is an integral part of this process, as it takes stock of the existing challenges and initiatives in the Indian cooling sector, examines what other global leaders in this sector are doing, and provides recommendations for policymakers on how to ratchet up the minimum energy performance standards of room air conditioners. In this way, it represents a crucial step in developing sustainable cooling solutions and the realization of the ICAP targets set in 2019. It is an important contribution to the overall discussion on climate change mitigation and energy efficiency strategies in India, but more specifically, it offers a way forward in the cooling space, which is the need of the hour.

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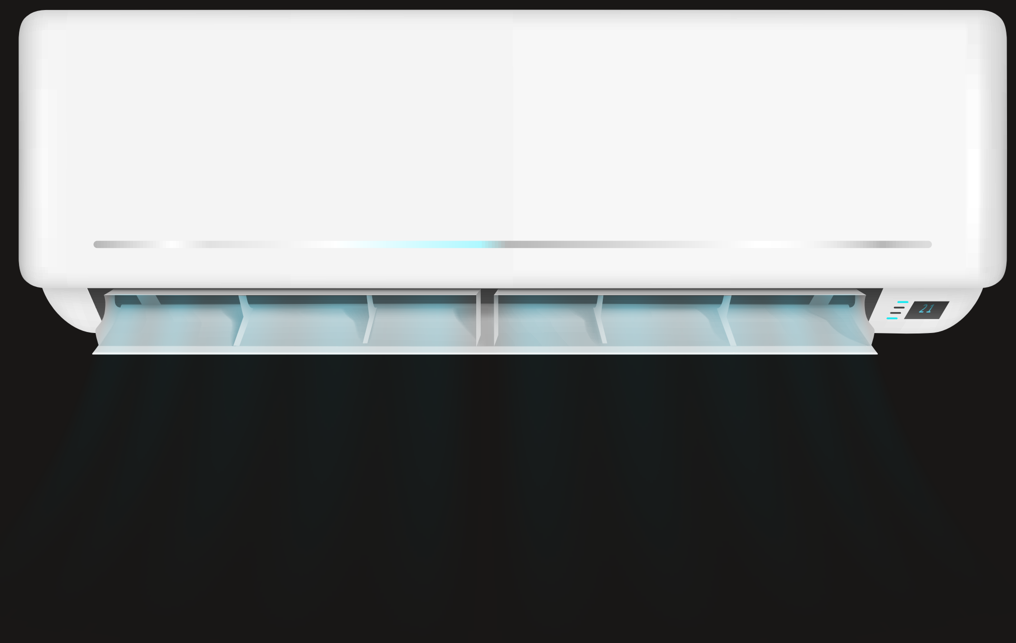
Abbreviations and Acronyms

4E TCP	Technology Collaboration Programme on Energy-Efficient End-Use Equipment
°C	Degree Celsius
ACC	Advanced Cooling Challenge
AEEE	Alliance for an Energy Efficient Economy
APF	Annual Performance Factor
AQSIQ	Authority of State Administration of Quality, Supervision, Inspection, and Quarantine
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAU	Business As Usual
BAT	Best Available Technology
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
Btu	British thermal unit
C&AG	Comptroller and Auditor General
CAGR	Compound Annual Growth Rate
CC	Cooling Capacity
CDD	Cooling Degree Day
CEAMA	Consumer Electronics and Appliances Manufacturers Association
CEEW	Council on Energy, Environment and Water
CECP	China Certification Centre for Energy Conservation Products
CECP	Cubic Feet Per Minute
CLASP	Collaborative Labelling and Appliance Standards Programme
CNIS	China National Institute of Standardisation
CNRA	California Natural Resources Agency
COP	Coefficient of Performance
COVID-19	Coronavirus Disease of 2019
CPRI	Central Power Research Institute
CSC	China Standards Certification Centre
CSEC	Cooling Seasonal Energy Consumption
CSIR	Council of Scientific and Industrial Research
CSPF	Cooling Seasonal Performance Factor
CSTL	Cooling Seasonal Total Load
DBT	Dry Bulb Temperature
DISCOM	Power Distribution Company
DST	Department of Science and Technology
EC Act 2001	Energy Conservation Act, 2001
EER	Energy Efficiency Ratio
EMI	Equated Monthly Instalment
ERDA	Electrical Research and Development Agency
ESEAP	EESL Super-Efficient Air Conditioning Programme
FY	Fiscal Year
GCP	Global Cooling Price
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GST	Goods and Services Tax
GT	Gigatonne
GWP	Global Warming Potential

h	Hour
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HPMP	Hydrochlorfluorocarbons Phase-out Management Plan
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, Ventilation, and Air Conditioning
HVAC&R	Heating, Ventilation, Air Conditioning, and Refrigeration
IAME	Independent Agency for Monitoring and Evaluation
IBEF	India Brand Equity Foundation
ICAP	India Cooling Action Plan
IDRS	Seasonal Cooling Performance Index
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IGEF	Indo-German Energy Forum
IGSD	Institute for Governance & Sustainable Development
IMF	International Monetary Fund
INMETRO	National Institute of Metrology, Standardisation, and Industrial Quality
INR	Indian Rupee
IoT	Internet of Things
IPEEC	International Partnership of Energy Efficiency Cooperation
IS	Indian Standard
ISEER	Indian Seasonal Energy Efficiency Ratio
ISHARE	Indian Society of Heating, Refrigerating and Air Conditioning Engineers
ISIRI	Institute of Standards and Industrial Research of Iran
ISO	International Organisation for Standardisation
JIS	Japanese Industrial Standard
IT	Information Technology
KEA	Korea Energy Agency
KWh	Kilowatt-hour
L	Litre
LBNL	Lawrence Berkeley National Laboratory
LED	Light-Emitting Diode
LPG	Liquefied Petrol Gas
m2	Square metre
MeitY	Ministry of Electronics & Information Technology
MEPS	Minimum Energy Performance Standard
METI	Ministry of Economy, Trade, and Industry
MFD	Multi-Function Device
MME	Ministry of Mines and Energy
MNIT	Malaviya National Institute of Technology Jaipur
MOCI	Ministry of Commerce & Industry
MOEF&CC	Ministry of Environment, Forest and Climate Change
MOTIE	Ministry of Trade, Industry, and Energy in Korea
MoP	Ministry of Power
MRP	Maximum Retail Price
MW	Megawatt
NABL	National Accreditation Board for Testing and Calibration Laboratories
NDRC	National Development and Reform Commission
NMEEE	National Mission for Enhanced Energy Efficiency
NRDC	National Research Development Corporation
ODP	Ozone Depleting Potential

OM	Operations Manual
PBE	Brazilian Labelling Programme
PROCEL	National Electricity Conservation Programme
QR	Quick Response
R&D	Research and Development
RAC	Room Air Conditioner
RAMA	Refrigeration and Air-conditioning Manufacturers Association
S&L	Standards and Labelling
SAC	Standardisation Administration of China
SBTS	State Bureau of Technical Supervision
SDA	State Designated Agency
SDG	Sustainable Development Goal
SDO	Standards Development Organisation
SEER	Seasonal Energy Efficiency Ratio
SEAD	Super-Efficient Appliance Deployment
SERC	State Electricity Regulatory Commission
SMES	Small and Medium-Sized Enterprises
SSEF	Shakti Sustainable Energy Foundation
TC	Technical Committee
TCM	Technical Committee Meeting
tCO2e	Tonne of Carbon Dioxide Equivalent
TERI	The Energy and Resources Institute
TR	Tonne of Refrigeration
TV	Television
TWh	Terawatt-hour
UHD	Ultra-High Definition
USD	United States Dollar
UJALA	Unnat Jyoti by Affordable LEDs for All
UT	Union Territory

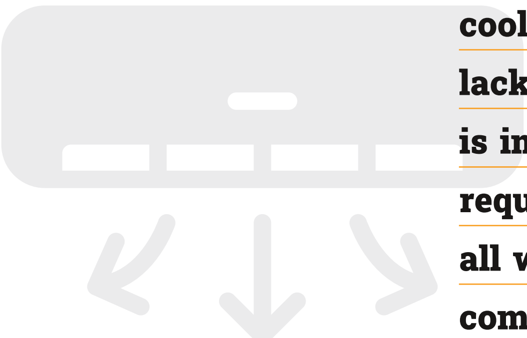


'Cooling' has been linked to economic growth and is defined as a catalyst for good health, well-being, and better productivity for occupants residing in hot climate zones, along with being one of the essential cornerstones for achieving the objectives of the Sustainable Development Goals (SDGs).

RACs have a low penetration rate of **7–9%** in the Indian residential sector. Despite their low penetration, they still contribute **~40–60%** of India's peak load, as they are used mainly during peak hours of the day, especially in major metropolitan areas, and constitute a dominant share of space cooling energy consumption—around **44% in 2017-18,** which is expected to increase up to **50% by 2037-38.**

Executive Summary

As per the India Cooling Action Plan (ICAP) 2019, 'cooling' has been linked to economic growth and is defined as a catalyst for good health, well-being, and better productivity for occupants residing in hot climate zones, along with being one of the essential cornerstones for achieving the objectives of the Sustainable Development Goals (SDGs). India is amongst the countries with the lowest access to cooling, with per capita energy consumption levels for space cooling at 69 kilowatt-hours (kWh), compared to the world average of 272 kWh. India has a tropical climate and is experiencing a rapid increase in average temperature, resulting in heat stress that could be effectively countered by room air conditioners (RACs), as they work well under such climatic conditions. However, RACs have a low penetration rate of 7-9% in the Indian residential sector. Despite their low penetration, they still contribute ~40-60% of India's peak load, as they are used mainly during peak hours of the day, especially in major metropolitan areas, and constitute a dominant share of space cooling energy consumption—around 44% in 2017-18, which is expected to increase up to 50% by 2037-38. It is projected that the RAC stock in households will be ~580 million units by 2037-38, and its market is projected to grow at a compound annual growth rate (CAGR) of 11% in the coming decade. The growth of RACs in the Indian appliance market is connected to multiple factors, including rapid urbanisation, the increasing purchasing power of middle income group consumers, bulk procurement by private or public entities, leading to cost reductions for them, which, in turn, drives further demand, increased access to electricity, rising temperatures, and heat stress. Thus, with the majority of India's RAC stock yet to come, i.e. 21% by 2027-28 and 40% by 2037-38, and the increasing contribution of RAC to space cooling energy consumption, compounded with lack of access to cooling and rising heat stress, it is imperative for India to address space cooling requirements and provide thermal comfort for all without compromising on its environmental commitments. Therefore, there is still a window to improve energy efficiency and develop policies to facilitate the transition towards environmentally-friendly technological interventions to reduce RAC-related space cooling energy consumption and greenhouse gas (GHG) emissions in the future.



With the majority of India's RAC stock yet to come, i.e. 21% by 2027-28 and 40% by 2037-38, and the increasing contribution of RAC to space cooling energy consumption, compounded with lack of access to cooling and rising heat stress, it is imperative for India to address space cooling requirements and provide thermal comfort for all without compromising on its environmental commitments.

In 2019, the Ministry of Environment Forest and Climate Change (MoEF&CC) launched ICAP, which highlights the extensive dependence on space cooling appliances—including refrigerant, non-refrigerant, and not-in-kind cooling technologies—and provides information on the amount of energy consumed and refrigerant leakage at the end of the space cooling appliance's lifecycle, in order to contribute to achieving thermal comfort, reduce thermal loads, and enhance space cooling appliances' energy efficiency. The ICAP recommends developing a roadmap for performance efficiency improvements in the space cooling sector. It lays out a two-pronged strategy on enhancing space cooling appliances' energy efficiency and phasing down the use of hydrofluorocarbons (HFCs) and provides a set of recommendations for the space cooling sector. One of ICAP's recommendations—ratcheting up minimum energy performance standards (MEPS) for RACs—has been extensively discussed in various forums, and there is a consensus amongst civil society, research institutions, and think tanks on the need to ratchet up the current level of MEPS and improve the enforcement of standards and labelling (S&L) programmes in India.

Therefore, in alignment with the ICAP recommendations, this report provides insights into the institutional and regulatory frameworks, market transformation strategies, and key initiatives adopted nationally and internationally to increase the performance and promote the use of super energy-efficient RACs. The report also presents detailed information regarding India's S&L programme and RAC scenario. Furthermore, the report provides recommendations on how to eliminate the identified barriers and move forward, based on the learnings from the review of RAC MEPS adopted in selected countries. In addition, a detailed analysis is presented in Annexure II on the interconversion between the Indian seasonal energy efficiency ratio (ISEER) and other various energy efficiency metrics for variable-speed RACs in all selected countries based on the cooling efficiency test conditions and outdoor temperature bin hours. This analysis was carried out by the sectoral experts Dr. Nihar Shah and Won Young Park from Lawrence Berkeley National Laboratory (LBNL)

The variable speed RAC market share was less than 1% in India, which increased to 54% of total sales by 2018-19; in contrast, the share of fixed speed RACs decreased from around 99% in 2015-16 to 46% in 2018-19. The 3-star RACs led the overall RAC sales, with fixed speed 3-star RACs having 73% and variable speed 3-star RACs having 77% of market share in their respective segments in 2018-19.

Key Observations

- **Institutional & Policy Advocacy Aspect**

  The report has mapped various ministries, regulatory bodies, and associations and their roles in increasing appliance efficiency in India. There are multiple institutions involved in the S&L program of RACs: Ministry of Power, Ministry of Commerce & Industry, Ministry of Consumer Affairs, Food, and Public Distribution, Bureau of Energy Efficiency (BEE), India Brand Equity Foundation (IBEF), Bureau of Indian Standards (BIS), Central Power Research Institute (CPRI), State Designated Agencies (SDAs), State Electricity Regulatory Commissions (SERCs), Refrigeration and Air-conditioning Manufacturers Association (RAMA), and Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE). These organisations work independently on different aspects related to RACs and provide various recommendations to the government. Hence, post policy development, it becomes a challenge to coordinate the efforts between different governmental entities to synchronize efforts for the implementation of the policy. Therefore, the report has recommended to establish a more permanent mechanism to coordinate various actions, in order to achieve the ICAP recommendations.

  Moreover, the report has emphasized upon the S&L program and its detailed process along with the challenges and suggestive actions being proposed by AEEE and the one's being reflected in the Comptroller and Auditor General (C&AG) of India 2020 report for the S&L program. The C&AG of India 2020 report recommended improving the efficacy of testing labs through third-party verification, periodic check testing, development of a roadmap to ensure compliance, and a mechanism for market phase-out of inefficient products.

  Further, the report has deep-dived into the S&L programme for RACs. The S&L programme for fixed-speed RACs was introduced by BEE in 2006 under a voluntary regime and transitioned to a mandatory regime in 2009. Then in 2015, BEE launched a voluntary S&L program for inverter RACs, which transitioned into a mandatory regime in 2018. At present, there is a combined S&L program for both fixed and inverter RACs. The S&L programme is revised every two years, and recently the MEPS for unitary and split RACs were revised, with an average annual energy efficiency improvement of 3.5% and 3%, respectively. However, before that, from January 2014 to January 2017, the MEPS for unitary RACs were not revised, and 2018, ISEER replace the energy efficiency ratio (EER), without any MEPS revisions. Similarly, the MEPS for split RACs remained stagnant for almost four years, from January 2014 to December 2017; and in 2018, ISEER replaced the EER with improvisation in the MEPS from EER 2.7 in 2017 to ISEER 3.1 in 2018.

To facilitate market transformation and improve the energy performance of RACs, it is essential to introduce market mechanisms that can incentivise the purchase of super energy-efficient RACs and implement regulations that mandate the stocking up of a certain percentage of 5-star or super energy-efficient RACs.

- **Market Aspect**

The report provides in-depth information on the Indian RAC market scenario, the types of RACs available on the market, the regulatory aspects of the RAC S&L programme, and the impact of S&L in driving RAC market transformation. The report has highlighted that, in 2015-16, the variable speed RAC market share was less than 1% in India, which increased to 54% of total sales by 2018-19; in contrast, the share of fixed speed RACs decreased from around 99% in 2015-16 to 46% in 2018-19. The 3-star RACs led the overall RAC sales, with fixed speed 3-star RACs having 73% and variable speed 3-star RACs having 77% of market share in their respective segments in 2018-19. Thus, the report suggests that to facilitate market transformation and improve the energy performance of RACs, it is essential to introduce market mechanisms that can incentivise the purchase of super energy-efficient RACs and implement regulations that mandate the stocking up of a certain percentage of 5-star or super energy-efficient RACs.

- **Initiatives & Best Practice Aspect**

The report provides a brief overview of several successful initiatives with coordinated action by public and private organisations to promote super energy-efficient RACs. These organisations/entities are making efforts to promote the penetration of super energy-efficient RACs through various types of initiatives: i) financial: EESL's bulk procurement schemes, RAC replacement schemes by power distribution companies; ii) technological: Global Cooling Prize (GCP) being led by RMI, Conservation X Labs, AEEE, and CEPT University, and Super-Efficient Appliance Deployment (SEAD) by Clean Energy Ministerial (CEM) and International Partnership of Energy Efficiency Cooperation (IPEEC) task group; and iii) policy-related: advocacy for RAC standards revision in India by non-state actors, harmonisation of standards by International Energy Agency (IEA), and development of model regulation guidelines for RACs by United for Efficiency (U4E). Therefore, the report suggests that overall, there is a need for an efficient and effective coordination mechanism between various actions to achieve the ICAP recommendations and keep track of new developments in the sector and initiatives being taken up by prominent agencies across the country and internationally. These efforts should be leveraged by developing periodic reports for the competent government authorities to enable informed decisions on energy efficiency activities.

There is a need for an efficient and effective coordination mechanism between various actions to achieve the ICAP recommendations and keep track of new developments in the sector and initiatives being taken up by prominent agencies across the country and internationally.

To compare the RAC MEPS improvement rate of other countries to that of India, the report examines the RAC MEPS of Japan, Brazil, China, and South Korea. The comparison of RAC MEPS in India to those of in China and South Korea over the past decade, are summarised in Table 1.

Table 1: Annual energy efficiency improvement rates – country wise[1]

Select countries	Rated capacity/ type	Period considered	Base MEPS	Revised MEPS	Annual energy efficiency improvement rate in RAC MEPS (Approximate)
South Korea	< 4.0 kW	2012-2021	3.37 (CSPF[2] in 2012)	4.5 (CSPF in 2021)	3.27%
China[3]	< 4.5 kW VSD & FSD	2020-2022	3.70	5.00 (SEER in 2022)	16.25%
	< 4.5 kW (Variable Speed Drive (VSD))	2013-2020	4.30 (SEER[4] in 2013)	5.00 (SEER in 2020)[5]	2.18%
	< 4.5 kW (Fixed Speed Drive (FSD))	2010- 2020	3.20 (EER in 2010)	3.70 (SEER in 2020)[6]	1.46%
India	Unitary RAC	2018-2021	2.5 (ISEER in 2018)	2.7 (ISEER in 2021)[7]	3.92%
	Split RAC		3.1 (ISEER in 2018)	3.3 (ISEER in 2021)[8]	3.18%

In South Korea and China, the annual energy efficiency improvement rate for RAC MEPS in 2010-2021 was around 3% and 7%, respectively. Similarly, in India, the annual energy efficiency improvement rate was approximately 3.5% for the considered period, indicating that India's S&L programme for RACs is on par with other selected countries in terms of the rate of annual energy efficiency improvement. However, the baseline RAC MEPS in China and South Korea were substantially higher than that of India in the considered period. The other two countries examined, Japan and Brazil, did not provide RAC MEPS for the considered period. Japan has the Top Runner Programme, which has not defined the RAC MEPS for recent years, i.e. post 2012, and Brazil has provided MEPS for the future financial years, which was not representative of the considered period for this study. Hence, both Japan and Brazil were only included as case studies in the later section of this report.

Based on the review of best practices in the selected countries with regards to increasing energy performance and the deployment of super energy-efficient RACs, the report has the following key takeaways:

1. RAC compressors' energy efficiency tends to decrease as the cooling capacity increases. Japan, South Korea, and China have set different RAC MEPS that vary based on the air conditioners' cooling capacity. Adopting this practice could allow India to make the lower capacity non-ducted RACs (ranging between 0.5 to 2.5 tonnes of refrigeration (TR)) more efficient, as they are mostly installed in residential setups, along with commercial complexes where buildings are not centrally cooled.

2. Japan, South Korea, and China provide incentive programmes or innovative tax rebate mechanisms such as the 'Eco-Point System', 'Carbon Cashbag' and 'feebate', and 'Energy Efficient Product Benefitting Resident Project' to promote the use of super energy-efficient appliances. Due to its high price sensitivity, the Indian market has not transitioned to super energy-efficient RACs, as they are more expensive and have a longer payback period.

3. Additional incentives and market mechanisms such as carbon cash bags or a carbon reward payback system that allow storage of 5-10% of the equipment value as carbon credit and use the credit to purchase another super energy-efficient appliance need to be developed. Mechanisms like these may incentivise customers to purchase super energy-efficient RACs, which should, in turn, increase the purchase of other super energy-efficient appliances.

1 This table has been prepared based on the information available in the public domain and deducing information from past reports by different agencies, as the regulatory documents were not available in public domain for each country with English translations. The values mentioned are approximations based on the authors' assessment of data taken from different reports.
2 CSPF stands for Cooling Seasonal Performance Factor.
3 China has proposed new RAC MEPS for 2020-2022, which is 5.00 SEER for both FSD and VSD.
4 Seasonal Energy Efficiency Ratio (SEER)
5 VSD — Cooling only split RACs. However, the revised MEPS applies to both split and window RACs.
6 FSD — Cooling only split ACs. However, the revised MEP applies to both split and window RACs.
7 For unitary air conditioners
8 For split air conditioners (both FSD and VSD)

4. In China, the 2020 MEPS for VSD RACs (5.00 SEER) is the new MEPS for both FSD and VSD RACs in 2022. China has the largest RAC market in the world, with over 50 million units sold/year, and now it has transitioned almost completely to variable speed/inverter RACs in two years, from ~50% sales in 2018 to ~98% in 2020.

Most important, the report maps and analyses the existing barriers in the Indian RAC and appliance sector and provides detailed recommendations (summarised in Table 2) that could be adopted by key stakeholders to circumvent those barriers in the near future.

Table 2: Barriers and recommendations

Barriers and policy gaps	Recommendations
To support the ratcheting up of RAC MEPS	
Regulatory barriers: Frequent standards revision	● BEE has scope to improve RAC efficiency, which several stakeholders have recommended under the umbrella of the Sustainable and Smart Space Cooling Coalition and ICAP. ● India needs to compete with international standards and test procedures and initiate action to harmonise efficiency parameters and testing standards. ● India could start considering the adoption of ecolabels for RACs, in order to stay ahead of the demand curve.
Market barriers: Need for innovative business & financial models	● The servitisation model, on-utility bill financing, or an on-wage (for salaried employees) innovative financing mechanism, which are the proven but underutilised models, could be adopted for the deployment of super energy-efficient RACs. ● Consumer purchase perception studies could also help in assessing other barriers and creating an enabling mechanism to enhance the purchase of super energy-efficient equipment.
Market barriers: Absence of incentives/ tax rebates for efficient products	● A reduction of the 28% goods and services tax (GST) would enhance the affordability of super energy-efficient RACs. Perhaps for super energy-efficient RACs, a lower GST could even be considered. ● Leveraging existing incentives and market mechanisms such as cashbacks and zero percent interest, a carbon cashback or a carbon reward payback system can be integrated or developed.
To enhance the appliance ecosystem	
Enforcement barriers: Limited SDA capacity	● Periodic capacity building and strengthening of SDAs with the support of additional trained specialists and energy professionals.
Enforcement barriers: Limited testing capacity	● Stock study of the existing test labs in India. ● Gap assessment on the need for testing lab upgradation. ● Development of a technology transfer platform to enable faster technological development.
Financial barriers: Absence of financial mechanisms to promote RAC R&D infrastructure	● Support required from existing or new programmes for innovative, disruptive, super-efficient, and eco-friendly technology development, supporting the 'Make in India' initiative. ● Need to review the utilisation of these funds and augment the funds to accelerate the research on super energy-efficient technologies.

Therefore, with the need of the hour to ratchet up RAC MEPS in India, all eyes are on India to see how it executes this ICAP recommendation. Based on the literature review of India's policy, regulatory, and institutional framework for appliances and the learnings gathered from the review of MEPS adopted in selected countries, it is clear that India's S&L programme is robust, well-designed, and highly impactful. However, there are some challenges and issues related to its consistent and coordinated implementation; there is substantial scope for improvement in India's S&L programme and its implementation, from coordinating the efforts at the central level with state and non-state actors, to supporting SDAs in enforcement and implementation. Furthermore, the availability of super energy-efficient technologies nationally and internationally as a result of the GCP offers India a unique opportunity to ratchet up its RAC MEPS. The GCP announced two winners in April 2021, which both met the prize criteria of 5 times lower climate impact compared to the average RACs available on the Indian market, indicating the global market is continuing to innovate, and the efficiency of all products is increasing, as RAC costs continue to fall.

Consumer behaviour studies could also provide a way forward to better understand consumer perceptions, barriers, and the demand scenario, in order to tailor strategies to current end-user requirements. Furthermore, with the new S&L notification and MEPS target for RACs in India yet to be developed beyond 2023, this could be the first significant policy action post ICAP development and could position India as a nation that is upholding its commitment through strong action and staying true to the course of action established in ICAP.

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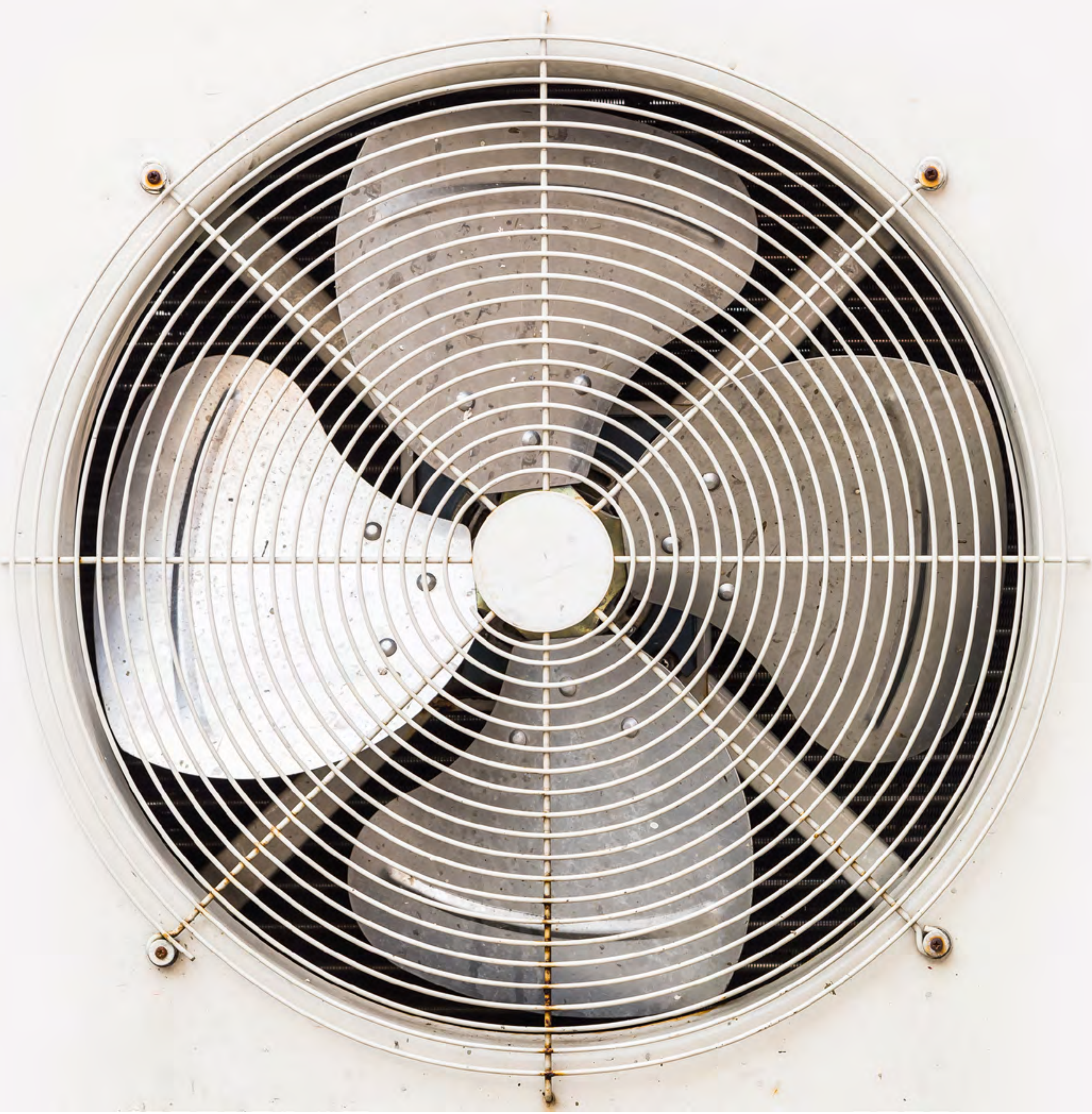
01 Introduction

This section will establish the context of this study by highlighting the heat stress challenge faced by India, along with increasing demand for space cooling technologies to achieve thermal comfort and the need to improve the performance efficiency of room air conditioners (RACs).



1.1 Background

As per the India Cooling Action Plan (ICAP) 2019, 'cooling' is linked to economic growth and is a catalyst for good health & well-being and better productivity for occupants residing in hot climate zones, along with being one of the essential cornerstones for achieving many of the Sustainable Development Goals (SDGs)[9].

India's average temperature has increased due to greenhouse gas (GHG)-induced global warming by ~0.7 degrees Celsius (°C) between 1901 and 2018 and is projected to rise by ~4.4°C by the end of the 21st century, which would result in extreme heat stress, with a devastating impact on human health, crop production, and energy security[10]. With a cooling degree day (CDD) value of over 3,000[11] per year in India[12], lack of access to cooling and thermal comfort, rising temperatures, and rapid population growth and urbanisation will amplify heat stress and fuel space cooling demand[13].

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India has a tropical climate, with most regions falling under the hot and humid climatic zones, generating significant space cooling demand, which could be effectively met with RACs, as they work well in environments with high humidity. Appliances are no longer a luxury item, but, rather, a necessity for achieving thermal comfort, access to cooling, better quality of life, and overall economic development. India is one of the countries with the lowest access to cooling, with per capita space cooling energy consumption at 69 kilowatt-hours (kWh), well below the world average of 272 kWh[14].

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Despite RACs' low penetration, they still contribute ~40-60%[15] of the summer peak power demand in India, especially in major metropolitan areas, and constitute a dominant share of space cooling energy consumption—around 42% in 2017-18, which is expected to increase to 52% by 2037-38[16]. With most of India's RAC stock yet to come, India urgently needs to address space cooling requirements without compromising on its environmental commitments.There is still a window to enhance the energy efficiency improvement rate and develop policies to include environmentally-friendly technological interventions to reduce RAC-related space cooling energy consumption and GHG emissions in the future.

Studies confirm that ratcheting up RAC Minimum Energy Performance Standards (MEPS) is feasible and could lead to energy savings. For example, the Alliance for an Energy Efficient Economy (AEEE)'s 2018 'Demand Analysis for Cooling by Sector in India in 2027' study commissioned by Indo-German Energy Forum (IGEF) stated that RAC efficiency levels could be ratcheted up by 5-6% p.a. based on the currently available technology and feedback received from the Bureau of Energy Efficiency (BEE) on the historical rate of efficiency gains. The study also estimated that there would be approximately 19% annual energy and indirect carbon emission savings in 10 years with the enhanced RAC MEPS, as shown in Table 3.

9. Ministry of Environment, Forest & Climate Change (MoEF&CC), "India Cooling Action Plan," 2019, http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf.
10 R. Krishnan et al., Assessment of Climate Change over the Indian Region: A Report of the Ministry of Earth Sciences (MOES), Government of India, 2020, https://doi.org/10.1007/978-981-15-4327-2.
11 A cooling degree day (CCD) is the number of degrees that a day's average temperature is above 18 °C. To calculate the annual CDD value: multiply the CDD value per day by 365 days/year.
12 Radhika Lalit and Ankit Kalanki, "How India Is Solving Its Cooling Challenge," World Economic Forum, 2019, https://www.weforum.org/agenda/2019/05/india-heat-cooling-challenge-temperature-air-conditioning/.
13 R. Krishnan et al., Assessment of Climate Change over the Indian Region: A Report of the Ministry of Earth Sciences (MOES), Government of India, 2020, https://doi.org/10.1007/978-981-15-4327-2.
14 Ministry of Environment Forest & Climate Change (MoEF&CC), "India Cooling Action Plan," 2019.
15 Nikit Abhyankar et al., "Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies," Lawrence Berkeley National Laboratory Working Paper, LBNL-1005798, no. April (2017): 1—30.
16 Sameer Pandita et al., "Policy Measures and Impact on the Market for Room Air Conditioners in India," 2020, https://www.clasp.ngo/research/all/policy-measures-and-impact-on-the-market-for-room-air-conditioners-in-india/.

Table 3: **RAC annual savings potential over a 10-year timeframe (AEEE-IGEF study)**

Parameter	2027 (BAU[17])	2027 (Improved)	Savings	% Savings
Annual energy consumption (TWh)	140	113	27	19%
Indirect emissions (million tCO2e)	114	93	21	19%

The 2017 Lawrence Berkeley National Laboratory (LBNL) study 'Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies' stated that the net present value of the consumer benefit between 2018 and 2030 could range from Indian rupees (INR) 4,000 crore (only if RAC prices increase as expected based on estimates of the current cost of efficiency improvement) to INR 173,000 crore (only if RAC prices do not increase with the efficiency improvement, as has been the case historically). However, there will be no change in the consumer welfare benefit due to the rebound effect, which could reduce the monetary benefit of efficiency improvements. The study suggested that the projected benefit can be achieved by ratcheting up India's one-star efficiency level RACs to the level of the 2016 five-star rating by 2022 and the level of current best available technology on the market by 2026. This makes the case stronger for ratcheting up the energy efficiency of RACs.

1.2 Objective

The ICAP, released by Ministry of Environment Forest and Climate Change (MoEF&CC), Government of India in 2019, lays out a two-pronged strategy that enhances cooling appliance energy efficiency while phasing down hydrofluorocarbons (HFCs). The ICAP has stressed that with the extensive dependence on, importance, and expected growth of RACs to provide thermal comfort, and the amount of energy consumed by India's space cooling sector will drastically increase. ICAP thus recommends that a long-term roadmap for performance efficiency improvements be developed. The ratcheting up of MEPS for RACs is one of the immediate recommendations that aligns with the ongoing Standard and Labelling (S&L) programmes designed and administrated by the BEE.

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This study aims to outline a policy approach in line with the ICAP recommendations on upgrading RAC efficiency norms while aligning market forces for its successful adoption. This study is part of AEEE's ongoing initiative 'SHEETAL[18]', which focuses on facilitating ICAP implementation. Through an in-depth review of the S&L policies and programmes implemented nationally and internationally, this study provides insights into the institutional and regulatory frameworks, market mechanisms, and key initiatives adopted to increase RAC performance in the selected countries. The report provides information about these countries' energy efficiency improvement rates and India's RAC scenario. In addition, the study also highlights the initiatives to catalyse market transformation in the RAC sector, such as the Global Cooling Prize (GCP) and Super-Efficient Appliance Deployment (SEAD) initiatives. Furthermore, the study compares the RAC MEPS improvement rate in India to that in other countries and provides recommendations that could be adopted to facilitate the transition towards super energy-efficient RACs in India.

The study will act as a catalyst for promoting technological innovations that enable the ratcheting up of MEPS within the national policy framework and low-global warming potential (GWP) refrigerants to achieve the prescribed efficiency norms based on learnings from international programmes. Through an extensive literature review, the study identifies the prevailing gaps in the existing national framework and provides recommendations for India based on the findings on RAC MEPS in selected countries. In order to identify necessary modifications to the current S&L programme, it is essential to understand India's present and historical RAC market and assess the impact of the current S&L programme, which is presented in the next chapter.

17 BAU = Business as usual.

18 Alliance for Sustainable Habitat Energy Efficiency and Thermal Comfort for All (SHEETAL) is a consortium of CSOs led by The Energy Resources Institute (TERI) and partners AEEE and Council on Energy, Environment and Water (CEEW) and supported by the Children's Investment Fund Foundation (CIFF) to facilitate the implementation of India Cooling Action Plan (ICAP) recommendations.

1 2 3 4 5

MORE STARS
MORE SAVINGS

POWER SAVINGS GUIDE

ENERGY EFFICIENCY

ISEER - 4.73*

Label Period : 1st Jan 2018 - 31st Dec 2021

Appliance/Type	: RAC/Split
Brand	: – – –
Model/Year	: – – –
Cooling Capacity (100%)	: 5000 (W)
Cooling Capacity (50%)	: 2500 (W)
Electricity Consumption	: 818.81 Units Per Year
Compressor Type	: Variable Speed
Heat Pump	: No

ENERGY IS LIFE
BEE
CONSERVE IT
BEE/AAB/02/002/10

*Under test conditions, when tested in accordance with ISO 16358 & based on 1600 operating hours per annum. Actual electricity consumption will depend on how the appliance being used.

02 India's Standards and Labelling Programme

The Indian S&L programme was formally launched on May 18, 2006 by the Ministry of Power (MoP) under the Section 14 of the Energy Conservation Act, 2001 (EC Act 2001). This chapter provides detailed information on India's institutional and policy landscape in the overall appliance energy efficiency sector and the S&L programme.

2.1 Institutional Framework Governing Appliances in India

The institutional framework for appliance labelling in India is governed by various ministries, regulatory bodies, and associations. The key government bodies at the central and state levels and other autonomous bodies that can impact India's standards and labelling are shown in Figure 1. In addition, the roles of these organisations are summarised in Table 4.

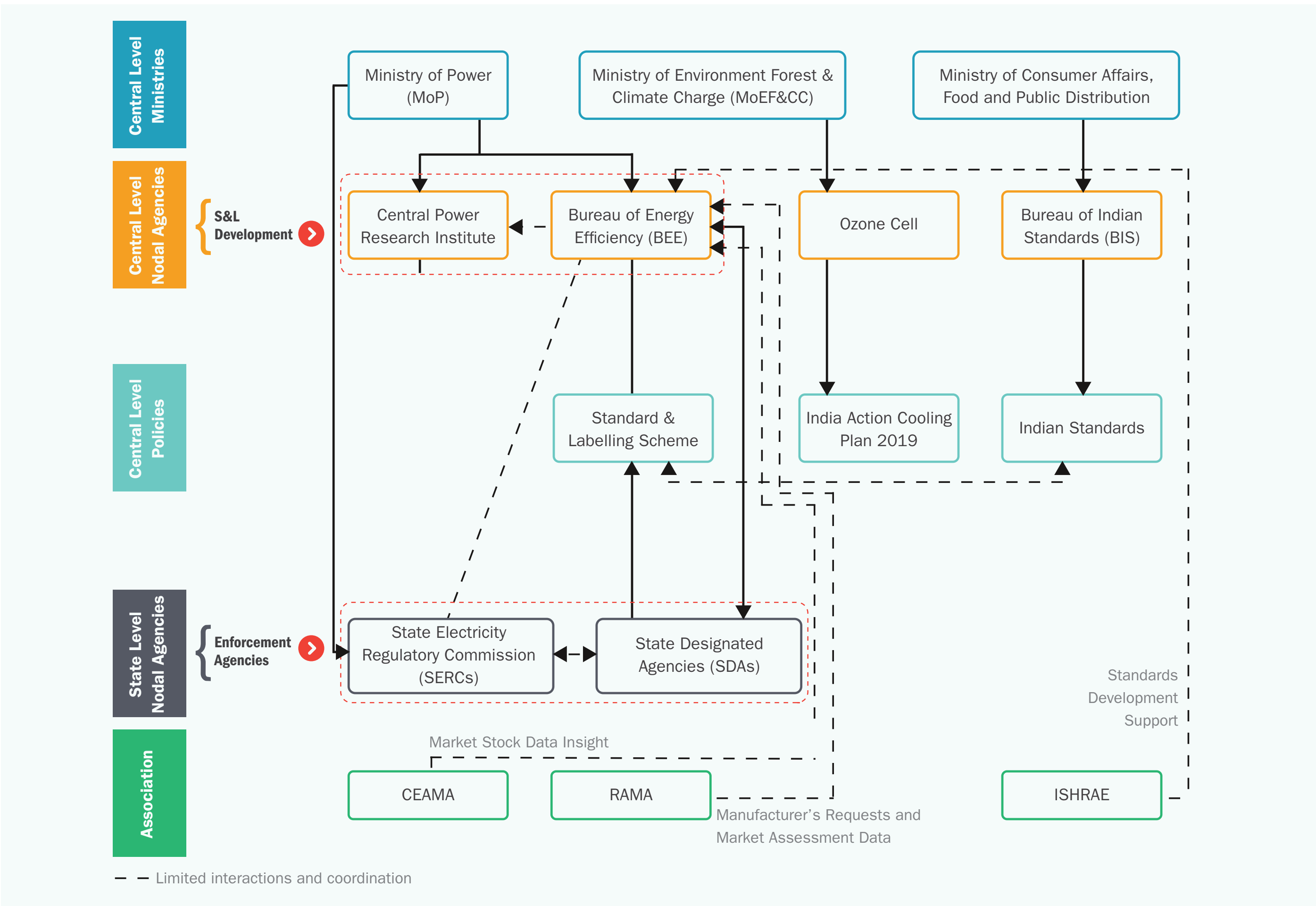

Figure 1: **Institutional framework governing S&L of Appliances in India**

As shown in Figure 1, the institutional framework governing S&L of Appliances in India has been mapped. Unfortunately, there is a lack of effective coordination between the entities/ bodies at different levels. Two-way communication only happens between a few entities. Moreover, the implementation of ICAP recommendations for the space cooling sector has been somewhat slow. There are thematic working groups formed under the purview of ICAP, but these groups only convene as and when required to suggests the next steps. Therefore, there is a need for a more permanent mechanism to coordinate various actions between the entities which are being mapped in Figure 1, in order to achieve the ICAP targets. Slow progress in ICAP implementation can also be attributed to the coronavirus disease of 2019 (COVID–19) pandemic, as it has hindered regular meetings and discussions, and most of the central ministries are only taking up the most essential tasks during this period. Thus, incorporating a more permanent mechanism dedicated to working with state and non-state actors and mobilising policy and technological developments can help fast-track ICAP implementation and is necessary to compensate for the time lost due to the pandemic. More detailed information on the roles of different stakeholders is provided in Table 4.

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Table 4: Roles of key organisations in appliance efficiency

Organisation name	Organisation description	Role in appliance efficiency
MoP[19]	The MoP is the apex body for formulation and administration of the rules, regulations, and laws related to the power sector in India. The MoP, under the framework of the EC Act 2001, has established the BEE.	Section 14 of the EC Act 2001 empowers the central government to develop an S&L programme, which was formally launched on May 18, 2006 by the MoP.
MoEF&CC[20]	The Ozone Cell under the MoEF&CC is responsible for all work related to ozone layer protection and implementation of the Montreal Protocol. They are engaged in the accelerated phase-out of production and consumption of hydrochlorofluorocarbons (HCFCs) in India as per the HCFC Phase-out Management Plan (HPMP) Stages I and II. As per the Kigali Amendment to the Montreal Protocol, India has agreed to freeze its HCFC production and consumption by 2030 (India will phase down HFCs from 2032 to 2047).	The ICAP was released on 8 March 2019 as an initiative of the Ozone Cell. The ICAP acted as the strategic document which created the foundation stone by describing the need for and steps to advance the future of energy-efficient cooling in India. It includes a long-term integrated 20-year (2017-18 to 2037-38) outlook across all sectors regarding India's cooling demand, technology options, refrigerant use, and energy consumption, including space cooling appliances. One of the ICAP recommendations is ratcheting up RAC MEPS.
Ministry of Consumer Affairs, Food, and Public Distribution[21&22]	The Ministry of Consumer Affairs, Food, and Public Distribution under the Government of India is divided into two departments, the Department of Food and Public Distribution and Department of Consumer Affairs. The Department of Consumer Affairs deals with consumer protection rights and administers the Bureau of Indian Standards (BIS).	Department of Consumer Affairs has been entrusted with implementing the Indian Standards Act, 2016, and under Article 3 of this act, the BIS was established for consumer rights protection.

19 Ministry of Power, "Overview | Government of India," 2016, https://powermin.nic.in/en/content/responsibilities.
20 Ministry of Environment Forest & Climate Change Government of India, "Introduction," 2020, http://moef.gov.in/en/about-the-ministry/introduction-8/.
21 Department of Consumer Affairs, Ministry of Consumer Affairs Food and Public Distribution, and Government of India, "Vision and Mission," 2020, https://consumeraffairs.nic.in/vision-and-mission.
22 Department of Food and Distribution, "About Us ," accessed March 4, 2021, https://dfpd.gov.in/about-us.htm.

Organisation name	Organisation description	Role in appliance efficiency
BEE[23]	The BEE's mission is to assist MoP in developing policies and strategies with a focus on self-regulation and market principles within the overall framework of the EC Act 2001, with the primary objective of reducing the energy intensity of the Indian economy. BEE initiated the S&L Programme in 2006 under Section 14 of the EC Act 2001. The programme has developed a framework for establishing performance standards and rating criteria.	The S&L scheme is a flagship programme of BEE. BEE defines the energy performance standards for appliances and equipment and promotes and facilitates their adoption through training, awareness, and capacity building programmes. Mandatory energy efficiency standards, coupled with energy performance labels enable consumers to make an informed choice regarding the purchase efficient products that save energy and reduce expenses. It is one of the most cost-effective policy tools for improving appliance and equipment energy efficiency and lowering energy costs for the end consumer.
BIS[24]	The BIS, under the aegis of the Ministry of Consumer Affairs, Food, and Public Distribution, is the national standard-setting body in India, established under the BIS Act 2016 for the harmonious development of standardisation, marking, and quality certification of goods.	BIS certification is the prerequisite for any appliances to be covered under the star labelling programme. The BIS has various committees involved in developing appliance safety, quality, product specification, and performance standards. BIS also certifies testing laboratories across India and develops test standards as per local conditions.
State Designated Agencies (SDAs)[25]	Under the provisions of Section 15(d) of the EC Act 2001, all state governments/ union territory (UT) administrations have designated SDAs to coordinate, regulate, and enforce the provisions of the EC Act within their respective states. BEE administers the SDAs and is responsible for setting up these cells within the states. These cells are usually housed under the state electricity board or state renewable energy development agency.	As per Energy Conservation (Inspection) Rules, 2010, and Section 17 of the EC Act 2001, the SDA needs to appoint an inspecting officer to undertake market surveillance and do check testing in order to ensure proper implementation of the provisions and norms specified under the S&L scheme for manufacturers. The Inspecting Officers have to report non-compliance cases to the BEE and coordinate with the State Electricity Regulatory Commission (SERC) for investigation.
SERC[26]	The SERCs have been established under the provisions of the Electricity Act, 2003. The primary responsibility of SERCs is to manage consumer electricity tariffs. They are also tasked with handling all power-related disputes.	The SERCs are responsible for undertaking the adjudication process post receipt of non-compliance complaints from SDAs under the S&L programme. To administer the non-compliances cases, Section 17 of the EC Act 2001 empowered SERCs to appoint adjudicating officers to conduct inquiries into matters related to implementing the EC Act.

23 Bureau of Energy Efficiency, "About BEE," 2020, https://beeindia.gov.in/content/about-bee.
24 Bureau of Indian Standards, "About BIS," accessed March 4, 2021, https://bis.gov.in/index.php/the-bureau/about-bis.
25 Bureau of Energy Efficiency, "Enforcement Machinery under Energy Conservation Act, 2001," accessed March 4, 2021, https://beeindia.gov.in/sites/default/files/Enforcement Machinery PPT.pdf.
26 Bureau of Energy Efficiency.

Organisation name	Organisation description	Role in appliance efficiency
Refrigeration and Air-conditioning Manufacturers Association (RAMA)[27]	RAMA is a non-profit association that was founded in 1991. It represents most of the manufacturers in the refrigeration and air conditioning industry in India and aims to further the interests of the RAC industry in the country while simultaneously maintaining the highest environmental, safety, and ethical standards in the industry.	RAMA provides information to BEE for developing and updating the RAC S&L Programme. RAMA also works with the BIS on evaluating existing standards and setting new standards for RAC and related processes based on the Indian climatic conditions.
Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE)[28]	ISHRAE was founded in 1981 in New Delhi by a group of eminent heating, ventilation, air conditioning, and refrigeration (HVAC&R) professionals with the objective to advance the sciences of heating, ventilation, air conditioning, and refrigeration engineering and related services. ISHRAE has recently become a standards development organisation (SDO) in India.	• ISHRAE helps develop performance standards and safety regulations for heating, ventilation, and air conditioning (HVAC) appliances. • It allows organisations to showcase the latest technologies & innovations in the HVAC&R field through ACREX India an annual conference for the air conditioning, refrigeration, ventilation, and building services industry.
Consumer Electronics and Appliances Manufacturers Association (CEAMA)[29]	CEAMA aims to enhance the development of the consumer electronics and appliance industry and its components. Its objective is to ensure fair competition among manufacturers, dealers, and other stakeholders.	CEAMA has been working in the energy efficiency domain, specifically on the star rating programme, supporting BEE with market data. In addition, CEAMA has been implementing electronic waste management initiatives.

To understand the importance of the institutions mentioned in Table 4 in terms of improving appliances' energy performance, the next section details India's S&L programme.

2.2 Regulatory Framework Governing Appliances in India

This section provides an overview of the Indian S&L programme for appliances.

2.2.1 Standards and Labelling Programme[30]

The S&L programme was initiated by the BEE under the EC Act 2001 on May 18th, 2006. The S&L programme is intended to reduce the energy consumption of appliances without diminishing the services they provide to consumers. The objective of the S&L programme is to enable consumers to make an informed choice while purchasing or comparing appliances with respect to their energy-saving potential and, cost-saving potential.

27 IIFL, "RAMA Supports BEE Labelling Programme, Clarifies on Recent CSE Report," accessed March 4, 2021, https://www.indiainfoline.com/article/general-csr/rama-supports-bee-labelling-programme-clarifies-on-recent-cse-report-116081700626_1.html.

28 "About ISHRAE: HVAC Industry Standards, Education & Training Programs," accessed March 4, 2021, https://ishrae.in/Home/about_ishrae.

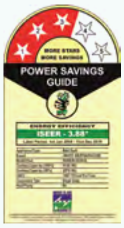
29 Consumer Electronics and Appliances Manufacturers Association (CEAMA), "Association Overview," accessed March 4, 2021, https://ceama.in/AssociationOverview.html.

30 Bureau of Energy Efficiency (BEE), "Standards & Labeling," 2020, https://beeindia.gov.in/content/standards-labeling.

There are two components to this programme, as described below:

- **Standards:** Standards prescribe limits on energy consumption or minimum energy performance levels of manufactured products. Based on the standard, the specified energy performance of the manufactured products can be evaluated; this also facilitates the removal of less efficient products from the market. Standards under the S&L programme refer to well-defined test protocols and test procedures developed by BIS to obtain an accurate estimate of a product's energy performance, or at least a relative ranking of different models based on their energy performance.
- **Labels:** Energy efficiency labels are informative labels affixed to products to describe their energy performance (usually in the form of energy use, efficiency, or energy cost); these labels give consumers the necessary information to make informed purchases. There are two types of labels, as shown in Table 5.

Table 5: BEE S&L Programme: types of labels



Comparative Label

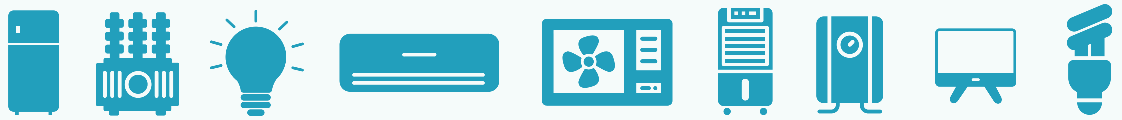
A comparative label enables consumers to compare the energy consumption of the specific product with defined star rating slabs and allows the consumer to compare multiple models of the same product, such as RACs. The comparative label varies from 1-star to 5-star, where 5-star-labelled products are the most efficient and 1-star are the least efficient or MEPS.

Endorsement Label

This label only indicates whether the product is energy-efficient or not and does not include details such as the product's energy consumption, energy efficiency ratio, or any other parameter to compare with other products.

Since the launch of the S&L programme in India with four products—RACs, frost-free refrigerators, distribution transformers, and tubular fluorescent lamps— the programme has come a long way, now covering 28 appliances, of which ten appliances are in the mandatory labelling regime, as shown in Table 6.

Table 6: Appliances under the BEE S&L programme mandatory and voluntary regimes[31]



Mandatory Labelling

Frost-Free (No-Frost) Refrigerator, Direct Cool Refrigerator, Tubular Fluorescent Lamp, RAC, Distribution Transformer, RAC (Cassette, Floor Standing Tower, Ceiling, Corner RAC), Electric Geyser, Colour Television (TV), Variable Capacity Air Conditioner, and Light-Emitting Diode (LED) Lamp.

Voluntary Labelling

Induction Motor, Agricultural Pump Set, Ceiling Fan, Liquefied Petrol Gas (LPG) Stove, Washing Machine, Computer (Notebook/Laptop), Office Equipment (Printer, Copier, Scanner, Multi-Function Device (MFD)), Monoset Pump, Solid State Inverter, Diesel Generator, Ballast (Electronic/-Magnetic), Chiller, Microwave Oven, Solar Water Heater, Light Commercial Air Conditioner, Deep Freezer, Ultra-High-Definition (UHD) TV, and Air Compressor.

S&L Programme Process

01 Selection of Appliance Market Analysis

- Market Size
- Total Energy Consumption
- Energy Saving Potential
- Ease in implementing the standard
- Availability of appliance testing procedures labs

Inception & Interim Phase

02 Technical Committees

- Star level parameters
- Star levels and upgrades

03 Technical/Baseline Analysis

- Testing standard's baseline
- Test data collection

Development Phase

04 Launch of MEPS (Voluntary)

- S&L online portal registration
- Scrutiny of applications
- Approval/rejection of models
- Label affixation on registered appliance

Implementation Phase

05 Enforcement

- Monitoring & Verification: Check Testing
- Penalty

Enforcemnet Phase

06 Conversion

- Based on market uptake of an appliance: conversion from voluntary to mandatory labeling
- Upgradation planning

Enforcemnet Phase

Figure 2: S&L programme phases[32]

31 Bureau of Energy Efficiency (BEE).
32 Adapted from Srishti Sharma, Akhil Singhal, and Tarun Garg, "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India," 2021, https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2021/9-products-appliances-ict/standard-and-labelling-for-evaporative-air-coolers-a-roadmap-to-affordable-sustainable-space-cooling-solutions-in-india/.

The BEE S&L process includes four phases, as shown in Figure 2. The phases under this process are detailed below[33,34&35]:

Inception & Interim Phase: In this phase, BEE selects an appliance to incorporate into the S&L programme based on the appliance's market size, total energy consumption, energy savings potential, share in terms of the organised & unorganised market, ease in standard implementation, and availability of test labs. There has been a great prominence on the test labs as they provide information on whether the selected appliance has met the set energy performance criteria through check testing or not, which helps in developing adequate energy efficiency performance standards. [36,37&38]

Development Phase: In this phase, BEE establishes separate technical committees for each appliance. These technical committees include key sectoral experts who play a crucial role in undertaking baseline estimation studies in order to finalise the inclusion of an appliance under the S&L programme and establish corresponding MEPS. A draft schedule is then developed for submission to MoP. [39,40&41]

Implementation Phase: In this phase, the Independent Agency for Monitoring and Evaluation (IAME) evaluates the applications. The permittees/manufacturers/applicants register themselves on BEE's S&L web portal and submit the fees, along with the required documentation and application. This is followed by model registration and submission of the label specimen as specified in the selected appliance schedule. After the application is approved by IAME, BEE gives permission to the permittee to affix the BEE star-rated label to the registered appliance.[42, 43 & 44]

Enforcement Phase: In this phase, monitoring and verification through check and challenge testing of the labelled appliances is conducted by BEE or its designated agencies, namely CPRI and the SDAs. Testing is conducted by a third party National Accreditation Board for Testing and Calibration Laboratories (NABL)-accredited laboratory. The CPRI and SDAs evaluates and verify whether the energy performance of the labelled appliance matches the energy performance claims made by the permittee, under the conditions mentioned in the selected appliance schedule.[45, 46 & 47]

33 Bureau of Energy Efficiency, "Guidelines for the Permittee-Standards and Labelling Program of BEE," 2016, https://www.beestarlabel.com/Content/Files/Scheme of energy efficiency labelling.pdf.
34 Srishti Sharma, Akhil Singhal, and Tarun Garg, "Decoding Evaporative Air Coolers" (New Delhi, June 2021), https://aeee.in/wp-content/uploads/2021/06/Decoding-Evaporative-Air-Coolers-Report.pdf.
35 Sharma, Singhal, and Garg, "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India."
36 Bureau of Energy Efficiency, "Guidelines for the Permittee-Standards and Labelling Program of BEE," 2016.
37 Sharma, Singhal, and Garg, "Decoding Evaporative Air Coolers."
38 Sharma, Singhal, and Garg, "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India."
39 Bureau of Energy Efficiency, "Guidelines for the Permittee-Standards and Labelling Program of BEE," 2016.
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43 Sharma, Singhal, and Garg, "Decoding Evaporative Air Coolers."
44 Sharma, Singhal, and Garg, "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India."
45 Bureau of Energy Efficiency, "Guidelines for the Permittee-Standards and Labelling Program of BEE, " 2016.
46 Sharma, Singhal, and Garg, "Decoding Evaporative Air Coolers."
47 Sharma, Singhal, and Garg, "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India."

In a scenario where the product fails the first compliance test, a second round of testing is carried out by BEE or its designated agencies. In case the product also fails the second test, BEE gives the applicant two months from the date of issuance of the intimation to either change the star label level, eliminate the appliance defects to meet the claimed energy performance level, or remove all the appliance stock from the market. After this, the applicant has to submit an action taken report, and if the report has not been submitted within the provided timeframe or does not comply with BEE's directions, BEE will withdraw the permission extended to the applicant to display a star label on the appliance. The main difference between check and challenge testing is summarised in the Table 7.

Table 7: Check testing vs. challenge testing

Check testing	Challenge testing
In check testing, the product to be tested is picked randomly from the market, which could be of any brand, model, and star label rating.	Challenge testing is done when a written complaint is received by BEE regarding a fraud declaration of the star label on the appliance. The permittee/manufacturer has to bear the cost of the required testing if fraud claims are found to be justified.

The SDA appoints an inspection officer to ensure compliance with the regulations. In the case of non-compliance by the permittee, the SDA prompts BEE to disqualify such appliances for retail sales and informs the SERC. The SERC appoints an adjudicating officer who follows the final adjudication process and then proposes the final verdict. In summary, SDAs and SERCs are part of S&L's enforcement mechanism, and BEE and CPRI are the part of S&L administration, as shown above in Figure 1.

Challenges Identified Under the S&L Programme[48]

The Comptroller and Auditor General (C&AG) of India has been given the responsibility to conduct audits and report to the parliament as per Articles 149 and 151 of the Constitution of India, respectively, and the Comptroller and Auditor General's (Duties, Powers and Conditions of Service) Act, 1971. The C&AG conducts audits of the expenditure of Government of India ministries/departments under Sections 132 and Section 173 of the Act. The bodies established by or under laws made by the parliament and containing specific provisions for audit by the C&AG are statutorily taken up for audit under Section 19(2) of the Act. The audit of other organisations (corporations or societies) is entrusted to the C&AG in public interest under Section 20 (1) of the Act. Furthermore, bodies or authorities that are substantially financed by grants/loans from the Consolidated Fund of India are audited by the C&AG under the provisions of Section 14(1) of the Act.

As per the C&AG of India 2020 Report, the C&AG test audit was conducted in 2017-18 and covered the BEE's S&L programme, among others. The C&AG examined the activities of the S&L programme under the 12th Plan (2012-13 to 2016-17). The objective of the audit was to:

- Check whether the energy savings targets were clear, quantifiable, and achieved.
- Check whether the rules, regulations, and procedures were adequate and adhered to.
- Check whether the scheme's implementation and monitoring mechanism was effective.

48 Comptroller and Auditor General of India, "Comptroller and Auditor General of India for the Year Ended March 2018," 2020, https://cag.gov.in/sites/default/files/audit_report_files/Union_Direct_Tax_Compliance_Revenue_Report_3_2016_Department_Revenue.pdf.

The audit criteria was derived from:

- EC Act 2001
- Rules and regulations notified by the central government
- Product schedules
- 12th Plan for S&L scheme
- Scheme documents and operations manual (OM) of BEE
- Benchmarks/standards set to assess the achievements
- Reports/studies conducted under the S&L scheme

Key audit findings

The activities to ensure proper implementation of S&L scheme include:

- Scrutiny of applications for model registration
- Check testing of registered models
- Label verification
- Collection of labelling fee
- Verification of production data provided by the permittees and enforcement action against non-compliant permittees.

Although BEE has established the required checks and balances for successful S&L programme implementation, there is still scope for improvement, in various areas, as detailed in the C&AG of India 2020 Report and summarised in Table 8: 1) check testing, which is the most important component for ensuring the programme's efficacy; 2) test lab capacity building, which is crucial to ensuring the high energy performance and quality of products; 3) label verification, which is needed to protect the consumers from the exploitation associated with counterfeit star labels; 4) a Quick Response (QR) code mechanism for collection of the correct labelling fee; and 5) energy savings reporting to ensure the coherence of the data and methods used in energy savings calculations[49].

49 Comptroller and Auditor General of India.

Table 8: BEE's S&L Programme: challenges and proposed solutions[50]

Issues highlighted by C&AG of India 2020 report	Challenges faced by BEE	Proposed solutions by AEEE[51]
IAME role	The IAME selected for the work in the past had inadequate experience and only worked on a limited part of the scope of work defined by BEE as eligibility criteria to be an IAME agency. Moreover, only a few IAME agencies were identified. Another challenge highlighted by BEE is the insufficient workforce.	Project management and enforcement support cell units should be placed in BEE to act as a knowledge partner and coordinating agency to support BEE & other agencies in streamlining all the activities under the S&L scheme (application evaluation, check testing, & label and data verification). This cell should develop a roadmap to stimulate the formation of IAME agencies and support BEE in robust planning, implementation, and impact evaluation of the S&L scheme.
Check testing and OM deficiency	The following issues were highlighted: ● Deficient check testing frequency plan. ● Negligible check testing and reporting. ● Non-compliance (after the first test, a second test was not conducted for some products). ● Inadequacies and deficiency in the OM for check testing standards and protocols. ● Long delays in subsequent check testing post non-compliance in the first test.	Constituting an advisory committee to advise on: ● Development of testing and verification protocols for appliances, including the sampling size and frequency of testing. ● Ensuring periodic check testing and random testing. ● Develop a binding enforcement mechanism. ● Developing a roadmap for periodic upgradation of the OM and test procedures. ● Development of an online platform to provide information about test results in the public domain.
Lab capacity building	Inadequate efforts to scale up the capacity of labs and standardise testing frameworks.	● Assigning a knowledge partner to support the scale-up of testing facilities and create a coalition of laboratories and testing technology providers. ● Facilitating the transfer of technology and best practices from other countries to stimulate the establishment of new labs and scale up the capacity of existing labs.

50 Comptroller and Auditor General of India.
51 Based on AEEE's previous experience and intel gathered in several stakeholder consultations.

Issues highlighted by C&AG of India 2020 report	Challenges faced by BEE	Proposed solutions by AEEE[51]
Label verification & QR code[52]	Label verification has not been implemented by BEE or IAME, as the process of label verification and check testing has not been streamlined and properly integrated. Furthermore, none of the IAME agencies hired has complied with the obligation of label verification, which is a critical component of check testing. Additionally, a consumer-centred QR code label verification option was launched by BEE, but the same has not been implemented yet, which has also resulted in insufficient collection of label affixing fees over time.	• Development of an autonomous digital system that can integrate the sales data into the BEE database on registered equipment using the unique identification serial number assigned to each product. • To achieve this high-level system integration, information technology (IT) tools are required that can enable the manufacturer to directly link the appliance sale data with BEE servers and allow the end-user to verify the label instantly using the QR code and unique serial number. • A feasibility study can be done on incorporating retailers into the label verification process at the time of sale of the product to the end-user, which could ensure that the affixed labels are not counterfeit and help regulate the revenue stream from collection of label affixing fees.
Energy savings reporting	Energy savings reporting is not streamlined and is inadequate in terms of the coherence of data and methods used in energy savings calculations. This results in misleading impact assessment, jeopardising the credibility of the S&L scheme and triggering consumer doubt regarding the overall process followed by BEE.	• A third-party, unbiased, periodic assessment of the S&L scheme should be done to determine the actual savings generated through the sale of energy-efficient equipment, in order to make the process credible and authentic. • A plan of action should be developed for digital reporting of the impacts using internet of things (IoT) technologies, in order to eliminate manual process errors.

To address the issues summarised in Table 8, the C&AG report provided umbrella recommendations for BEE's S&L programme: 1) Have third-party verification by approved labs to ensure the accuracy of star labelling at the time of registration; 2) Improved periodic check testing and label verification under the S&L programme and its reporting in the public domain; 3) Improved test lab capacity for undertaking check testing and development of a roadmap for monitoring and ensuring compliance with internal guidelines regarding model selection for check testing; and 4) Label verification and a phase-out mechanism for inefficient products to ensure compliance with the S&L programme[53].

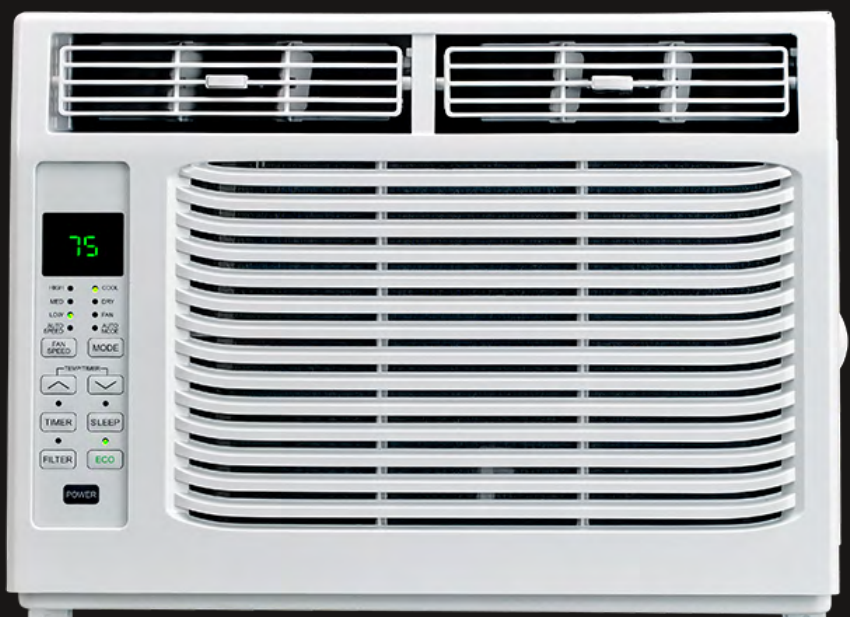
Building on the overview of the S&L programme provided in this chapter, the next chapter takes a closer look at RAC S&L, the evolution of RAC MEPS over time, and the RAC S&L programme's impact on the Indian RAC market.

52 Each appliance has a unique QR code to ensure the authenticity of the labels used on the market and thus prevent the misuse of star labels and empower consumers.

53 Comptroller and Auditor General of India, "Comptroller and Auditor General of India for the Year Ended March 2018."

In Financial Year (FY) 2019, the **Indian appliance and consumer electronics market** reached **INR 76,400 crore,** and it is expected to reach **INR 1.48 lakh crore by FY 2025,** with a compound annual growth rate (CAGR) of 11.7 percent

RAC stock will be **324–580 million units by 2037–38**, and its market is projected to grow at a CAGR of **11%** in the coming decade.



03 RAC Energy Efficiency in India

This chapter provides in-depth information on the Indian RAC market, the regulatory aspects of the RAC S&L programme, and the impact of S&L in catalysing RAC market transformation.

3.1 India's RAC Market[54]

There is a need to rapidly increase the local manufacturing of RAC components and assembly units, which would also create new jobs.

As per International Monetary Fund (IMF) 2020 data, the Indian economy is projected to reflect a gross domestic product (GDP) contraction of 10.3% this fiscal year; however, India's per capita GDP is expected to reach United States Dollar (USD) 3,273.85 by 2023, with maximum expenditure by consumers towards sectors namely food, housing, consumer durables, transport, and communication[55].

In Financial Year (FY) 2019, the Indian appliance and consumer electronics market reached INR 76,400 crore, and it is expected to reach INR 1.48 lakh crore by FY 2025, with a compound annual growth rate (CAGR) of 11.7 percent[56]. Amongst consumer electronics appliances, air conditioners, refrigerators, electric fans, LED TVs, washing machines, and laptops are some of the appliances with the highest demand. Amongst these, the demand for space cooling appliances, specifically RACs, has been rapidly increasing. It is projected that the domestic RAC stock will be 324-580 million units by 2037-38, and its market is projected to grow at a CAGR of 11% in the coming decade[57]. However, due to the COVID-19 pandemic, India is facing an economic slowdown. The Government of India has launched a COVID recovery package and initiatives such as Make in India, Product Linked Incentive scheme, and revised foreign direct investment policies to create favourable market conditions, develop domestic the RAC industry, and position India as a market leader and a manufacturing hub for RACs exports. However, there are still several challenges, as most of the components used in RACs are imported from other countries such as China, Thailand, and Vietnam. Therefore, there is a need to rapidly increase the local manufacturing of RAC components and assembly units, which would also create new jobs.

54 Bureau of Energy Efficiency, "Room Air Conditioners ," accessed March 5, 2020, http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.

55 India Brand Equity Foundation Report, "Indian Consumer Durables Presentation," accessed March 5, 2021, https://www.ibef.org/industry/consumer-durables-presentation.

56 India Brand Equity Foundation Report.

57 Ministry of Environment, Forest & Climate Change (MoEF&CC), "India Cooling Action Plan," 2019, http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf.

> There is a high demand for RACs as a space cooling appliance, with the January-June period in the calendar year accounting for 70% of primary RAC sales and March-May alone accounting for half of the total sales[58]. Based on the intel gathered by AEEE during stakeholder consultations, it was understood that with the country being severely impacted by the COVID-19 pandemic and a lockdown across the country from March 2020 to mid-September 2020, there has been a significant drop in economic activity. RAC manufacturers have seen their sales come to a halt in the peak sales season of this financial year due to supply chain issues associated with the continuous lockdown. At the same time, as more people stayed home, energy consumption from the installed RAC stock has increased in the residential sector, despite the negative sales trend. ISHRAE has issued operating guidelines, with operating temperatures of 24°C-30°C as a preventive measure to combat COVID-19. GHG emissions have increased during the pandemic due to increased usage of electrical appliances and significant load coming from RACs.

The RAC market is largely divided into two main types of air conditioners[59&60]:

Window/Unitary RACs: In unitary RACs, all the components (compressor, condenser, expansion valve, evaporator, and fan) are enclosed in a single box and installed in the window of a residential or commercial building.

Table 9: Advantages & disadvantages of window RACs[61]

Advantages	Disadvantages
Lower purchase price	Lower efficiency
Easy installation	Noisier operation
Multiple installation options	Improper installation can result in significant air leakage.

58 Nilesh Bhaiya and Pratik Singh, "Consumer Durables," Automotive Engineer (London) 35, no. 4 (2010): 38–39, https://doi.org/10.4324/9780429043352-11.
59 Pandita et al., "Policy Measures and Impact on the Market for Room Air Conditioners in India."
60 United for Efficiency (U4E), "Accelerating The Global Adoption Of Energy-Efficient And Climate-Friendly Air Conditioners," 2017, 80, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-Final.pdf.
61 United for Efficiency (U4E).

Split RAC: A split RAC comprises an indoor unit (consisting of the evaporator and cooling fan) and an outdoor unit (compressor, condenser, and expansion valve) fitted outside the conditioned space.

Table 10: Advantages & disadvantages of split RACs[62]

Advantages	Disadvantages
More efficient than window air conditioners	Typically higher purchase price than window air conditioners
Quieter operation, as the compressor sits in the outdoor unit	Installation requirements
	Space requirement for outdoor units

Split RACs can further be divided into the following types:

- **Wall-mounted RACs:** In a wall-mounted split RAC, the indoor unit is mounted on the wall of the conditioned space. It is installed at least 8-10 feet above the floor but is usually accessible enough for easy cleaning and maintenance. segment has the largest market share in the RAC market due to better aesthetics, higher efficiency, and competitive prices.
- **Roof-mounted or Cassette RACs:** In the case of a cassette RAC, the indoor unit is installed on the roof/ceiling rather than the wall of the building. This type of indoor unit is usually installed in larger spaces, as these occupy a larger portion of the ceiling. These units are designed to provide 360-degree airflow, and ceilings, being unobstructive, ensure better air circulation within the conditioned space. Cassette units are more expensive than typical split air conditioners. In addition, these units have to be suspended from the roof, and at times there is not enough suspension space available between the ceiling and floor; thus, it is not appropriate for all type of buildings.
- **Floor-mounted RACs:** In a floor-mounted RAC, the indoor unit is installed on the floor in the space to be cooled. These units provide unidirectional and high rate of airflow and are more commonly used to cool large areas. This type of installation offers a unique advantage, the systems can be installed in locations where wall or ceiling mounting of indoor units is not feasible.

62 United for Efficiency (U4E).

RACs can also be categorised into fixed speed (non-inverter type) and variable speed (inverter type), as detailed below[63]:

- **Fixed Speed RACs:** Fixed speed RACs only have two stages in the compressor cycle: either off or on. When the system is on, it works at 100% capacity, and once the thermostat reaches the set temperature level, the compressor automatically shuts off, with only a fan, in RACs, under operation until the temperature of the surroundings is not more than the set temperature.
- **Variable Speed RACs:** In this type of RAC, the compressor is always on and draws more or less power depending upon the inlet air temperature and the level set in the thermostat. This type of RAC is way more energy-efficient than a non-inverter type RAC. It is also more economical, achieves the desired temperature faster, with no or minimal temperature fluctuations, and is smoother in operation than the fixed speed RAC. It is also cheaper in terms of its overall lifecycle cost. Furthermore, it consumes less electricity due to its variable speed compressor and is also good for the environment. The market share of inverter RACs has rapidly increased since their introduction into the Indian market in 2015, with a share of 30% as of 2017[64].

Table 11: Advantages of Variable Speed RACs over Fixed Speed-types RACs[65]

More efficient than Fixed speed-types RAC
Quieter operation, as the compressor sits in the outdoor unit
Achieves desired temperature quicker with no temperature fluctuations

3.2 Energy Efficiency of RACs under the S&L Programme

The S&L programme for fixed-speed RACs was introduced by BEE in 2006 under a voluntary regime and transitioned to a mandatory regime in 2009. Then in 2015, BEE launched a voluntary S&L program for inverter RACs, which transitioned into a mandatory regime in 2018. At present, there is a combined S&L program for both fixed and inverter RACs. The S&L programme is distinct for window/unitary split RACs and cassette, floor standing tower, ceiling, and corner RACs up to 11 kW, and covered under Schedule 3 and Schedule 3A. The efficiency bands for RACs were based on their energy efficiency ratio (EER) until 2018. EER is the ratio of cooling output (watts) to the total power input (watts) in the given standard rating condition. The higher the EER, the more efficient the RAC and the lower the EER, the less efficient is the RAC. The benchmarking criteria transitioned from the EER to the Indian Seasonal Energy Efficiency Ratio (ISEER) In 2018. ISEER is the ratio of Cooling Seasonal Total Load (CSTL) to Cooling Seasonal Energy Consumption (CSEC)—i.e. the ratio of the total annual amount of heat that the equipment can remove from an indoor space when operated for cooling in active mode to the total annual amount of energy consumed by the equipment over the same period. ISEER computes an RAC's energy efficiency based on the measured performance at 35°C, the calculated performance at 29°C, and the weighted average of its estimated performance at outside temperatures between 24°C and 43°C. ISEER is an effective parameter that captures the efficiency benefits of the part-load operation of inverter RACs. The revised S&L schedule with the ISEER performance metric covers fixed and inverter units under the same labelling scheme.

63 United for Efficiency (U4E).
64 Pandita et al., "Policy Measures and Impact on the Market for Room Air Conditioners in India."
65 United for Efficiency (U4E), "Accelerating The Global Adoption Of Energy-Efficient And Climate-Friendly Air Conditioners."

BEE has established a technical committee that periodically (currently every 2-3 years) raises the MEPS and label levels which is inclusive of stakeholders namely BIS, the Collaborative Labelling and Appliance Standards Programme (CLASP), technical experts, manufacturers, RAMA, and testing laboratories (INTERTEK, CPRI, and Electrical Research and Development Agency (ERDA)). This technical committee establish standards for each product, along with its implementation framework. The increase in the EER/ISEER for window RACs and split RACs from 2009 to 2023 is summarised in Table 12 and Table 13, respectively.

Table 12: India's MEPS for unitary RACs[66]

Star level	1 January 2009 to 31 December 2011	1 January 2012 to 31 December 2013	1 January 2014 to 31 December 2015	1 January 2016 to 31 December 2017	1 January 2018 to 31 December 2020	1 January 2021 to 31 December 2023
	EER	EER	EER	EER	ISEER	ISEER
1-star	2.3	2.3	2.5	2.5	2.5	2.7
2-star	2.5	2.5	2.7	2.7	2.7	2.9
3-star	2.7	2.7	2.9	2.9	2.9	3.1
4-star	2.9	2.9	3.1	3.1	3.1	3.3
5-star	3.1	3.1	3.3	3.3	3.3	3.5

Table 13: India's MEPS for split RACs[67]

Star level	1 January 2009 to 31 December 2011	1 January 2012 to 31 December 2013	1 January 2014 to 31 December 2015	1 January 2016 to 31 December 2017	1 January, 2018 to 31 December 2020	1 January 2021 to 31 December 2023
	EER	EER	EER	EER	ISEER	ISEER
1-star	2.3	2.5	2.7	2.7	3.1	3.3
2-star	2.5	2.7	2.9	2.9	3.3	3.5
3-star	2.7	2.9	3.1	3.1	3.5	3.8
4-star	2.9	3.1	3.3	3.3	4.0	4.4
5-star	3.1	3.3	3.5	3.5	4.5	5.0

It can be seen in Table 12 and Table 13 that the EER/ISEER for unitary RACs have been stagnant for almost 6 years and split RACs, for 4 years. Based on information gathered by AEEE during a few stakeholder consultations, this stagnancy period was due to the declining market share of fixed speed RACs and the development of new test methods and a performance metric (ISEER) that could measure the performance of variable speed RACs accurately in India. Since the launch of ISEER, the BEE is again on track with the ratcheting up of RAC MEPS every 2 years,

66 Bureau of Energy Efficiency, "Room Air Conditioners ," accessed March 5, 2020, http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.

67 Bureau of Energy Efficiency, "Room Air Conditioners ," accessed March 5, 2020, http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.

and the new RAC MEPS are put into effect for the following two years. BEE has also provided information about MEPS through December 2023, which allows manufacturers to plan for the future and stay ahead of the demand curve.

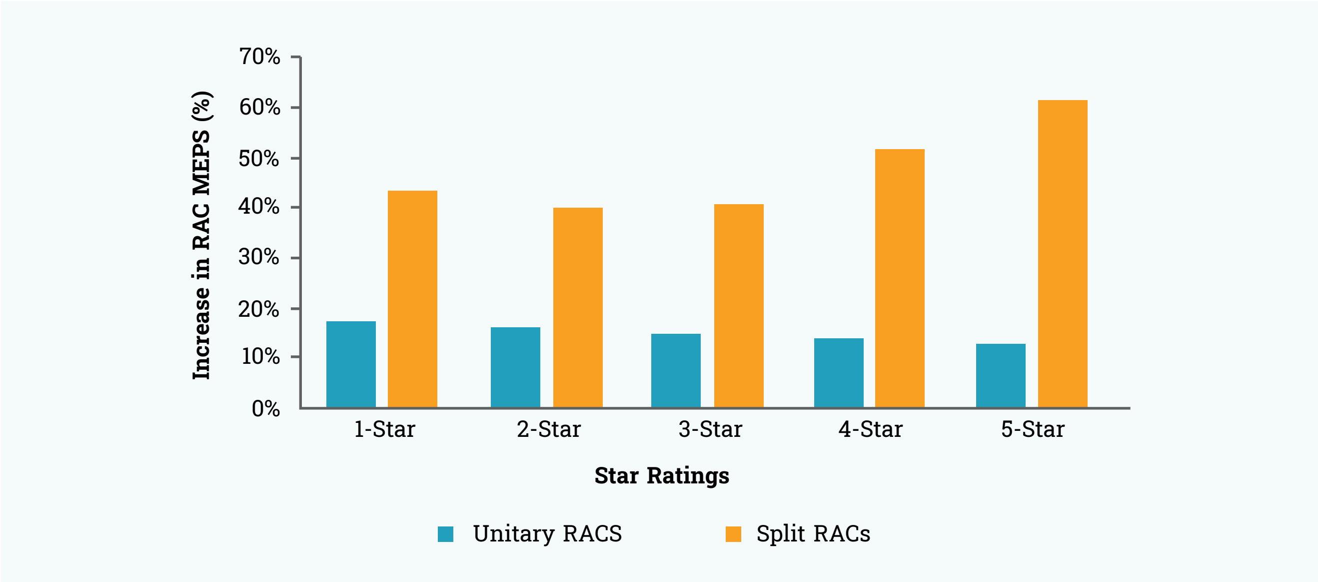


Figure 3: **Improvement in India's RAC MEPS (2009-2023)**[68]

The improvement trajectory from 2009 to 2023 can be seen in Figure 3 above. After consultation with stakeholders, BEE revised the MEPS for unitary RACs and split RACs in 2018, with an annual efficiency improvement of 2% and 4.3%, respectively. Although RAC MEPS levels are not yet aligned with the ICAP targets, there is still an opportunity for their ratcheting up, as the current S&L regime is only valid until 2023, and new MEPS to be implemented from 2024 are yet to be defined. Furthermore, several initiatives implemented in the past focused on mainstreaming super energy-efficient technologies that surpassed the 5—star label category efficiency requirements. Chapter 4 presents some of those initiatives, which have focused on improving the performance efficiency and use of RACs.

RAC MEPS levels are not yet aligned with the ICAP targets, there is still an opportunity for their ratcheting up, as the current S&L regime is only valid until 2023, and new MEPS to be implemented from 2024 are yet to be defined.

3.3 Impact of RAC S&L Programme on the Indian Market

In 2015-16, the market share of variable speed RACs was less than 1%; this figure increased to 54% of total sales by the year 2018-19. As a result, the share of fixed speed RACs reduced from around 99% in 2015-16 to 46% in 2018-29, as shown in Figure 4.

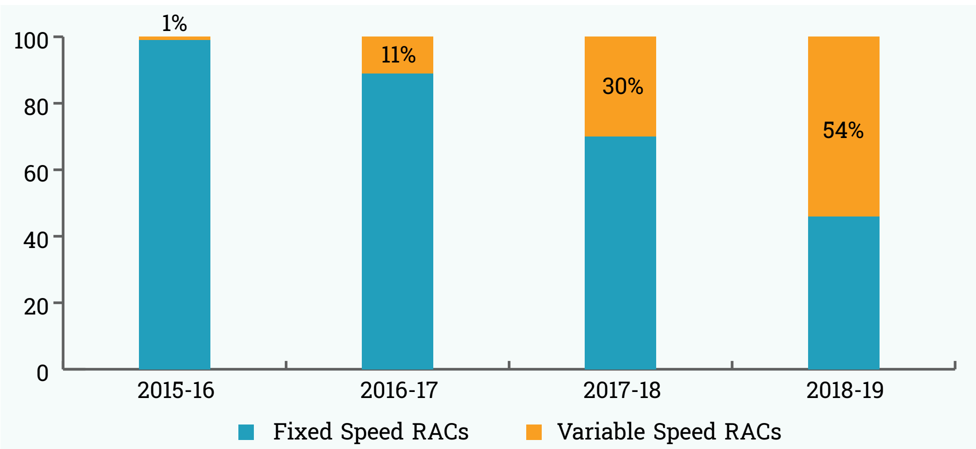


Figure 4: **Market share of fixed and variable speed RACs**[69]

68 The authors' analysis is based on data extracted from Bureau of Energy Efficiency, "Room Air Conditioners ," accessed March 5, 2020, http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.

69 The authors' analysis is based on data extracted from Bureau of Energy Efficiency, "Impact of energy efficiency measures," accessed March 6, 2021, www.beeindia.gov.in.

In terms of star rating, the 3-star band leads the sales in the overall RAC market, in both the fixed and variable speed RAC segments, from 2015-16 to 2018-19. Figure 5 and Figure 6 depict the star rating wise sales trends, derived from BEE labelling data.

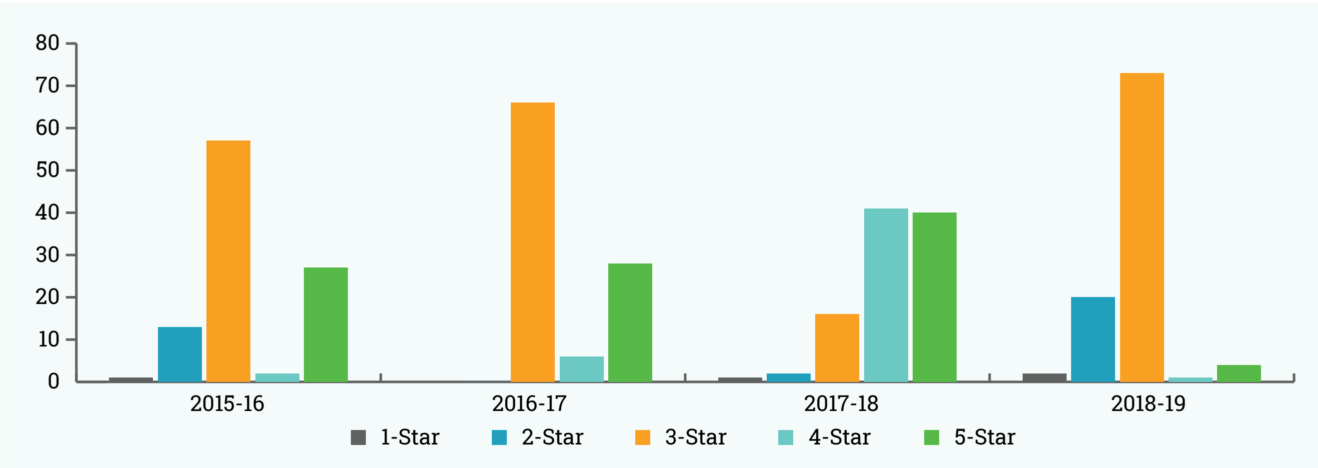


Figure 5: **Star rating wise sales data for fixed speed RACs**[70]

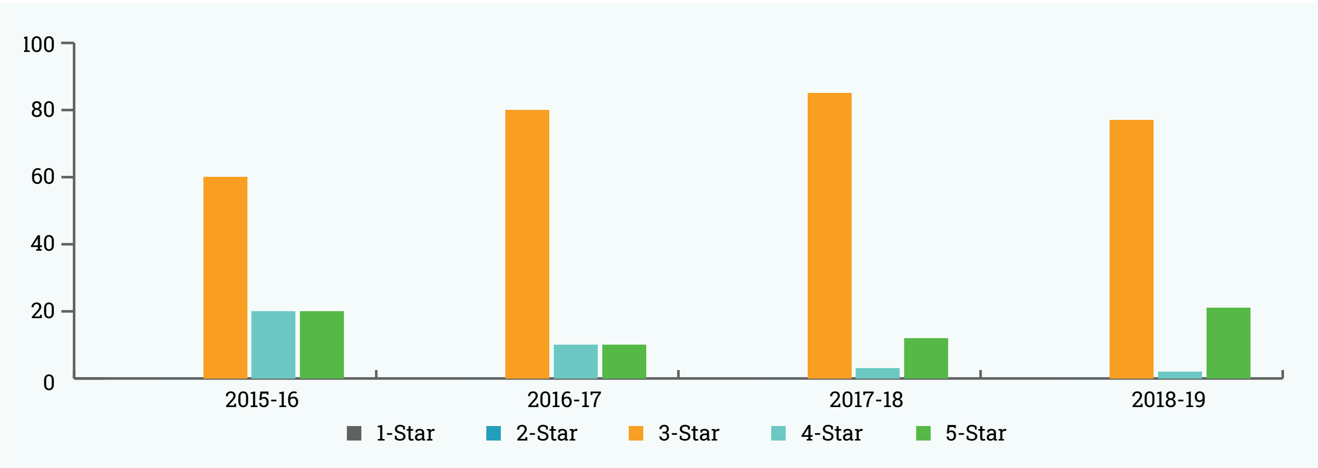


Figure 6: **Star rating wise sales data for variable speed RACs**[71]

The fixed and variable speed RAC sales trends indicate that consumers prefers 3-star RACs over higher-star-rated RACs. This could be due to, first, the affordability of 3-star RACs compared to the more expensive 5-star RACs available on the market. Second, retailers play a crucial role in persuading a customer to purchase an efficient product. They usually do not stock equipment with high energy efficiency, as there is less demand for such products and in this case even if a customer wishes to purchase a higher energy-efficient RAC, they get persuaded by the retailer to purchase the less efficient products, in stock. Thus, the vicious cycle of greater supply and demand of 3-star RACs vs. 5-star RACs continues.

3.3.1 Energy Savings Achieved from RACs

In 2020, BEE published a report titled "Impact of Energy Efficiency Measures in the Year 2018-2019" [72], which provides a snapshot of the impact of BEE's initiatives. In addition, the report provides data on the energy savings generated due to efficient RACs, taking into consideration the verified annual sales data submitted by manufacturers on a quarterly basis.

70 The authors' analysis is based on data extracted from Bureau of Energy Efficiency, "Impact of energy efficiency measures," accessed March 6, 2021, www.beeindia.gov.in.

71 The authors' analysis is based on data extracted from Bureau of Energy Efficiency, "Impact of Energy Efficiency Measures for the Year 2018-19," accessed March 6, 2021, www.beeindia.gov.in.

72 Bureau of Energy Efficiency, "Impact of Energy Efficiency Measures for the Year 2018-19," 2020.

The methodology BEE used to calculate the RAC energy savings entailed the following four-step process:

- **Step 1:** Collection of 2015-2019 sales data (2018-2019 data was collected quarterly), as summarised in Table 14.

Table 14: RAC sales data (2015-2019)

RAC sales data				
Types of RACs	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Fixed speed RACs	4676022	5741229	5384058	3287843
Variable speed RACs	25006	702652	2267364	3909378
Total	**4701028**	**6443881**	**7651422**	**7197221**

- **Step 2:** Defining a baseline value and capturing the rated power consumption or energy requirement. To estimate the energy consumption baseline for RACs, the cooling capacity or CSTL (in the case of variable RACs) was divided by 2.3 (i.e. the EER of 1-star RACs through 2014 for fixed air conditioners).

- **Step 3:** Assessing the operational hours and setting the hours of annual operation. For fixed speed RACs, the total number of operational hours was taken as 1200 hours, and for variable speed RACs, the total was taken as 1600 hours.

- **Step 4:** Calculating the energy savings in each financial year. The annual energy savings are shown in Figure 7.

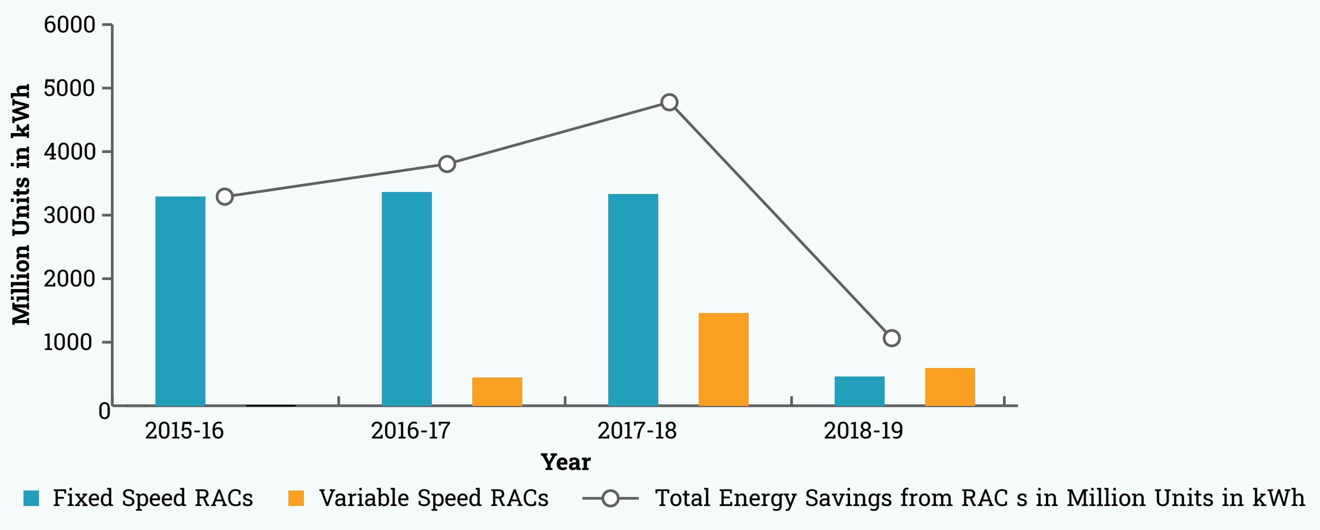


Figure 7: RAC energy savings in Million Units in kWh[73]

The following formulas were used in the calculations:

- **Annual energy savings for appliances sold before 1st April 2018:**

  Annual energy savings (kWh/year) = [kW Baseline — kW Star-rated] x Sales FYn x Hr Annual where:

  $kW_{Baseline}$ = Baseline energy consumption of the respective appliance

  $kW_{Star\text{-}rated}$ = Energy consumption of the star-rated appliance

  $Sales_{FYn}$ = Sales volume of the star-rated appliance for the given FY

  Hr_{Annual} = Annual operating hours of the appliance.

73 The authors' analysis is based on data extracted from Bureau of Energy Efficiency, "Impact of Energy Efficiency Measures for the Year 2018-19," accessed March 6, 2021, www.beeindia.gov.in.

- **Annual energy saving for appliances sold after 1st April 2018 (FY 18-19):**

  Annual energy savings (kWh/year) = **ES Q1 + ES Q2 + ES Q3 + ES Q4**

  where, **ES (Q1 to Q4)** = Energy savings for the respective quarter (Q1 to Q4) = [kW Baseline – kW Star-rated] x $Sales_{Qn}$ x Hr_{Qn}

  $kW_{Baseline}$ & $kW_{Star\text{-}rated}$ = Same meaning as in previous equation

  $Sales_{Qn}$ = sales volume of the star-rated appliance for the respective quarter (Q1 to Q4)

  Hr_{Qn} = quarterly operating hours of the appliance for the respective quarter (Q1 to Q4).

3.4 RAC Market Data and Energy Savings Findings

Analysis of the market data and energy savings calculated by BEE as shown in the section above reveals the following:

01 There was a sharp decline in energy consumption in 2018-2019. This can be attributed to the different methods used to calculate energy savings. Up to 2017, the energy savings were calculated based on the assumption of 100% hours of operation, and annual energy savings were calculated accordingly. In contrast, in 2018-2019, the energy savings were calculated for each quarter, i.e. the quarterly sales data and quarterly operating hours of respective appliances were used, providing a more accurate estimate of energy consumption and the corresponding energy savings. For example, if more products were sold in Q4, this would be reflected in lower energy savings, which is more accurate and closer to the actual annual energy savings.

02 BEE revises its S&L programme periodically and increases the stringency of energy performance thresholds, which has fostered the development of the Indian RAC market by bringing in more efficient RACs.

03 The introduction of S&L for variable speed RACs has also enabled the transition to more efficient RACs. The market share of variable speed RACs was negligible in 2014-15 but had increased to 54% by 2018-19.

04 For fixed speed RACs, the market share declined from 99% to 46% in a period of only years. Consequently, the energy savings generated by this segment have also gradually decreased.

05 3-star RACs have the highest penetration amongst the star labelled RACs, which may due to the higher price of 5-star RACs.

To facilitate market transformation and the ratcheting up of RAC MEPS, it is essential to introduce market mechanisms that incentivise the purchase of super energy-efficient RACs and implement regulations that mandate retailers to stock up on a certain percentage of super energy-efficient RACs. Incentivising the purchase of super energy-efficient RACs will contribute to the creation of an Indian economy where there is greater grid resilience, better air quality, lower operational costs for consumers and businesses, and other such co-benefits. At the same time, there are trade-offs such as job impacts, consumer price shocks, and product scarcity, among others, that policymakers should consider when implementing these market mechanisms. Such mechanisms require substantial initial capital, and, thus, multiple entities need to collaborate to create coordinated efforts and a funding platform to make it a reality. Successful initiatives where coordinated action led to effective promotion of super energy-efficient RACs are presented in the next chapter.


TIMER
MODE
20
SPEED
SWING

04 Initiatives to Promote Super Energy-Efficient RACs

Various public and private organisations are making efforts to increase the penetration of super energy-efficient RACs. This section examines different types of initiatives, namely, financial, technological, and policy-related, which have been introduced into the market to increase super energy-efficient RAC uptake and penetration.

4.1 Financial Initiatives

EESL launched a bulk procurement programme to promote investment in the energy efficiency sector. An overview of the programme is presented below.

4.1.1 Bulk Procurement Programme by Energy Efficiency Services Limited[74,75&76]

Energy Efficiency Services Limited (EESL) was established in 2009 as a joint venture of four reputed public-sector undertakings—NTPC Limited, Power Finance Corporation Limited, REC Limited, and Power Grid Corporation of India Limited. After successful deployment of LEDs nationwide under the Unnat Jyoti by Affordable LEDs for All (UJALA) programme, in 2019, EESL launched **"EESL Super-Efficient Air Conditioning Programme (ESEAP)"** to promote air conditioners that are ~40% more efficient than the business as usual (BAU) 3-star RACs available on the market. Phase 1 of the programme targeted deployment of 50,000 super energy-efficient and environment-friendly RACs with 5.4 ISEER with low-GWP refrigerants. This type of RACs has an energy consumption of about 1041 kWh, whereas a similarly-priced RAC available on the market has a rated consumption of 1253 kWh for 5-star RACs and 1591 kWh for 3-star RACs. Along with significant savings, EESL is also offering a hassle-free service experience, including customer redressal support throughout the programme's existence. Additionally, EESL offers various equated monthly instalment (EMI) options via selective banks. The programme also offers a buyback option for customers looking to upgrade their RACs. Furthermore, to enhance the customer experience and make it convenient for customers to place orders, EESL has developed a web portal, www.EESLmart.in. The website features a product catalogue, product specifications and images, a payment gateway, stock status, and order completion and shipment information, as well as 24×7 customer service, and post-shipping support. Even though EESL is offering a comprehensive service package, to date, less than 2000 units of super-efficient RACs have been deployed, which can be attributed to the lack of consumer awareness regarding the energy performance difference of the RACs sold by EESL compared to the RACs available in the retail market within the same star rating category.

74 Energy Efficiency Services Limited, "Training Program of Channel Partners IEES Model & Super-Efficient Air Conditioner Program," 2021, https://eeslindia.org/wp-content/uploads/2021/04/SEAC-PPT_09.04.21.pdf.
75 EESLmart, "EESL Mart," accessed March 5, 2021, https://eeslmart.in/#about.
76 Energy Efficiency Services Limited, "About Us," accessed March 5, 2021, https://eeslindia.org/en/about-us/.

4.1.2 RAC Replacement Schemes by Power Distribution Companies[77&78]

Power distribution companies (DISCOMS) such as BSES & Tata Power have initiated RAC replacement schemes that allows their consumers to exchange their old working RACs with new 5-star rated 1.5 tonne RACs at a substantial discount of up to 60% on the maximum retail price (MRP) [79] in the case of BSES and up to 50% in the case of Tata Power[80]. The DISCOMs have tied up with major manufacturers, including Voltas, Daikin, Bluestar, LG, etc. The process to apply for the replacement is similar for both DISCOMs, and a replacement request can be generated either online or telephonically. However, similar to the EESL initiatives, these DISCOM initiatives have not yet seen high customer participation, which could be due to the limited number of colour options that match the aesthetic of the rooms where the RACs will be installed by the customers. Furthermore, the price difference at which the replacement is made available is not significant. The discount is given on MRP, which is still higher than the market price of an RAC available in the retail market. Therefore, even with ease of ordering and installation, these replacement schemes have not been availed of on a large scale. Consumer perception studies could help in understanding customer needs and wants, according to which improvements could be made in both bulk procurement and replacement schemes, which would, in turn, facilitate large-scale implementation of these initiatives.

4.2 Technological Initiatives

The Government of India, in partnership with international organisations, has initiated the GCP and SEAD initiatives to promote technological innovations in RACs.

4.2.1 Global Cooling Prize[81,82,&83]

To address the increasing climate impacts of residential air conditioning, the Department of Science & Technology, Government of India, and Mission Innovation launched GCP in November 2018. The GCP was led by RMI, Conservation X Labs, AEEE, and CEPT University. The competition aimed to drive and support incubation, commercialisation, and ultimately mass adoption of innovative technologies in India, followed by the scale-up of those technologies in other countries. The competition was backed up with prize money of 200,000 USD for each finalist, and the winners were awarded 1 million USD to help them finance and support the commercialisation of their technologies. The competition was designed to incentivise the development of a residential cooling solution that would have at least five times lower climate impact than the BAU RAC units. A technical review committee was established to select the winning technology. The winning technology was supposed to prevent up to 100 gigatonnes (GT) of carbon dioxide equivalent (CO2e) emissions by 2050 and put the world on a roadmap to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries globally. This award facilitated the efforts of innovators by providing them worldwide attention, along with recognition, encouragement, and support. This award also acted as a collaborative platform that utilised the potential of researchers to multiply the impacts of public research towards climate action.

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77 BSES, "BSES Rajdhani Power Limited," 2019, https://www.bsesdelhi.com/web/brpl/home (December, 2019).
78 TATA Power DDL, "User Manual for AC Registration," accessed October 14, 2021, www.tatapower-ddl.com.
79 BSES, "BSES Rajdhani Power Limited."
80 TATA Power DDL, "User Manual for AC Registration."
81 Global Cooling Prize, "Timeline and Milestones," accessed March 6, 2021, https://globalcoolingprize.org/prize-details/timeline/.
82 RMI, "Global Cooling Prize: Solving the Cooling Dilemma ," accessed June 11, 2021, https://rmi.org/insight/global-cooling-prize-solving-the-cooling-dilemma/.
83 Mission Innovation, "Global Cooling Prize: Finalists to Be Announced in November," accessed March 4, 2021, http://mission-innovation.net/2019/09/06/global-cooling-prize-finalists-to-be-announced-in-november/.

Figure 8: **GCP timeline**[84]

Following the prize launch in November 2018, around 2000 entries were received from start-ups, innovators, universities, research institutes, and key RAC manufacturers. Out of these, 445 teams submitted their preliminary ideas through the intent to apply form by 30 June 2019, and 139 teams from 31 countries submitted the complete detailed technical application by 31 August 2019. The technical review committee carried out the detailed review process in August-October 2019.

The companies' prototypes/applications were evaluated by the technical review committee based on the following selection criteria:

Table 15: **GCP technology selection criteria**[85]

Parameter	Specifications
Climate impact & social impact	The climate impact of the solution must be at least 5 times lower than that of the baseline RAC unit, and the installed cost to consumers for the solution must not be more than twice that of the baseline RAC unit when manufactured at a scale of 100,000 units.
Supplementary performance and environmental criteria	
Power	The solution should consume no more than 700 W of power from the grid.

84 Global Cooling Prize, "Global Cooling Prize," 2021, https://globalcoolingprize.org/.
85 Global Cooling Prize, "Details And Criteria About The Global Cooling Prize," 2019.

Water	The solution should not consume more than a daily maximum limit of 28 L, if any is required for operation.
Emissions	The solution should have no onsite emissions from any heat source.
Refrigerant	The solution should use a refrigerant with zero Ozone Depleting Potential (ODP), be of lower toxicity (Class A), and comply with IEC 60335-2-40 or ISO 5149.
Scalability	The solution should be scalable and not exceed 2 times the size of the baseline RAC unit.
Materials	The solution should be manufactured with minimal usage of rare earth elements and embodied carbon.
Operation	The solution should be designed to meet a 1.5 TR (5.3 kW) cooling load at standard outdoor conditions as specified in IS 1391 (Part 1): 2017, IS 1391 (Part 2): 2018, and ISO 16358:1 - 2013.
Temperature and relative humidity	The solution should maintain a dry bulb temperature (DBT) below 27°C and relative humidity of 60% in indoor conditions under varying outdoor conditions when the outdoor air temperature is above 20°C DBT, except for the defined unmet hours allowance.

The technical review committee considered and compared the performance of all prototypes against the baseline unit, representing the most commonly sold RACs on the Indian market in 2017. The baseline was a fixed speed and mini-split RAC unit with a 3.5 ISEER rating that used R22 as the refrigerant. The technical review committee then verified and shortlisted eight cooling innovations that fulfilled all the selection criteria. The eight finalists were announced in November 2019: Daikin, Barocal, Gree, Godrej, Kraton, S&S Design Start-Up Private Limited, M2 Thermal Solutions, and Transaero. Their proposed technologies are summarised in Annexure 1, Table 27. The finalists were given the first instalment of 200,000 USD to develop and deliver two working prototypes of their proposed cooling technologies from November 2019 to August 2020. This was followed by prototype testing in Indian locations between September 2020 and March 2021, after which the winners, Daikin and Gree Electric Appliances Inc., were announced on April 29, 2021 at the grand awards ceremony. The technical specifications of the winning companies' cooling technologies are given in Table 16.

Table 16: GCP winners' technology specifications[86]

S.No.	Name	Technology specification
1	**Daikin and partner Nikken Sekkei Ltd.**	The cooling system adopts the following two innovative methods to achieve higher efficiency and lower climate impact: ● The multi-split method is used to connect two indoor units with one outdoor unit. This method helps optimise the refrigerant flow rate for each of the two indoor units based on the ever-changing cooling load and uses refrigerant control technology to closely modulate the capacity. ● The system uses control technology that measures the outdoor temperature with sensors and applies the control system to automatically spray water under high ambient temperature conditions where the cooling load seems exceptionally high.
2	**Gree Electric Appliances Inc. of Zhuhai and partner Tsinghua University**	Gree's innovative Zero Carbon Source cooling technology integrates advanced vapour compression refrigeration, photovoltaic direct-driven technology, evaporative cooling, and ventilation, efficiently using renewable energy sources and free cooling sources. Gree's cooling solution has automatic, climate-smart operation with three unique modes: vapour compression refrigeration, evaporative cooling, and ventilation, which can operate individually or in parallel, depending on the outside weather conditions, to provide optimised indoor cooling and dehumidification.

86 Global Cooling Prize, "About The Finalists," accessed June 2, 2021, https://globalcoolingprize.org/about-the-finalists/.

4.2.2 Super-Efficient Equipment and Appliance Deployment[87&88]

SEAD is an initiative of the Clean Energy Ministerial (CEM) and International Partnership of Energy Efficiency Cooperation (IPEEC) Task Group established in 2010. The objective of SEAD is to convert knowledge into action and revolutionise the global market through a transition to super energy-efficient products. SEAD promotes the manufacture, purchase, and use of super energy-efficient products, including daily-use appliances, equipment, lighting, and other electronic devices. Twenty-one countries/regions are participating in this initiative: Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Denmark, the European Commission, Germany, Ghana, India, Indonesia, Korea, Mexico, Nigeria, Russia, Saudi Arabia, South Africa, Sweden, and the United Kingdom. The governments of these 21 countries are working to strengthen and fast-track the design and implementation of super energy-efficient appliance policies. Through high-quality research and technical analysis, SEAD develops tools and product databases to implement programmatic changes. SEAD accelerates market transformation through three key programme strategies: research & analysis, implementation & training, and dialogue & collaboration:

- **Research & Analysis:** provides member governments with access to high-quality research and expertise around various product areas and market transformation policies.
- **Implementation & Training:** facilitates the introduction of high-quality, high-efficiency products into markets by building tools and campaigns and testing and awarding products for efficiency.
- **Dialogue & Collaboration:** fosters peer-to-peer exchange between policymakers to drive collaboration and share policy-related best practices and technical information.

SEAD's global and collaborative approach to appliance energy efficiency policies is key to reaching the Paris Agreement targets. Policy measures taken up by SEAD member countries between 2010 and 2015 are expected to save 727 TWh of electricity every year through 2030. The Institute for Governance & Sustainable Development (IGSD), LBNL, and United Nations Environment Programme (UNEP) supported dialogue and collaboration amongst member countries and created several policy exchange forums to propose RAC and refrigerant policies and best practices that can lead to increased efficiency and reduced GWP for RACs.

In June 2016, CEM launched the Advanced Cooling Challenge (ACC). This challenge encourages government and industry players to develop and deploy scalable super-efficient, smart, climate-friendly, and affordable cooling technologies that are the need of the hour. It promotes the use of super energy-efficient RACs that will foster global growth of the RAC industry. As a result, over thirty participants, including governments, NGOs, RAC manufacturers, distributors, retailers, and consumer organisations, have made commitments to support the challenge. These commitments leveraged USD 1.4 billion for the deployment of efficient cooling solutions on a global level. The solutions ranged from developing and selling super energy-efficient and low-GWP refrigerant-based RACs, to procurement and deployment of super energy-efficient RACs in new buildings and retrofits. In response to this challenge and with the support of SEAD partners, India developed the ISEER metric for RAC performance testing.

Each market transformation initiative has fostered the development of new and efficient technologies that surpass all the existing technologies. However, these initiatives could have been aligned sequentially, with a pragmatic approach of each initiative building on the previous one's output. However, it is still feasible to invest in the solutions developed during these programmes and make them commercially viable and the new normal by coordinating the efforts of different entities and countries and focusing on deployment, rather than constantly developing new technologies.

87 Clean Energy Ministerial, "Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative," 2019, http://climateinitiativesplatform.org/index.php/Super-efficient_Equipment_and_Appliance_Deployment_(SEAD)_Initiative.

88 Clean Energy Ministerial, "Super-Efficient Equipment and Appliance Deployment | Clean Energy Ministerial |Super-Efficient Equipment and Appliance Deployment ," accessed March 4, 2021, http://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/super-efficient-equipment-and-appliance-deployment.

4.3 Policy Initiatives

Non-state actors and international multilateral and bilateral organisations have adopted various strategies to promote the penetration of super energy-efficient RACs, such as advocacy for ratcheting up of RAC MEPS in India, harmonisation of standards, and development of model regulation guidelines for RACs.

4.3.1 Advocacy for Ratcheting up RAC S&L by Non-State Actors[89]

ICAP places particular importance on RACs, since they constitute a dominant share of the building sector's space cooling energy consumption. BEE, in alignment with the ICAP 2019 recommendations, proposed an update to the RAC S&L programme, but industry players requested BEE to delay the revisions during the 11th Technical Committee Meeting (TCM) held on 19th March 2019. In this context, the India Cooling Coalition (formerly Sustainable and Smart Space Cooling Coalition)[90], a multi-stakeholder group of non-state actors from academia, non-profits, industry associations, and research institutions engaged extensively in sustainable cooling technology research and application, provided their feedback during BEE's TCMs on ratcheting up RAC MEPS in India. The key observations presented in the TCMs were based on the Coalition's preliminary analysis, which concluded that BEE's original proposal to ratchet up RAC MEPS would result in a ~5% increase per annum in the energy efficiency of newly-sold split RACs (the most prevalent units), as shown in Table 17. However, the industry's counter proposal as shown in Table 17, would imply a drop in annual efficiency improvements to just 3.5% over the next seven years, which is only a marginal improvement over the BAU scenario and less than half of what is needed to meet ICAP's goal. Subsequently, BEE notified revised RAC MEPS with an annual improvement of 3.7% up to December 2023.

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89 This section is based on AEEE's own information based on past initiatives and author's analysis.

90 Members of the Sustainable and Smart Space Cooling Coalition: AEEE. CEEW, CEPT, Center for Policy Research, CLASP, Greentech Knowledge Solutions, Fairconditioning, MNIT, NRDC, Prayas Energy Group, Smart Joules, and SSEF.

Table 17: Historical MEPS of unitary & split RACs and proposed future pathways

		Before ICAP										ICAP Launch	After ICAP							Year-on-year ISEER growth rate		
																				Historical	BEE proposal	Manuf. proposal
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	(2009-2019)	(2020-2024)	(2020-2026)
Unitary	1-Star	2.3	2.3	2.3	2.3	2.3	2.5	2.5	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.7	2.7			0.8%	1.6%	1.1%
													2.5	2.5	2.7	2.7	2.7	2.7	2.7			
	2-Star	2.5	2.5	2.5	2.5	2.5	2.7	2.7	2.7	2.7	2.7	2.7	2.9	2.9	2.9	2.9	2.9			0.8%	1.4%	1.0%
													2.7	2.7	2.9	2.9	2.9	2.9	2.9			
	3-Star	2.7	2.7	2.7	2.7	2.7	2.9	2.9	2.9	2.9	2.9	2.9	3.1	3.1	3.1	3.1	3.1			0.7%	1.3%	1.0%
													2.9	2.9	3.1	3.1	3.1	3.1	3.1			
	4-Star	2.9	2.9	2.9	2.9	2.9	3.1	3.1	3.1	3.1	3.1	3.1	3.3	3.3	3.3	3.3	3.3			0.7%	1.3%	0.9%
													3.1	3.1	3.3	3.3	3.3	3.3	3.3			
	5-Star	3.1	3.1	3.1	3.1	3.1	3.3	3.3	3.3	3.3	3.3	3.3	3.5	3.5	3.5	3.5	3.5			0.6%	1.3%	0.8%
													3.3	3.3	3.5	3.5	3.5	3.5	3.5			
																			Weighted Average	~0.7%	~1.3%	~0.9%
Split	1-Star	2.3	2.3	2.3	2.5	2.5	2.7	2.7	2.7	2.7	3.1	3.1	3.3	3.3	3.5	3.5	3.5			3.0%	2.5%	1.7%
													3.1	3.1	3.3	3.3	3.5	3.5	3.5			
	2-Star	2.5	2.5	2.5	2.7	2.7	2.9	2.9	2.9	2.9	3.3	3.3	3.5	3.5	4	4	4			2.8%	3.9%	2.8%
													3.3	3.3	3.5	3.5	4	4	4			
	3-Star	2.7	2.7	2.7	2.9	2.9	3.1	3.1	3.1	3.1	3.5	3.5	4	4	4.5	4.5	4.5			2.6%	5.2%	3.7%
													3.5	3.5	4	4	4.5	4.5	4.5			
	4-Star	2.9	2.9	2.9	3.1	3.1	3.3	3.3	3.3	3.3	4	4	4.5	4.5	5	5	5			3.3%	4.6%	3.2%
													4	4	4.5	4.5	5	5	5			
	5-Star	3.1	3.1	3.1	3.3	3.3	3.5	3.5	3.5	3.5	4.5	4.5	5	5	5.5	5.5	5.5			3.8%	4.1%	2.9%
													4.5	4.5	5	5	5.5	5.5	5.5			
																			Weighted Average	~3%	~5%	~3.5%

Notes for Table 17:

1. In the "Year-on-year ISEER growth rate" section, blue represents historical improvement, green represents BEE's proposal, and pink represents the manufacturer's proposal.
2. The weighted average considers the latest star distribution in RAC sales, as per BEE data.
3. The split RAC category warrants particular attention, as it represents 87% of the overall RAC market and is also the segment where the manufacturer-proposed pathway would, in many cases, be worse than the pre-ICAP pace of ISEER improvement.
4. The blue border under 3-star split RAC highlights the category with the highest market penetration in Indian RAC sector, with a 66% share of the current RAC market.

BEE's proposal was encouraging and directionally aligned with the ICAP's intervention scenario. If enacted, it could contribute towards GHG emissions reduction, as well as decrease the peak electricity demand and help address climate change issues. In contrast, the manufacturers' proposal (as compared to BEE's original proposal) would result in 500 megawatts (MW) of additional peak load (5 additional power plants), 6 TWh of increased electricity consumption, and 4 million metric tonnes of CO2 emissions through 2025. Therefore, the India Cooling Coalition expressed their concern and took exception to the manufacturer-proposed ISEER revision cycle, and appealed to BEE to devise a suitable action plan for ratcheting up RAC energy efficiency levels as early as possible as per the ICAP recommendations.

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4.3.2 Harmonization of Standards[91&92]

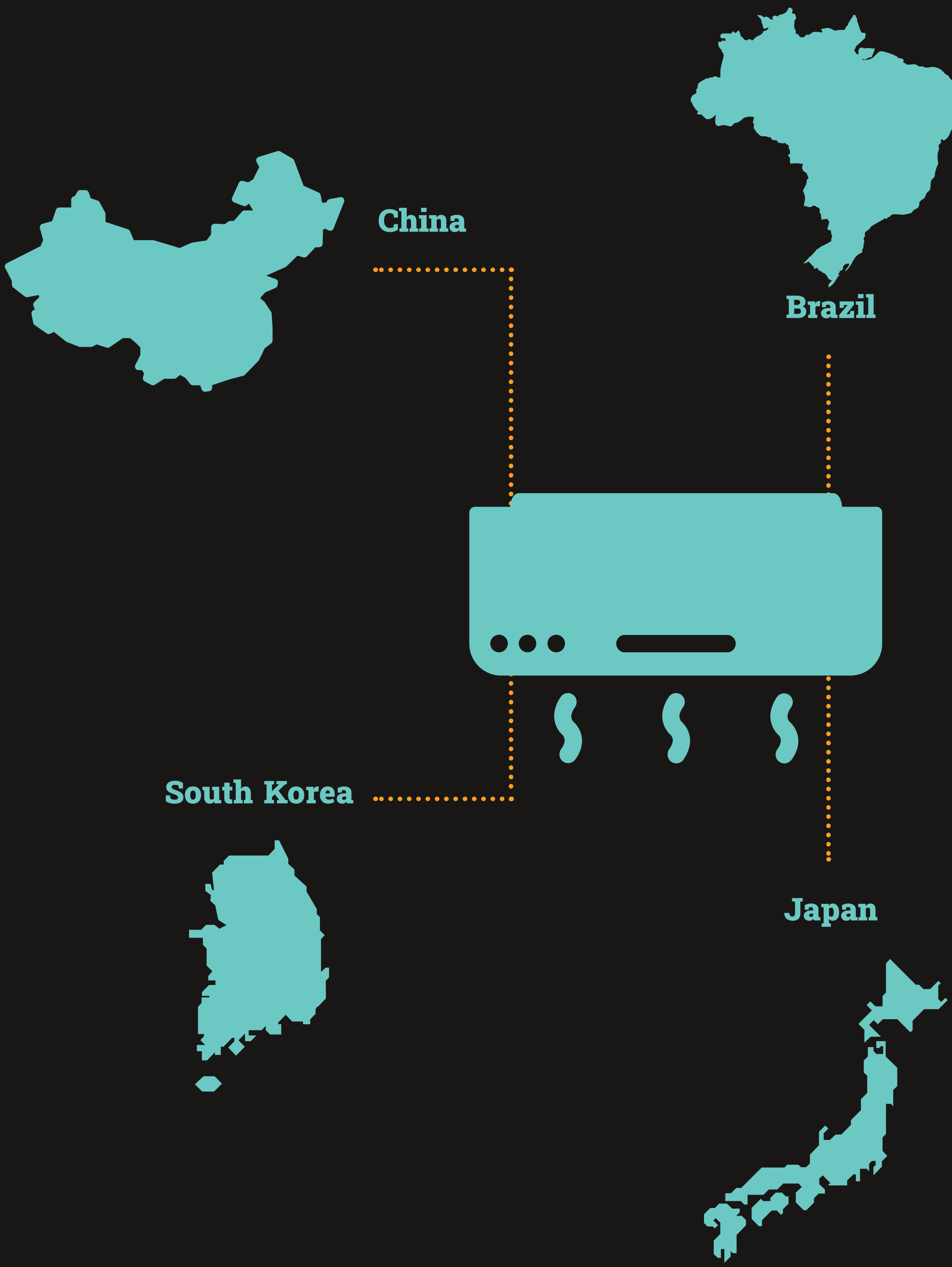
The work on harmonization of standards or Product Energy Efficiency Trend was initiated by **Technology Collaboration Programme on Energy-Efficient End-Use Equipment (4E TCP) by the International Energy Agency (IEA)** to assist governments with policy development to encourage innovation and improve access to super energy-efficient products. The project aims to monitor the energy efficiency of a core set of products[93] in 4E member countries/regions[94] (India is not a member country, yet) and provide information on their yearly progress. RAC test methods and standards were reviewed for the member countries, which revealed that, despite the test methods for domestic RACs being well aligned and many countries having adopted the seasonal efficiency metrics, there are still opportunities for harmonisation of test procedures, including test temperature adjustments, compressor loading conditions, standardised reporting, and nomenclature standardisation. If India wishes to take become a leading global producer of RACs, it needs to pace up the ratcheting up of RAC MEPS in coherence with international standards and ensure better performance of 'Make in India products' when tested under different conditions, in order to stay ahead of the demand curve.

4.3.3 Model Regulation Guidelines[95&96]

The **Model Regulation Guidelines are developed by U4E** and over sixty volunteer technical experts from various organisations were consulted for the development of the policy guide "Accelerating the Global Adoption of Energy-Efficient and Climate-Friendly Air Conditioners". The guide provides policy makers with information and best practices on how to promote energy-efficient and climate friendly RACs and low-GWP refrigerants in their respective national markets. The model regulation guideline for RACs is voluntary guidance for governments in developing and emerging economies that are considering a regulatory or legislative framework that requires new RACs to be energy-efficient and use refrigerants with a lower GWP than typical legacy refrigerants. The scope of the regulations applies to all new electrical single-phase non-ducted single-split, self-contained air-cooled air conditioners, air-to-air reversible heat pumps, and portable air conditioners with a rated cooling output at or below 16 kW placed on the market for any application and will guide countries aiming to improvise or develop testing methods and MEPS for RACs. The regulations are currently being put into practice as part of different voluntary financial mechanisms in a variety of countries, as the basis for regional policy harmonisation in East and Southeast Asia and Southern Africa, and in national regulatory programmes.

91 Baker; Rob, Carmichael; Sarah, Widder; Nathan and Brychta DeWitt, Jessica; Warren, Stem; Michael, "Domestic Air Conditioner Test Standards and Harmonization," 2020, https://www.iea-4e.org/wp-content/uploads/publications/2020/03/AC_Test_Methods_Report_Final_V2_incl_JP_KO.pdf.
92 IEA, "PEET Efficiency Trends Analysis," 2021.
93 Such as electric motor systems, solid state lighting, electronic devices and networks, power electronic conversion technology, and any related appliances.
94 Austria, Australia, Canada, China, Denmark, European Commission, France, Japan, Korea, New Zealand, Netherlands, Sweden, Switzerland, the United Kingdom, and the United States of America.
95 United for Efficiency (U4E), "Accelerating The Global Adoption Of Energy-Efficient And Climate-Friendly Air Conditioners."
96 Brian Holuj et al., "Model Regulation Guidelines - RACs," 2019.

With these initiatives underway, there is a need for an efficient and effective mechanism that can coordinate these actions to achieve the set ICAP targets, keep track of the new developments in the sector and initiatives being taken up by prominent agencies within the country and internationally, and develop periodic reports for the competent authorities for informed decision making on energy efficiency activities, as a first step. To get a holistic view of the global best practices, a review of RAC MEPS adopted in selected countries is presented in the next chapter.


China
Brazil
South Korea
Japan

05 Review of RAC MEPS adopted Internationally

This chapter presents an in-depth review of RAC MEPS in selected countries, namely, Japan, Brazil, China, and South Korea. These countries were selected based on how long their S&L programmes have been in existence and their relatively maturity, i.e. S&L initiatives in the selected countries have been in existence for more than ten years in most cases. The country selection was discussed in brief one-on-one interactions with national and international RAC experts.

5.1 Japan

Japan's Energy Conservation Law initiated the Top Runner Programme in 1998 to improve the energy consumption efficiency of energy-intensive appliances, machinery, and other items, amongst which RAC was one of the appliance categories[97]. Furthermore, Japan's Energy Conservation Law always focused on establishing energy consumption efficiency standards for appliances, machinery, and other items to foster energy conservation in the residential and commercial sectors[98].

5.1.1 Institutional Framework & Functions[99]

As shown in Figure 9, the Top Runner Programme was established by the Ministry of Economy Trade and Industry (METI) under the Energy Conservation Law. More specifically, the Advisory Committee for Natural Resources and Energy was established under the Ministry of Economy, Trade and Industry Establishment Law. The Advisory Committee for Natural Resources and Energy has a subcommittee, Energy Efficiency and Conservation Subcommittee, under which the Top Runner Programme was developed. To flesh out the programme details, working groups on Classification Standards have been established for each product category under the Energy Efficiency and Conservation Subcommittee. The working groups discuss the technical details of the programme, and the Energy Efficiency and Conservation Subcommittee approves the results and makes decisions to complete the process. These committees and subcommittees are assisted and administered by an office in charge of the Agency for Natural Resources and Energy. METI and its committees comprise representatives from academia, manufacturers, consumer groups, industry, and local government.

97 Abhyankar et al., "Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies."
98 Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy-Efficient Appliance and More," 2015.
99 Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy- Efficient Appliance and More," 2015.

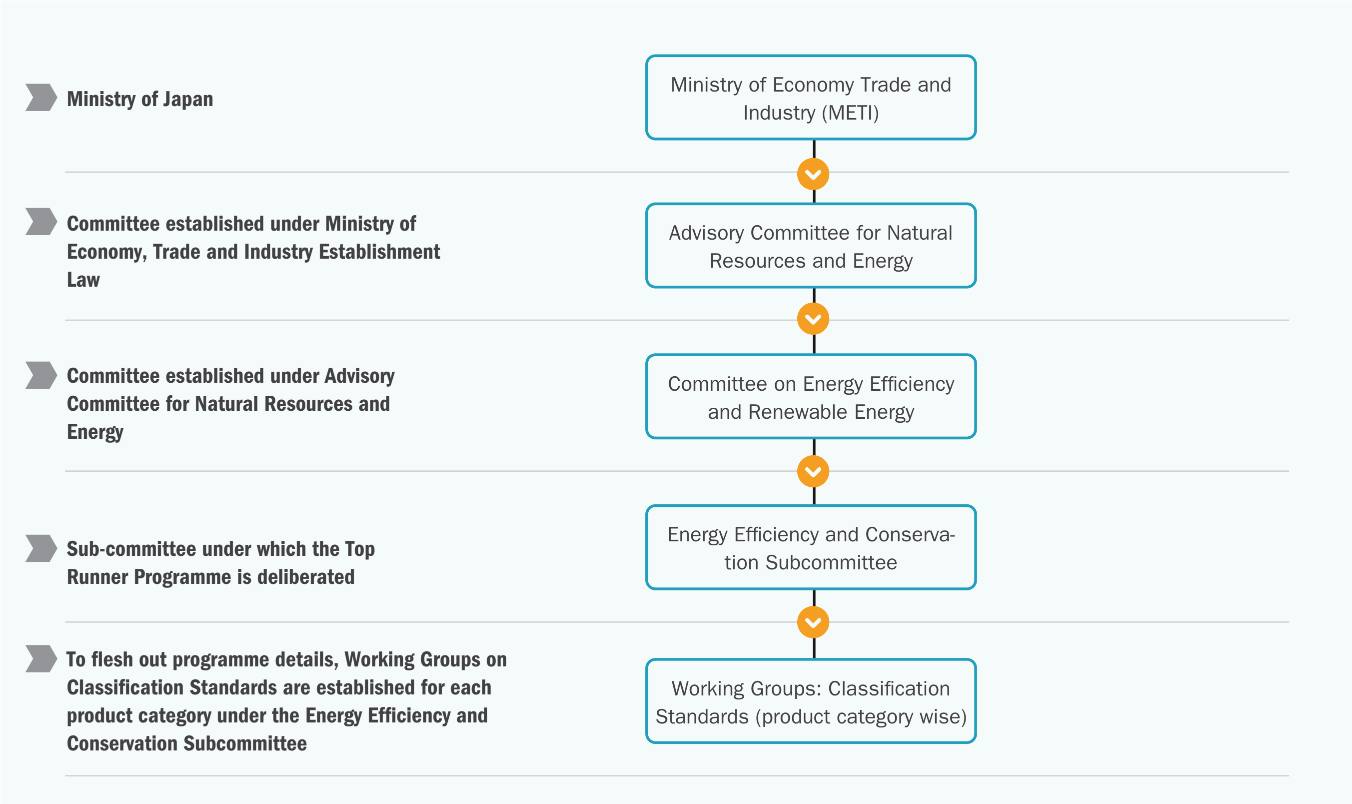


Figure 9: **Top Runner Programme institutional framework**[100]

Functions[101&102]

The Advisory Committee for Natural Resources and Energy has an Energy Policy Division that plays a vital role in selecting the types of appliances, machinery, and other products suitable for the Top Runner Programme. The appliances, machinery, and other items that fulfil the below-mentioned requirements are recommended to the Energy Efficiency and Conservation Subcommittee under the Committee on Energy Efficiency and Renewable Energy:

- Large product volume available in Japan,
- Energy insensitivity
- Requirement of particular efforts to improve energy consumption.
- Trends in marketplace for appliances, machinery, and other items
- Products with high energy efficiency potential

The Energy Efficiency and Conservation Subcommittee further analyses the recommendations received and finalises the need for studies on the targeted appliances, machinery, and other items. After that, the working groups on Classification Standards are established to undertake studies to set standard values. METI then finalises the energy efficiency standards based on the recommendations provided in the Energy Efficiency Standard Subcommittee's final report.

However, sometimes the finalisation of appliances, machinery, and other items is complicated under the Top Runner Programme. In such cases, studies are undertaken before the Energy Efficiency and Conservation Subcommittee discussions. These studies are carried out within a working group consisting of public service corporations, industrial organisations

100 Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy- Efficient Appliance and More," 2015.
101 Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy- Efficient Appliance and More," 2015.
102 Kimura Osamu, "The Role of Standards: The Japanese Top Runner Program for End- Use Efficiency. Historical Case Studies of Energy Technology Innovation in: Chapter 24, The Global Energy Assessment," in Chapter 24,The Global Energy Assessment (Cambridge University Press, 2012), 231–43, https://iiasa.ac.at/web/home/research/researchPrograms/TransitionstoNewTechnologies/12_Kimura_Japan_TopRunner_WEB.pdf.

with connections to the appliances, machinery, and other items, academic experts, and consumers, and are primarily approached from a technological viewpoint. The resulting report developed by the working group is made available to the public for their review and comments. Once the working group receives the comments, they prepare the final report. Then, the Energy Efficiency and Conservation Subcommittee approves the draft Top Runner standards submitted. After the subcommittee's approval, the draft report is finally approved by METI. Next, the standard values are reported to the World Trade Organisation to avoid trade barriers on the imported products for the standard establishment. After this, the standard values are added to the range of Top Runner target appliances, machinery, and other items. This whole process of setting the standards under the Top Runner Programme usually takes a year or two for a single product.

5.1.2 Top Runner Programme: Implementation Approach & RAC Energy Efficiency[103]

The Top Runner Programme sets product standards by considering the energy efficiency of the super energy-efficient version of the product available in the market as the base value. The potential technological efficiency improvements are also considered when setting the standard value. The Top Runner standards are voluntary, as there is no minimum level defined. This system facilitates manufacturers' voluntary energy efficiency activities. The standard values are left to be set as per manufacturers' discretion. Therefore, this system focuses on giving the manufacturers incentives to develop super energy-efficient products. This programme also recommends that industry players should support the manufacturers by promoting super energy-efficient products that meet the defined standards. This programme follows the Japanese Industrial Standard (JIS) for developing energy consumption efficiency measurement methods. [104]

The Top Runner Programme follows the implementation approach shown in Figure 10.

Figure 10: Top Runner Programme implementation approach[105]

The standards are set based on the most efficient product available on the market, which becomes the basis of the standard. The manufacturers and importers must ensure that the weighted average of the product's energy efficiency, made available in the market in the target year, should meet the set standard.

Standard revisions are made as per the product's energy efficiency improvement potential. The committees and sub-committees mentioned in Section 5.1.1 select the product groups to be included in the programme and execute the standard-setting process. Manufacturers must ensure that all their appliances, machinery, and other products have met the relevant fiscal year's target efficiency.

If there is non-compliance with the target standard, METI will first reach out to the non-compliant manufacturer and provide advice. If the manufacturers do not act on this advice, public announcements are made by the government stating that the company has failed to meet the target, with the mandate for the manufacturer to follow the provided advice,

103 Naturvårdsverket, "The Top Runner Program in Japan -Its Effectiveness and Implications for the EU ISBN 91-620-5515-1," accessed February 18, 2021, www.naturvardsverket.se.
104 Naturvårdsverket.
105 Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy-Efficient Appliance and More," 2015.

although financial deterrents such as fines are also applicable. The programme has been very successful thus far, with most manufacturers meeting the targets by the specified dates. When the target year is reached, new target levels can be reviewed and established. Similarly, in the case of non-compliance with the display requirements, METI first provides recommendations to the manufacturer; if the manufacturer does not follow the advice, the advice is made public, and the manufacturer is ordered to follow the recommendations. If the manufacturer still does not obey the order in question, penalties are imposed.

RAC energy efficiency under the Top Runner Programme

Under this programme, non-ducted/wall-mounted RACs with a capacity of 4 kW or less had an energy efficiency improvement of 16.3% from FY 2005 to FY 2010[106]. Japan has four distinct seasons, with the climate ranging from subarctic to subtropical. Northern Japan has warm summers, eastern Japan has hot and humid summers, and western Japan has hot and humid summers (with temperatures sometimes reaching 35 oC or above)[107]. Therefore, RACs are used in Japan throughout the year, either for heating or cooling, and the RAC S&L programme has been in existence in Japan for a long time.

Under the Top Runner Programme, the Coefficient of Performance (COP) was initially used as the parameter to calculate RAC efficiency. COP is defined as the ratio of the heating capacity in watts to the effective power input in watts at given rating conditions. The higher the COP, the higher the energy efficiency and energy savings potential. In the late 2000s, COP was replaced by the Annual Performance Factor (APF), which is the ratio of the total amount of heat that the equipment can remove from and add to the indoor air during the cooling and heating seasons, respectively, in active mode to the total amount of energy consumed by the equipment in both seasons[108]&[109]. The APF is considered a more accurate measure of air conditioner efficiency because it is measured under actual running conditions and considers the variability in intraseasonal temperatures[110]. The Top Runner Programme standard is based on ISO 5151 and 13253, with country-specific adjustments to the testing conditions[111]. It should be noted that the energy efficiency of RAC compressors tends to increase with a decrease in the cooling capacity (CC), and Japan has set the S&L requirements as per different CCs[112]. For non-ducted wall-mounted RACs with 2005 as the target year under the Top Runner Programme, cooling capacities (in COP) range from 3.65 kW to 5.27 kW.

In addition, the MEPS were revised for RACs manufactured after 2010, with RACs divided into two categories: residential and commercial. RACs with CCs up to 4.0 kW were categorised under the residential category MEPS, ranging from 4.9 to 6.6 APF. The RAC specifications and energy efficiency targets are summarised in Table 18.

Table 18: RAC MEPS in 2005 (COP) & 2010 (APF)[113]

S. No.	Cooling capacity (kW)	COP (2005)	APF (2010)
1	Up to 2.5	5.27	-
2	Up to 3.2	4.90	5.8
3	Over 3.2-4.0	3.65	4.9

The higher the COP, the higher the energy efficiency and energy savings potential. In the late 2000s, COP was replaced by the Annual Performance Factor (APF), which is the ratio of the total amount of heat that the equipment can remove from and add to the indoor air during the cooling and heating seasons, respectively, in active mode to the total amount of energy consumed by the equipment in both seasons & . The APF is considered a more accurate measure of air conditioner efficiency because it is measured under actual running conditions and considers the variability in intraseasonal temperatures.

106 Adapted from Ministry of Economy Trade and Industry, "Top Runner Program. Developing the World's Best Energy- Efficient Appliance and More," 2015.

107 "Japan Meteorological Agency | General Information on Climate of Japan," accessed February 18, 2021, https://www.data.jma.go.jp/gmd/cpd/longfcst/en/tourist.html.

108 Holuj Brian, Won Young Park, and Nihar Shah, "Model Regulation Guidelines. Energy-Efficient And Climate-Friendly Air Conditioners," 2019, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-AC-Guide-201705-.

109 Kensuke Kubo and KOJIMA Watanabe, MarikoJapan Michikazu, "Should Energy Efficiency Be Traded Off for Other Product Attributes ? An Analysis of Air-Conditioner Regulation in Japan," no. 607 (2016), https://www.ide.go.jp/library/English/Publish/Download/Dp/pdf/607.pdf.

110 Kubo and Watanabe, MarikoJapan Michikazu.

111 Kubo and Watanabe, MarikoJapan Michikazu.

112 Holuj Brian, Won Young Park, and Nihar Shah, "Model Regulation Guidelines. Energy-Efficient And Climate-Friendly Air Conditioners," 2019, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-AC-Guide-201705-.

113 Naturvårdsverket, "The Top Runner Programme in Japan-Its Effectiveness and Implications for the EU ISBN 91-620-5515-1."

The Top Runner Programme established 'display obligations' to push the set standards of the target appliances, machinery, and other items.

A new target to be achieved in 2010 was established in 2006. To achieve this target, a 20% improvement was required. In addition, the efficiency metric was changed to APF from COP to enable accurate crediting of the savings achieved by variable speed/inverter RACs and their cooling and heating mode performance. The 2010 targets were met. After 2009, RAC energy efficiency improvements were supported by financial incentives through the Japanese government's Eco-Point System[114]. Overall, the programme has been successful, and the share of 4- and 5-star RACs increased from 20% in 1990 to 96% in 2015. [115]

5.1.3 Market Transformation Strategies[116]

The Top Runner Programme established 'display obligations' to push the set standards of the target appliances, machinery, and other items. This strategy aims to make potential buyers aware of the information concerning energy consumption efficiency at the time of purchase. Under this initiative, the manufacturers of target appliances, machinery, and other items must display energy-efficiency related information under "Notifications", including the heat loss prevention performance and closely related parameters, product name, type, and energy consumption, and manufacturer's name.

The programme also includes the 'energy saving labelling programme' and 'label display programme for retailers', which act as a catalyst for the promotion of target super energy-efficient appliances, machinery, and other items on the market and specifically amongst consumers. In addition to this, an energy efficiency performance catalogue has been published to allow consumers to quickly compare products' energy efficiency when making the purchase decision. Moreover, this programme also provides incentivisation by providing an award to retailers who actively promote super energy-efficient products. These strategies were implemented to facilitate the rapid uptake of super energy-efficient products and encourage manufacturers and retailers to improve products' energy efficiency.

5.1.4 Impact of Top Runner Programme

The programme has had the following positive and negative impacts, specifically in the RAC category:

Positive impacts:

Manufacturers' vigorous efforts and continuous push from ministries have led to significant energy efficiency improvements in target product categories. Specifically, wall-mounted RACs attained efficiency improvements that exceeded the government's initial expectations.

Non-ducted/wall-mounted RACs with a capacity of 4 kW or less had an energy efficiency improvement of 16.3% from FY 2005 to FY 2010.

For other non-ducted RACs, the efficiency improved by about 15.9% over the FY 2006 level by those with a target fiscal year of FY 2012.

Negative impacts:

Price hike of the products due to new technological developments made by manufacturers to exceed the set MEPS.

An increase in the burden on manufacturers, as consumers may not buy the higher-priced products available in the market, can lead to the failure of this programme.

There may be cases in which some products are not even considered for inclusion in this programme as they are not available in the market or are only available in limited numbers.

114 Under Japan's "eco-points" system, points are awarded to consumers on the purchase of products with 4- or above 4-star ratings in the national system of energy efficiency standards. Consumers earn eco-points by buying four kinds of government-designated high-efficiency products: RACs, refrigerators, televisions, and LEDs. Since 2011, only 5-star appliances are eligible for eco-points.

115 Naturvårdsverket, "The Top Runner Program in Japan-Its Effectiveness and Implications for the EU ISBN 91-620-5515-1."

116 Ministry of Economy, Trade, and Industry, "Top Runner Program. Developing the World's Best Energy-Efficient Appliance and More," 2015.

5.2 South Korea

The Korea Energy Agency (KEA) was established in 1980 to administer the national policies for energy efficiency improvement, new and renewable energy dissemination, and climate change mitigation for smart and efficient demand-side management in South Korea. This section provides an overview of Korea's S&L Programme.

5.2.1 Institutional Framework & Functions

As shown in Figure 11, KEA has five departments led by individual directors. Each department has several divisions, and within the demand side management department of KEA, there is the Energy Efficiency Division, which is responsible for developing policies and initiatives on energy efficiency in industries, buildings, transport, and appliances and equipment.

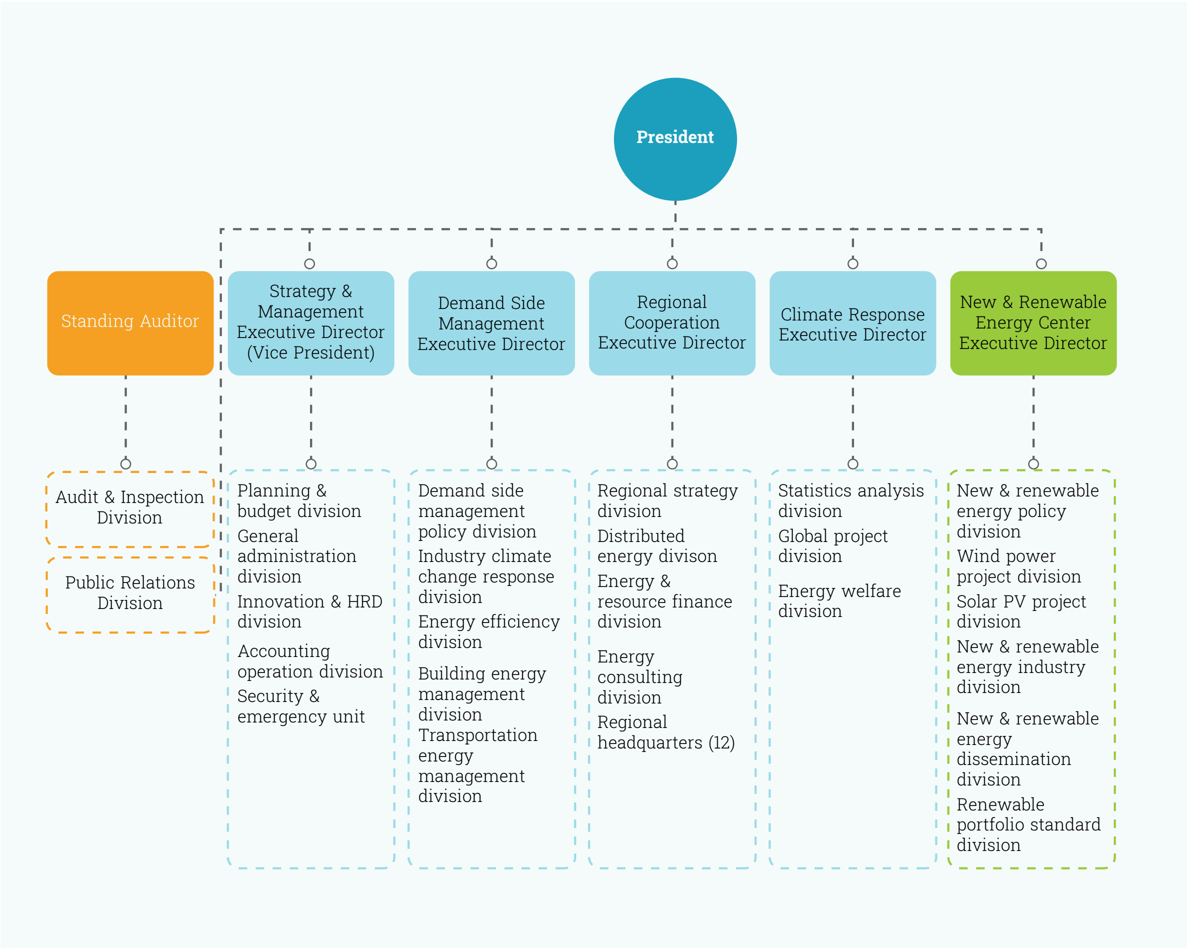


Figure 11: KEA's organisational structure[117]

5.2.2 KEA's Energy Efficiency Initiatives

KEA has three initiatives that target appliance and equipment energy efficiency directly at the manufacturing level, through the development and implementation of equipment standards. Furthermore, KEA also has a subsidy programme that promotes the use of super energy-efficient products in low-income settings and at the industry level. Table 19 describes how each initiative aims to increase the use of efficient appliances and products.

117 KEA, "Korea Energy Certification | Nemko," n.d.

Table 19: **Overview of KEA's appliance energy efficiency initiatives**

Programme title	Brief description
Energy Efficiency Labelling and Standard[118] 	This programme was introduced by KEA in 1992 and aimed to implement MEPS for commonly used products that use a large amount of energy, along with energy efficiency rating labelling. The efficiency rating range is based on five increasing levels (1-5), with level 1 representing the least energy-consuming products, and level 5 representing the highest. The programme helps accelerate the development of super energy-efficient technology, as the products that do not meet the MEPS are banned from production and sale in the market. The programme is mandatory, and manufacturers and importers are obliged to report products' energy efficiency ratings. Currently (as of 2021), the programme targets 35 products, mostly home appliances, including refrigerators, freezers, air conditioners, and washing machines.
High-Efficiency Appliance Certification[119] 	The high-efficiency appliance certification programme is a voluntary programme that was also launched in 1992 by KEA. It aims to develop and promote super energy-efficient technology/equipment, with the specific objective of creating relevant markets by promoting certified facilities that use this equipment. This, in turn, maximises energy conservation and raises the technological standards of small and medium-sized enterprises (SMEs). The programme currently (as of 2021) targets 45 products in seven different categories, including lighting equipment, insulation equipment (insulating doors, adhesive films for glazing), electricity equipment (uninterruptible power supply, motors, fans, pumps), and heating and cooling equipment (large-scale equipment).
e-Standby Power[120] 	This programme was designed and launched in 1999 by KEA to promote technologies for power reduction in standby mode and reduce widespread energy consumption during product standby. This programme sets the recommended values for standby consumption and specifically targets electronics and peripherals such as IT equipment (computers, monitors, printers), microwaves, phones, cassette players, and other entertainment devices. The equipment that meets the standards is allowed to have the energy savings label; otherwise, a warning label has to be affixed on the equipment.
High-Efficiency Electric Product Subsidy[121]	This programme has been implemented by the KEA's foundation fund since 2001 for the power industry as a demand-side measure. It aims to reduce power consumption and promote energy use rationalisation by encouraging the use of high-efficiency products that lower power consumption. The programme targets high-efficiency equipment such as LED lamps, inverters, RACs, and coolers. It also aims to promote electricity load management equipment such as cold storage systems, remote-controlled systems, and district cooling systems. Under this specific programme, KEA also replaced high-efficiency devices for free for the energy-poor, such as low-income groups and those in social welfare facilities.

5.2.3 RAC Energy Efficiency under KEA's S&L Programme

The MEPS for window and split RACs of up to 23 kW cooling capacity were brought into effect in 2004[122]. In 2013, the Grade 1 (most efficient) energy performance rating for RACs (i.e. the EER) stood at 4.4 and was replaced with an average Cooling Season Performance Factor[123] (CSPF) of 7.20 in 2015[124&125]. In addition to the energy efficiency labelling and standards, Korea

118 KEA, "Korea Energy Agency," energy.or.kr, 2018, http://www.energy.or.kr/renew_eng/main/main.aspx.
119 KEA, "Appliance Energy Efficiency," 2019.
120 KEA, "Appliance Energy Efficiency," 2019
121 KEA, "Appliance Energy Efficiency," 2019
122 Nihar Shah et al., "Opportunities for Simultaneous Efficiency Improvement and Refrigerant Transition in Air Conditioning," Lawrence Berkeley National Lab, no. July (2017):18.
123 CSPF: ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period.
124 Nihar Shah et al., "Opportunities for Simultaneous Efficiency Improvement and Refrigerant Transition in Air Conditioning," Lawrence Berkeley National Lab, no. July (2017):18.
125 KEA, "Appliance Energy Efficiency."

also has energy frontier appliances that are even more efficient than the Grade 1 appliances, as shown in Figure 12 and Table 20.

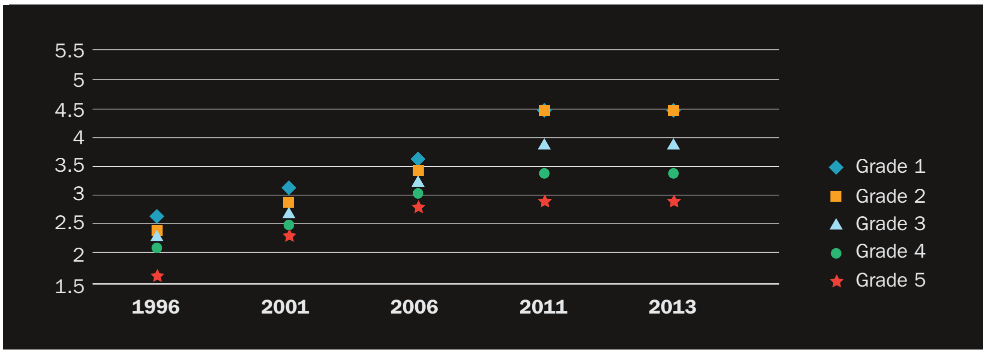


Figure 12: **RAC EER: 1996–2013**[126]

Table 20: **2015 RAC energy efficiency levels (CSPF) in South Korea**[127]

CC RT128	GRADE 5 (MEPS) - CSPF	GRADE 1 - CSPF	Best Available Technology (BAT) - CSPF
0.75	3.5	6.36	7.10
1	3.5	6.36	7.80
1.5	3.15	8.20	8
2	3.15	8.20	9.60

5.2.4 Market Transformation Strategies

In order to accelerate the transition from inefficient old RACs to super energy-efficient RACs, the Ministry of Trade, Industry, and Energy (MOTIE) launched a financial incentive programme called "Carbon Cashbag"[129&130]. This initiative rewarded low-carbon product end-users with carbon credits, similar to credit card rewards points, which can be used for transport, paying utility bills, or purchasing other super energy-efficient products. The government also introduced an innovative tax rebate mechanism called feebate[131] , which created resources to support the purchase of super energy-efficient products by low-income households[132].

In addition, KEA also supports the implementation of high-efficiency certification and deployment of super energy-efficient products through various means, such as:

- **Loans and Tax incentives**

  KEA provides financial support for the procurement of super energy-efficient equipment. Furthermore, tax rebates are provided for an amount equivalent to 3% of the investment made to procure such equipment in a given tax year.

- **Public Procurement and Institutional Buildings**

  MOTIE has mandated that public and institutional buildings should make super energy-efficient products their first choice in equipment installation or replacement. The public procurement services are also responsible for recommending highly efficient certified products to the applicants who request the purchase of certain appliances over other items in the same category.

126 Ministry of Trade, Industry, and Energy (MOTIE), "Korea Energy Efciency Policies: Korea's Energy Standards & Labeling," n.d.
127 Holuj Brian, Won Young Park, and Nihar Shah, "Model Regulation Guidelines. Energy-Efficient And Climate-Friendly Air Conditioners," 2019, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-.
128 1 RT = 3.52 kW.
129 Nihar Shah et al., "Opportunities for Simultaneous Efficiency Improvement and Refrigerant Transition in Air Conditioning," Lawrence Berkeley National Lab, no. July (2017):18.
130 Stephane De la Rue du Can et al., "Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances," Energy Policy 72 (2014): 56—66, https://doi.org/10.1016/j.enpol.2014.04.035.
131 A feebate is a tax or "fee" on less-efficient equipment that is used to fund a rebate on more efficient equipment. If designed and monitored carefully, this financing mechanism can be a revenue-neutral policy and can be independent of general government budgets. However, careful, continuous monitoring is required to make sure the balance is maintained (de la Rue du Can et al., 2014)
132 De la Rue du Can et al., "Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances."

- **Financial Incentives**

  The South Korean government provides financial incentives for installing super energy-efficient certified products such as LEDs and inverters. The government recommends the use of super energy-efficient certified products for buildings and apartments having an area of over 3000 square metres (m2). In addition, an energy-saving worksheet needs to be submitted to the head of the local government for verification and declaration.

5.3 China

China is the world's largest producer and consumer of household appliances, and appliance efficiency standards were first introduced in China in 1988 after the enactment of the Standardisation Law of China. This section provides an overview of China's S&L programme.

5.3.1 Institutional Framework & Functions

China's standards and labelling programme is administered under the State Administration of Quality, Supervision, Inspection, and Quarantine (AQSIQ), formerly known as the State Bureau of Technical Supervision (SBTS), as depicted in Figure 13[133]:

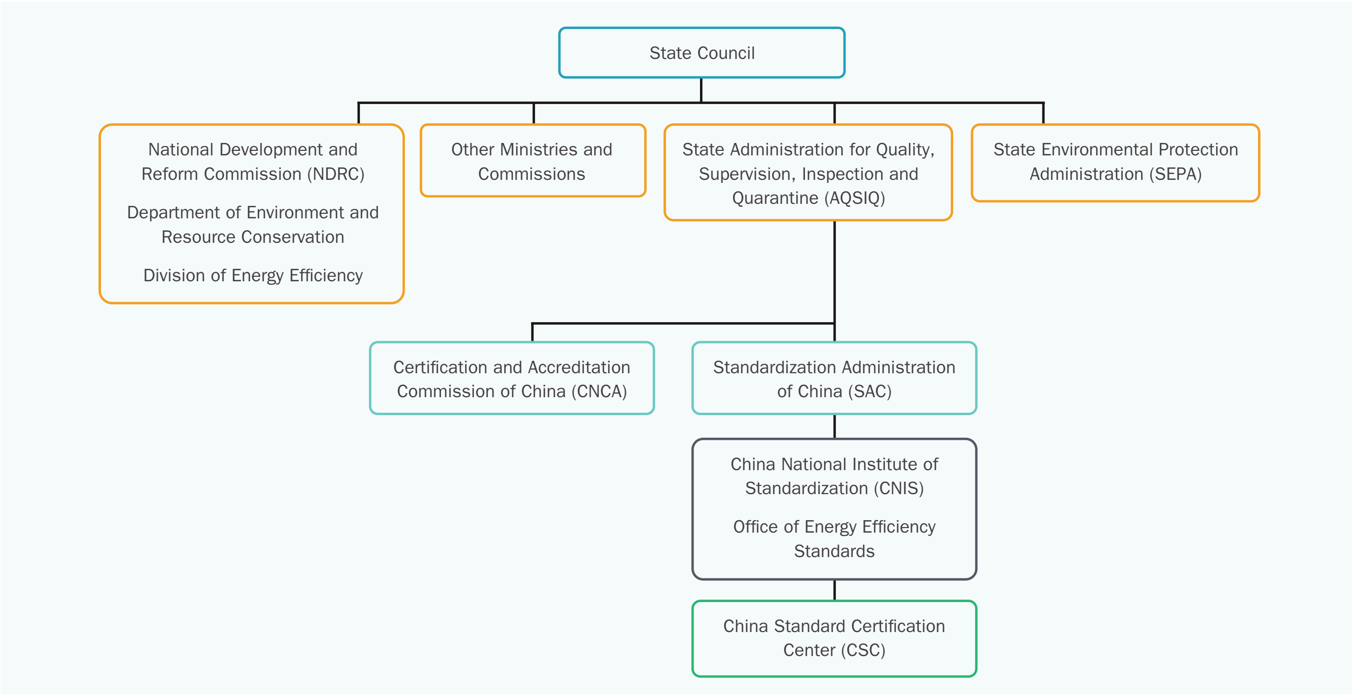


Figure 13: Governance structure of China's S&L programme[134]

AQSIQ's administrative functions related to standardisation are carried out by the Standardisation Administration of China (SAC), responsible for reviewing and approving new energy standards. Technical development work on energy standards has been delegated to the China National Institute of Standardisation (CNIS), Office of Energy Efficiency Standards. In 1998, China established the China Certification Centre for Energy Conservation Products (CECP, now China Standards Certification Centre or CSC), to implement a voluntary energy efficiency labelling programme. However, overall energy efficiency policy is developed and managed by the powerful National Development and Reform Commission (NDRC), based on the energy conservation framework laid out in the National Energy Conservation Law of 1998. Although administratively separate, CNIS and CSC both provide technical support to NDRC and are responsive to the new policy directions developed by NDRC[135].

133 Nan Zhou, "Status of China's Energy Efficiency Standards and Labels for Appliances and International Collaboration," Structure, no. March (2008).
134 Nan Zhou, "Status of China's Energy Efficiency Standards and Labels for Appliances and International Collaboration," Structure, no. March (2008).
135 Nan Zhou, "Status of China's Energy Efficiency Standards and Labels for Appliances and International Collaboration," Structure, no. March (2008).

5.3.2 China's Energy Efficiency Initiatives

The first batch of MEPS was introduced in 1989 and included different categories of equipment covered under the programme, as summarised in Table 21[136]:

Table 21: Appliances covered under the S&L programme in China[137]

Category	Products covered
Household Appliances	Washing machines, refrigerators, RAC units, and gas water heaters
Lighting Products	Fluorescent lamps, high-pressure sodium lamps, ballasts for metal halide lamps
Commercial Equipment	Water coolers, power supply adapters, air conditioning units, etc.
Industrial Equipment	Motors, compressors, pumps, transformers
Vehicles	Includes passenger vehicles
Office Equipment	Monitors, copiers

As shown in Figure 14, China took almost twenty years to fully implement and enforce the MEPS. Despite being launched earlier, the MEPS were not formalised up until the launch of the energy conservation law in 1997.

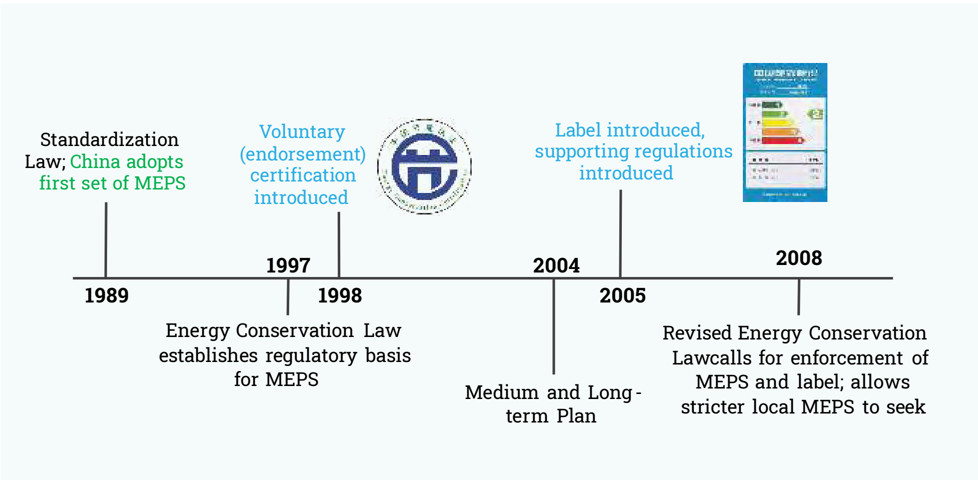


Figure 14: Evolution of S&L programme in China[138]

136 IEA, "Minimum Energy Performance Standards (MEPS)," n.d.
137 IEA, "Minimum Energy Performance Standards (MEPS)," n.d.
138 Nan Zhou et al., "Development and Implementation of Energy Efficiency Standards and Labeling Programs in China: Progress and Challenges," 2013, https://china.lbl.gov/sites/all/files/china_sl_info.pdf.

After the energy conservation law was brought into force, the CSC launched a new voluntary energy efficiency endorsement labelling programme targeting the top 25% most efficient products in 1998. In 1999, the CNIS began the process of revising single-period mandatory energy efficiency standards and developed new standards based on international best practices. In addition to the standards revision, China also developed medium- and long-term energy conservation plans and introduced mandatory standards and labels in 2005. Every 2-3 years, the standards are revised, and new products are added to the abovementioned list of appliances[139].

5.3.3 RAC Energy Efficiency under China's S&L programme

China accounts for almost 40% of global RAC sales and 70% of global RAC production[140] and aims to eliminate the bottom 20% of the least efficient products. Therefore, China recently revised the MEPS for RACs based on the Seasonal Energy Efficiency Ratio (SEER) and introduced five grades of efficiency ratings ranging from 1 to 5, with grade 1 being the most efficient and grade 5 being the least efficient or minimum energy threshold to be achieved, as shown in Table 22:

Table 22: China's RAC efficiency grades (2020-2022) [141]

Type	CC	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Split, Cooling Only (SEER)	CC ≤ 4.5 kW	5.80	5.00	5.00	3.90	3.70
	4.5 kW ≤ CC ≤ 7.1 kW	5.50	5.10	4.40	3.80	3.60
	7.1 kW < CC ≤ 14.0 kW	5.20	4.70	4.40	3.70	3.50
Split, Reversible (APF)	CC ≤ 4.5 kW	5.00	4.50	4.00	3.50	3.30
	4.5 kW ≤ CC ≤ 7.1 kW	4.50	4.00	3.50	3.30	3.20
	7.1 kW < CC ≤ 14.0 kW	4.20	3.70	3.30	3.20	3.10

From 2013 to 2020, China followed separate standard energy performance criteria for FSD and VSD RACs, with MEPS being 4.30 for VSD and 3.20 for FSD. The current standard (applicable since 2020) covers both FSD and VSD RACs in one energy performance metric. The revised performance metric proposed for VSD starts from Grade 3 values, and the one for FSD starts from Grade 5 values, as shown in Table 22. The new standard is valid from 2020-2022, where the 2020 MEPS for VSD RACs (5.00 SEER) is the new MEPS for both FSD and VSD RACs in 2022, with an annual energy efficiency improvement rate of ~16 percent[142]. The requirements of the standard also differentiate performance thresholds based on the RAC CC, as the energy efficiency of RAC compressors (e.g. rotary compressors) tends to decrease as the cooling capacity increases[143].

5.3.4 Market Transformation Strategies

China's RAC market is the largest in the world, with over 50 million units sold/year, and now it has transitioned almost completely to variable speed/inverter RACs in 2 years, from ~50% sales in 2016 to ~98% in 2020, after the adoption of a SEER for FSD and VSD RACs in 2020 and the launch of the two-phase RAC MEPS improvement plan for 2020 and 2022[144]. This trend is leading to cost reduction in inverter RACs, not only in China, but also in the global market, making those mature technologies cost-competitive with conventional technologies. Furthermore, to improve domestic sales, China has developed incentive programmes to

139 Nan Zhou, Nina Zheng Khanna, and David Fridley, "Development and Implementation of Energy Efficiency Standards and Labeling Programs in China : Progress and Challenges," no. January (2013), Lawrence Berkeley National Laboratory.

140 Brian Holuj et al., "Energy-Efficient And Climate-Friendly Air Conditioners-Model Regulation Guidelines-Supporting Information," 2019, https://united4efficiency.org/countries/country-assessments.

141 Brian Holuj et al., "Energy-Efficient And Climate-Friendly Air Conditioners-Model Regulation Guidelines-Supporting Information," 2019, https://united4efficiency.org/countries/country-assessments.

142 Brian Holuj et al., "Energy-Efficient And Climate-Friendly Air Conditioners-Model Regulation Guidelines-Supporting Information," 2019, https://united4efficiency.org/countries/country-assessments.

143 Brian Holuj et al., "Energy-Efficient And Climate-Friendly Air Conditioners-Model Regulation Guidelines-Supporting Information," 2019, https://united4efficiency.org/countries/country-assessments.

144 Amol Phadke et al., "Chinese Policy Leadership Would Cool Global Air Conditioning Impacts: Looking East," Energy Research & Social Science 66 (August 1, 2020): 101570, https://doi.org/10.1016/J.ERSS.2020.101570.

promote the use of super energy-efficient equipment and appliances. One such programme launched is the "Energy Efficient Product Benefitting Resident Project", which was launched in 2009 and allowed consumers to buy super energy-efficient appliances at subsidised rates[145]. The project has been designed to expand domestic demand and drive economic development, in order to increase the market share of super energy-efficient products. This project led to substantial energy savings—around 10 million kWh[146].

5.4 Brazil[147,148 & 149]

Brazil established the Brazilian Labelling Programme (PBE) for energy-intensive appliances in 1984. The programme's objective was to motivate manufacturers to produce super energy-efficient appliances and sensitise consumers to help them make informed purchase decisions. This section provides an overview of Brazil's S&L programme, i.e. PBE.

5.4.1 Institutional Framework & Functions[150,151 & 152]

PBE is administered by the National Institute of Metrology, Standardisation and Industrial Quality system (INMETRO) under the Energy Efficiency Law of 2001, with support from the National Electricity Conservation Programme (PROCEL), in Brazil. The PBE is based on the standards of the International Organisation for Standardisation (ISO), International Electrotechnical Commission (IEC), and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and, it also considers inputs from manufacturers and retailers. The programme includes thirty appliances, such as lighting equipment, RACs, and other household and commercial appliances.

INMETRO, which comes under the Ministry of Development, Industry, and Foreign Trade, is the federal executive body in Brazil responsible for establishing standard testing procedures and laboratories to assess the compliance of an appliance with the set standards and MEPS. The responsibility of appliance labelling and incentivisation lies with PROCEL, a federal government programme under the Ministry of Mines and Energy (MME). To support the PBE, PROCEL also operates a labelling and rewards programme, which identifies and labels super energy-efficient products in each appliance category with a seal of approval, using criteria established jointly by INMETRO and PROCEL.

5.4.2 RAC Energy Efficiency under Brazilian Labelling Programme

In 1996, PROCEL launched the first voluntary Selo PROCEL endorsement label for window RACs, and in 2004, Selo PROCEL was launched for split RACs. This was followed by the implementation of mandatory comparative labelling under the PBE in 2006, which was later revised in 2009, 2011, and 2013.

Brazil is the largest importer of air conditioners in Latin America, and with the reduction in import tariff rates, there is a significant increase in demand for air conditioners in the country. As a result, Brazil's air conditioner market is expected to further grow in 2019-25.[153] Given this, Brazil updated its MEPS for air conditioners in July 2020 by introducing the CSPF (IDRS in Portuguese) and reclassifying the energy efficiency categories for window and split air conditioners. As shown in Table 23 and Table 24, it has introduced a two-phase approach to double the efficiency of A-rated RACs (the most efficient category).

China has developed incentive programmes to promote the use of super energy-efficient equipment and appliances. One such programme launched is the "Energy Efficient Product Benefitting Resident Project", which was launched in 2009 and allowed consumers to buy super energy-efficient appliances at subsidised rates.

145 Xianli Zhu, Quan Bai, and Xiliang Zhang, "Good Practice and Success Stories on Energy Efficiency in China," 2017, https://c2e2.unepdtu.org/wp-content/uploads/sites/3/2017/06/good-practice-and-success-stories-on-ee-in-china.pdf.
146 Zhu, Bai, and Zhang.
147 ProcelInfo, "Procel Seal," accessed March 6, 2021, http://www.procelinfo.com.br/main.asp?TeamID=%7B88A19AD9-04C6-43FC-BA2E-99B27EF54632%7D.
148 CLASP, "Assessment of Brazil's Labeling Program for Air Conditioners," 2019.
149 Center for Clean Air Policy, "Minimum Performance Standards and Labeling to Improve Energy Efficiency Brazil," 1980, http://ccap.org/assets/CCAP-Booklet_Brazil.pdf.
150 "Procel Seal," accessed March 6, 2021, http://www.procelinfo.com.br/main.asp?View=%7BB70B5A3C-19EF-499D-B7BC-D6FF3BABE5FA%7D.
151 Abhyankar et al., "Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies."
152 ProcelInfo, "The Program," accessed March 6, 2021, http://www.procelinfo.com.br/main.asp?TeamID=%7B921E566A-536B-4582-AEAF-7D6CD1DF1AFD%7D.
153 6Wresearch, "Brazil Air Conditioner (AC) Market (2019-2025) - Size, Share & Trends," accessed March 6, 2021, https://www.6wresearch.com/industry-report/brazil-air-conditioner-ac-market-2019-2025.

The two-phase programme has the following energy efficiency criteria[154]:

Phase 1, from December 2022: 'A' labelled RACs must be at least 52% more efficient than current 'A' rated models.

Phase 2, from December 2025: 'A' labelled RACs must be at least 108% more efficient than current 'A' rated models.

In this latest revision, ISO 16358 is used to evaluate RAC performance.[155]

Table 23: MEPS for window RACs up to 2022[156]

Window air conditioners (with the period of adequacy for manufacture and import until 12/31/2022)				
CLASS	Seasonal Cooling Performance Index - IDRS (Wh/Wh)			
	Category 1	Category 2	Category 3	Category 4
	9,000 Btu/h	9,001-13,999 Btu/h	14,000-19,999 Btu/h	20,000 Btu/h
	2,637 W	2,638-4,102 W	4,103-5,859 W	5,860 W
A	3.10	3.21	2.95	2.89
B	3.01	3.12	2.87	2.81
C	2.93	3.03	2.79	2.72
D	2.84	2.94	2.71	2.65

As per Brazil's new regulations, the window RAC MEPS is 2.65 IDRS as shown in Table 23.

Table 24: MEPS for split RACs up to 2025[157]

Split RACs		
CLASS	Seasonal Cooling Performance Index - IDRS (Wh / Wh)	
	Adequacy period for manufacture and import until 12/31/2022	Adequacy period for manufacture and import until 12/31/2025
A	5.50	7.00
B	5.00	6.00
C	4.50	5.30
D	4.00	4.60
E	3.50	3.90
F	3.14	3.50

The MEPS for split RACs is 3.14 IDRS up to December 2022 and 3.50 IDRS up to December 2025, as shown in Table 24. (Phase 2). On comparing the split RAC MEPS of Brazil and India, Brazil had stated 3.14 IDRS as its MEPS till the year 2022, whereas India already set a MEPS of 3.1 ISEER for split RACs from 1st January 2018 to 31st December 2020. Likewise, Brazil has a MEPS of 2.65 IDRS for window RACs up to 2022, and India already had 2.5 as its MEPS for split RACs from 1st January 2018 to 31st December 2020. This shows that India has a better ratcheting up plan for RACs compared to Brazil.

154 Cool Coalition, "Brazil Publishes New AC Energy Efficiency Label Regulation," accessed March 6, 2021, https://coolcoalition.org/brazil-publishes-new-ac-energy-efficiency-label-regulation/.

155 JICA, "Energy Efficient Air Conditioners in Brazil: Revising Energy Efficiency Standards through Public-Private Partnerships," accessed March 6, 2021, https://www.jica.go.jp/english/news/field/2020/20201022_02.html.

156 Quality and Technology Ministry of Economy / National Institute of Metrology, "Official Diary Of The Union Ordinance NO. 234, OF JUNE 29, 2020," accessed March 6, 2021, https://www.in.gov.br/web/dou/-/portaria-n-234-de-29-de-junho-de-2020-264423659.

157 Quality and Technology Ministry of Economy / National Institute of Metrology, "Official Diary Of The Union Ordinance NO. 234, OF JUNE 29, 2020," accessed March 6, 2021, https://www.in.gov.br/web/dou/-/portaria-n-234-de-29-de-junho-de-2020-264423659.

5.5 Key Takeaways

It should be noted that India's ISEER performance metric and the threshold values of metrics used by other countries were not directly comparable, primarily because of the differences in RAC energy efficiency test conditions applied by each country. Therefore, the report focuses on providing an overview of the rate of improvement of RAC MEPS in each selected country and initiatives taken in these countries to promote the use of super energy-efficient RACs.

- The energy efficiency of RAC compressors tends to decrease as the CC increases. Only Japan, South Korea, and China have set their RAC MEPS as per different CCs.
- Japan, South Korea, and China have provided incentive programmes or innovative tax rebate mechanisms such as the Eco-Point System, Carbon Cashbag, feebate, and Energy Efficient Product Benefitting Resident Project to promote the use of super energy-efficient equipment and appliances.
- As part of marketing strategy, Japan has implemented display obligations, the Energy Saving Labelling Programme, and label display programme for retailers, which act as a catalyst for promoting the target super energy-efficient appliances, machinery, and other items in the market, especially amongst consumers.
- On comparing the MEPS for window RACs between Brazil and India, it was observed that brazil had stated 2.65 IDRS as its MEPS till the year 2022. However, India had already stated 2.5 as its MEPS for split RACs from 1st January 2018 to 31st December 2020. This states that India has a better retching up plan for air conditioners when compared to Brazil for RACs.
- China's annual energy efficiency improvement rate for RAC MEPS between 2020 and 2022 is ~16%, which is the highest amongst the selected countries. The 2020 MEPS for VSD RAC (5.00 SEER) is the new MEPS for both FSD and VSD RACs in 2022.

The energy efficiency improvement rate findings are summarised in Table 25:

Table 25: Energy efficiency improvement rates — country wise[158]

Country	Rated capacity/ type	Period considered (number of years)	Base MEPS	Revised MEPS during the standard upgrade	Annual energy efficiency improvement rate in RAC MEPS (approximate)
Japan[159]	< 3.2 kW	2005-2010 (5)	4.90 (COP in 2005)	5.8 (APF in 2010)	3.43%
South Korea[160]	< 4.0 kW	2012-2021 (9)	3.37 (CSPF in 2012)	4.5 (CSPF in 2021)	3.27%
Brazil[161]	< ~2.5 kW	2022- 2025 (3)	3.14 (CSPF expected in 2022)	3.5 (CSPF expected in 2025)	3.68%

158 This table has been prepared based on the information available in the public domain and deducing information from past reports by different agencies, as the regulatory documents were not available in public domain for each country with English translations. The values mentioned are approximations based on the authors' assessment of data taken from different reports.

159 Naturvårdsverket, "The Top Runner Programme in Japan-Its Effectiveness and Implications for the EU ISBN 91-620-5515-1."

160 Holuj Brian, Won Young Park, and Nihar Shah, "Model Regulation Guidelines. Energy-Efficient And Climate-Friendly Air Conditioners," 2019, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-AC-Guide-201705-.

161 Brazil's S&L programme for RACs is in the voluntary phase until December 2021.

Country	Rated capacity/ type	Period considered (number of years)	Base MEPS	Revised MEPS during the standard upgrade	Annual energy efficiency improvement rate in RAC MEPS (approximate)
China[162]	< 4.5 kW VSD & FSD	2020-2022 (2)	3.70	5.00 (SEER in 2022)	16.25%[163]
	< 4.5 kW VSD	2013-2020 (7)	4.30 (SEER in 2013)	5.00 (SEER in 2020)[164]	2.18%
	< 4.5 kW FSD	2010-2020 (10)	3.20 (EER in 2010)	3.70 (SEER in 2020)[165]	1.46%
India[166]	Unitary RAC	2018-2021 (3)	2.5 (ISEER in 2018)	2.7 (ISEER in 2021)[167]	3.92%
	Split RAC		3.1 (ISEER in 2018)	3.3 (ISEER in 2021)[168]	3.18%

**The later year indicates that the new standards have been implemented from that particular year onwards in the given country.*

In China and South Korea, the average annual energy efficiency improvement rate in the past has been around 7% and 3%, respectively, for RAC MEPS in the considered period. In comparison, in India, the annual efficiency improvement rate for RAC MEPS is approximately 3.5 % in the considered period. This indicates that India's S&L programme for RACs is almost on par with those in other selected countries. However, the baseline MEPS for the selected countries were substantially higher than the RAC MEPS in India in the considered period. Looking at Japan and Brazil, Japan has the Top Runner Programme, which did not define the RAC MEPS in recent years, i.e. post 2012, and Brazil only provided MEPS for future financial years, which did not align with the period considered in this study. Hence, they were included only as case studies. In Japan and Brazil, the average annual energy efficiency improvement rate in the past has been around 3.43% and 3.68%, respectively, for RAC MEPS in the considered period.

Considering the best available technologies in India, the period between 2021 and 2023 is a great opportunity for India to ratchet up its RAC MEPS, especially since the new S&L regime and MEPS targets for RACs are to be developed beyond 2023. This could be the first significant policy action post ICAP development, which would position India as a strong nation that backs up its declarations with action. It is therefore imperative to stay true to the course of action established collaboratively in the ICAP. Based on the review of RAC MEPS adopted internationally, the next chapter discusses the existing barriers in the Indian RAC and appliance sector and provides detailed recommendations that could be adopted by key stakeholders to circumvent those barriers in the near future in India.

In addition, a detailed analysis has been done on the interconversion between ISEER and various energy efficiency metrics for VSD units for all the selected countries based on the cooling efficiency test conditions and outdoor temperature bin hours. This analysis has been carried out by sectoral experts Dr. Nihar Shah and Won Young Park from LBNL and is presented in Annexure II.

162 Holuj Brian, Won Young Park, and Nihar Shah, "Model Regulation Guidelines. Energy-Efficient And Climate-Friendly Air Conditioners," 2019, https://united4efficiency.org/wp-content/uploads/2017/06/U4E-AC-Guide-201705-.
163 China has proposed the new RAC MEPS for 2020-2022, which is 5.00 SEER for both FSD and VSD RACs. Its annual energy efficiency improvement rate is around 16 percent.
164 VSD – Cooling only split RACs. However, the revised MEPS applies to both split and window RACs.
165 FSD – Cooling only split RACs. However, the revised MEPS applies to both split and window RACs.
166 Bureau of Energy Efficiency, "Room Air Conditioners ," accessed March 5, 2020, http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.
167 For unitary RACs
168 For split RACs (both FSD and VSD)

06 Recommendations & Conclusion

In March 2019, the BEE convened the TCM for RACs to discuss the further scope of improvement in RAC energy efficiency levels, since the star rating schedule for both windows and split type air conditioner was going to expire on 31st December 2019. During the meeting, BEE proposed an annual efficiency improvement of a 5% in split RACs, which is in line with ICAP recommendations to the committee members (including representatives from manufacturers and industry associations). However, the manufacturers countered BEE's proposal, seeking a delay in the revisions and suggesting that the existing star rating schedule be extended for the next two years. Therefore, the committee decided to finalise the new star rating schedule later. Subsequently, BEE revised its proposal to have an annual improvement of 3.7% in 2020-21 and 2022-23, which is only a marginal improvement over the BAU scenario and less than half of what is needed to meet ICAP's goal.

The market shares of different star-rated RACs have varied since the inception of the RAC S&L programme, as depicted in Figure 4 in Chapter 3. The 3-star models lead RAC sales in 2018-19, with a 73% market share in the fixed speed segment and 77% share in the variable speed segment. Despite the greater potential energy savings of 5-star RACs, consumers are still preferring the 3-star models due to the 5-star models' higher upfront costs. Moreover, manufacturers have expressed their inability to lower the production costs of their 5-star models due to the higher input costs of the required technology and raw material. These demand- and supply-side factors result in a lower market share for the super energy-efficient RACs. This presents policymakers with a great challenge, to understand and work on the barriers that cause hindrances to energy efficiency improvements, beyond the ratcheting up of RAC MEPS. While the primary recommendation of this study is to ratchet up the RAC MEPS improvement rate from 3% to 6% annually, in coherence with the ICAP's recommendation, the report also suggests ecosystem-level interventions, including tackling various aspects such as institutional (including regulation and enforcement), financial, and market barriers.

Table 26 summarises the barriers to increasing energy efficiency in the RAC and the overall appliance ecosystem, related observations, and recommendations on how to overcome these barriers. The recommendations have been divided into two sets. The first set of recommendations are specific to 'supporting the ratcheting up of RAC MEPS' and are based on the learnings drawn from S&L programmes in the other countries reviewed in the report. The second set of recommendations include 'sector-specific suggestions' that could help enhance the appliance ecosystem and overall strengthen BEE's S&L programme and are based on AEEE's overall experience and expertise in the appliance domain.

BEE revised its proposal to have an annual improvement of 3.7% in 2020-21 and 2022-23, which is only a marginal improvement over the BAU scenario and less than half of what is needed to meet ICAP's goal.

Table 26: Identified barriers and policy gaps and recommendations

Barrier/policy gap	Observations	Recommendations
Recommendations to support the ratcheting up of RAC MEPS		
Regulatory barriers: frequency of ratcheting up RAC S&L	BEE has been revising the standards for split RACs every 2-3 years. However, manufacturers have expressed their concern about these shorter changeover periods, as this does not provide enough time to establish and generate consumer interest in a 5-star rated product during that time period. In other countries, the frequency of revision is usually 5 years, keeping in mind the efficiency improvement targets, while BEE is revising the standards more frequently and not allowing the market to settle down. The test procedure of India is based on Indian climatic conditions and thus only applicable to the Indian sub-continent or countries with similar weather profiles.	In the four studied countries, the average annual improvement rate was around 5%, even if the standards are being revised every 3-5 years. However, in the case of India, the rate of annual efficiency improvement is only around 3.5 percent. Thus, BEE has scope to increase the rate of efficiency improvement, which several stakeholders have recommended under the umbrella of the Sustainable and Smart Space Cooling Coalition and ICAP. In addition, to become a major RAC exporter, India needs to compete with international standards and test procedures and initiate action towards harmonising efficiency parameters and testing standards to make them on par with global standards such as ISO or ASHRAE. Moreover, India could start considering the adoption of ecolabels for RACs to stay ahead of the demand curve for the next phase of RAC standards revision, as the new standards are yet to be designed and will be implemented starting in January 2024.
Market barriers: need to develop innovative business & financial models	EESL introduced the bulk procurement model, which has brought down the prices of super energy-efficient equipment substantially. However, the deployment of super energy-efficient RACs still is a challenge due to the higher upfront cost associated with these products, which does not allow the payback to be less than five years.	A servitisation model could be adopted for the deployment of super-efficient RACs. In servitisation, the consumer does not pay the entire amount upfront, but rather pays a fixed charge on the monthly usage based on the contract tenure. This model is beneficial for consumers, and there could be intermediaries at a local level to facilitate such transactions, increasing super-efficient RAC penetration and facilitating access to cooling and thermal comfort for all. Innovative financial mechanisms such as on-utility bill financing or on-wage (for salaried employees) financing for super energy-efficient RAC deployment could also be adopted in India to accelerate the transition to super energy-efficient RACs and reduce RACs' share in building sector energy consumption. In addition, consumer purchase perception studies could help assess other barriers and create enabling mechanisms to increase the purchase of super energy-efficient equipment.
Market barriers: absence of incentives/ tax rebates for efficient products	Based on periodic changes in the S&L, the manufacturers make investments to produce five star-rated appliances, which result in higher product MRPs and lower consumer demand, despite the products' potential energy savings. Reducing import duties and taxes on LEDs has resulted in a significant drop in their MRPs and a drastic increase in their market share. There has periodically been a debate on extending the differential tax mechanism to other appliances, but no significant steps in this direction have been taken so far. Internationally, super-efficient products have been promoted through incentive schemes such as carbon cash bags, eco-point systems, or feebate, allowing end-users to accumulate credits that can be used in subsequent purchases.	Reduction of the 28% goods and services tax (GST) would increase the affordability of super energy-efficient RACs. Perhaps for super-efficient RACs, a lower GST could even be considered. Leveraging existing incentives and market mechanisms such as cashbacks and zero percent interest, a carbon cashback or a carbon reward payback system can be integrated or developed. The system could consider allowing storage of carbon credits (5-10% of the equipment value) and utilise the credits to purchase other super energy-efficient equipment. Mechanisms like these may shift customer preferences towards super energy-efficiency equipment. For example, the purchase of 5-star RACs, could, in turn, encourage the purchase of other super energy-efficient products in the future.

Barrier/policy gap	Observations	Recommendations
Recommendations to enhance the appliance ecosystem		
Enforcement barriers: limited SDA capacity	The Energy Conservation Act has defined a two-tier structure: BEE at the centre to formulate the policies and SDAs at the state level to enforce and implement the policies. The primary purpose of SDAs is to coordinate, regulate, and enforce the provisions of EC Act within the state and ensure implementation of the provisions and norms specified under the S&L scheme. The role of the SDAs is thus critical from a policy implementation perspective. However, despite having the legal provisions, the SDAs lack the required know-how and resources, which hinders them in executing the enforcement tasks and has also led to several compliance and verification related issues in the past.	Regular capacity building of SDAs can help ensure better enforcement, as SDA officials keep changing within the governmental setup, and it is important to apprise the new officials of the SDA's roles and responsibilities. Furthermore, strengthening SDAs with the support of additional trained specialists and energy professionals could help fast-track the implementation of energy conservation efforts besides the S&L programme.
Enforcement barriers: limited testing capacity	Another aspect w.r.t enforcement is the availability of sufficient third-party testing labs. The appliance market has grown exponentially, and to ensure that these appliances comply with the efficiency norms, they have to be tested and certified. Unfortunately, there is a gap between the existing testing lab capacity and required capacity.	There is a need to take stock of the existing government, private, and industry test labs in India available for appliance testing and their regional presence, in order to ensure sufficient testing capacity in every state. Furthermore, there should be an assessment of the need for testing lab upgradation to meet global standards. Moreover, a technology transfer platform could be created to enable swift and faster development of technologies to equip labs with state-of-the-art technologies for appliance testing on par with international standards.
Financial barriers: absence of financial mechanisms to promote RAC R&D infrastructure	Achieving efficiency improvements in the appliances requires both technical and financial resources. Although the manufacturers, with support from sectoral experts (internal and external), BEE's capacity building programme, and think tanks, can harness the technical know-how, the pending issue is the availability of financial resources to facilitate these macro-level research initiatives and deployment of innovative technologies. The GCP is one such initiative that has encouraged the coupling of financial rewards with technological innovations. However, a mechanism that facilitates large-scale replication of these innovations is yet to be developed.	More programmes should support disruptive, super-efficient, and eco-friendly technology development and the 'Make in India' initiative. While R&D departments such as the Department of Science and Technology (DST) & Council of Scientific and Industrial Research (CSIR) have funds, they can invest in syndicated research, there is a need to review the utilisation of these funds and augment the funds to accelerate research on super energy-efficient technologies. The information on such funds could be widely disseminated so that the private sector can partner with recognised government research institutions and access these funds. Furthermore, the fund allocation should only be made based on critical evaluation, including the product's affordability, scalability, ability to be immediately deployed, job creation, and circularity as key criteria, in addition to the proposed technologies' climate impact and energy efficiency to foster eco-system development.

Based on the literature review of India's institutional and regulatory framework for appliances, it appears that India's S&L programme is robust, well-designed, and highly impactful. However, there are challenges and issues related to its consistent and coordinated implementation. Hence, there is substantial scope for improvement in India's S&L programme, from coordinating the efforts at the central level with state and non-state actors, to supporting it's efficient and effective enforcement and implementation.

07 Way Forward

A Critical Opportunity for BEE to Demonstrate Leadership and Meet ICAP Targets.

Consumer behaviour studies could also provide a way forward for better understanding the consumer perceptions, barriers, and demand scenario, in order to tailor strategies to current end-user requirements.

With soaring temperatures, rising income levels, and increased RAC adoption in India, efficiency standards will play a key role in determining whether India meets its Paris Agreement commitments or not. Moreover, as one of the world's leading market for RAC growth, India is under scrutiny for actions being taken to meet its soaring cooling demand in an energy-efficient manner. The ICAP has earned well-deserved accolades and attention globally for the government of India for putting forth this bold and proactive policy document; it took exemplary interdepartmental and cross-sectoral collaboration to develop the ICAP jointly. Nevertheless, now all eyes are upon India to see how it can realise the targets and recommendations established in ICAP 2019. Thus, India cannot fall short on the implementation front. Based on the literature review of India's institutional and regulatory framework for appliances, it appears that India's S&L programme is robust, well-designed, and highly impactful. However, there are challenges and issues related to its consistent and coordinated implementation. Hence, there is substantial scope for improvement in India's S&L programme, from coordinating the efforts at the central level with state and non-state actors, to supporting it's efficient and effective enforcement and implementation.

Moreover, the availability of innovative, super energy-efficient technologies nationally and globally as a result of GCP offers India a unique opportunity to ratchet up the RAC MEPS. The GCP announced two winners in April 2021, which both met the prize criteria of five times lower climate impact compared to the average RAC available on the Indian market, indicating the global market is continuing to innovate and the efficiency of all products is increasing, while RAC costs continue to fall.

In addition, consumer behaviour studies could also provide a way forward for better understanding the consumer perceptions, barriers, and demand scenario, in order to tailor strategies to current end-user requirements. Furthermore, given the severity of the social, economic, and environmental consequences, BAU is no longer an option, as moving slowly, in this case, is akin to losing surely. Moreover, most important, the period from 2021 to 2023 gives India a unique opportunity to take the lead and set an ambitious target for other areas of ICAP intervention, especially since the new S&L regime and MEPS targets for RACs are yet to be developed beyond 2023. This could be the first significant policy action post ICAP development, which would position India as a strong nation that upholds its commitments. Therefore, it is imperative for India to stay true to the course of action established collaboratively in the ICAP, as anything less would disrupt the ethos of ICAP and may threaten its future relevance.

The period from 2021 to 2023 gives India a unique opportunity to take the lead and set an ambitious target for other areas of ICAP intervention, especially since the new S&L regime and MEPS targets for RACs are yet to be developed beyond 2023. This could be the first significant policy action post ICAP development, which would position India as a strong nation that upholds its commitments.

Annexure I

Finalist Companies and Technology specifications[169]

Table 27: GCP's eight Finalist Companies and their Technology specifications

S.No.	Name	Technology specification
1	**Barocal Ltd**	This non-vapour compression technology, i.e. barocaloric cooling technology, could transform existing air conditioning technology and make it more climate-friendly. Instead of using refrigerants with high GWP typical to vapour compression technology, this solid-state barocaloric cooling technology takes advantage of the properties of solid organic 'plastic crystal' materials to provide cooling. Plastic crystals are flexible materials that are widely available, low in cost, and nontoxic.
2	**Daikin and partner Nikken Sekkei Ltd.**	The cooling system adopts the following two innovative methods to achieve higher efficiency and lower climate impact: 1. The multi-split method is used to connect two indoor units with one outdoor unit. This method helps optimize the refrigerant flow rate for each of the two indoor units depending on the ever-changing cooling load and uses refrigerant control technology to modulate the capacity closely. 2. The system uses control technology that measures the outdoor temperature with sensors and applies the control system to automatically spray water under high ambient temperature conditions where the cooling load seems exceptionally high.
3	**Godrej and Boyce Manufacturing Company Ltd. and partner ATE Enterprises Pvt. Ltd.**	This cooling technology integrates Godrej's high-efficiency vapour compression system with a natural, low-GWP refrigerant and advanced evaporative cooling technology. The advanced evaporative cooling technology reduces the cycle temperature, which optimizes compressor performance. The grid electricity consumption of the cooling system is further reduced by improving the heat exchanger efficiency and by using a small integrated solar photovoltaic panel to offset part of the total power demand of the solution. The smart controls optimise the performance of this integrated solution depending on the set indoor temperature and humidity requirements of the space.
4	**Gree Electric Appliances Inc. of Zhuhai and partner Tsinghua University**	Gree's innovative Zero Carbon Source cooling technology integrates advanced vapour compression refrigeration, photovoltaic direct-driven technology, evaporative cooling, and ventilation, efficiently utilising renewable energy sources and free cooling sources. Gree's cooling solution has an automatic, climate-smart operation with three unique modes: vapour compression refrigeration, evaporative cooling, and ventilation, which can operate individually or in parallel depending on the outside weather conditions to provide optimised indoor cooling and dehumidification. This climate-adaptive residential air conditioner has 5X lower climate impact than today's conventional air conditioners. Gree's cooling solution highlights how the upper-efficiency limit of today's predominant technology-vapour compression technology-can be primarily expanded through smart, hybrid design.
5	**Kraton and partners Infosys, IIT Bombay, and Porus Labs**	Nexar Cool technology integrates a membrane-based dehumidifier with a water-based direct evaporative cooling system to achieve air conditioning without refrigerant. The technology utilizes the moisture transport properties of the Nexar membrane. The membrane-based dehumidifier system removes moisture from the room air and ejects it outside, thus dehumidifying the indoor air. This integration has lower energy consumption than conventional air conditioners. In addition, the solution has a lower climate impact because no refrigerant is used.

169 Global Cooling Prize, "About The Finalists."

S.No.	Name	Technology specification
6	**M2 Thermal Solutions**	This cooling solution integrates an evaporative cooling technology with a membrane system in a packaged design that can independently cool and dehumidify room air, enabling dramatically lower energy consumption. In this system, an evaporative cooler first cools the room air while increasing its humidity. The cool and humid air is then passed through a membrane system to remove the excess water vapour from the cool air, resulting in decreased air humidity. The solution also can bypass either of these processes and use a ventilation mode depending on outdoor weather conditions. The water supplied to the evaporative cooler is generated by the membrane system, which reduces the water footprint. This solution can achieve significantly lower climate impact than typical AC units sold today as it has no compressor or refrigerant, with an innovative approach to independent cooling and dehumidification.
7	**Transaera and partner Haier**	The cooling solution is designed to operate a high-efficiency RAC in parallel with a novel dehumidifier to provide optimal thermal comfort, especially in regions with hot and humid climates. In addition, by separating the temperature and humidity control processes, this RAC can reduce energy consumption by as much as 70 per cent compared with standard air conditioners. Transaera's technology comprises a proprietary desiccant material and heat exchanger that spontaneously absorbs this water vapour, allowing room air to dry. Dry air is easier to cool with a high-efficiency AC unit, thus reducing the overall electricity consumption. In addition, Transaera's material can be regenerated using exhaust heat from the cooling subsystem, a source of energy that is usually wasted. Finally, the solution provides a direct evaporative cooling option at the condenser inlet to improve further condensing efficiency and a small integrated solar photovoltaic panel and battery to reduce peak grid consumption.
8	S&S Design Start-up Solution Private Limited Information not available	

Annexure II

This section has been prepared by the sectoral experts, Dr Nihar Shah and Won Young Park from Lawrence Berkeley National Laboratory (LBNL).

Seasonal Energy Efficiency Metrics for Air Conditioners[170]

Seasonal energy efficiency ratio (SEER) metrics have been designed to estimate air conditioner (AC) performance, based on part- and full-load operations at multiple temperature conditions depending on climate. Local climatic conditions affect the amount of time an AC operates at part or full load, so climate-specific weighting is used in calculating SEER to provide a more representative measure of performance than the traditional energy-efficiency ratio (EER), typically defined as rated cooling capacity (CC) over rated power input.[171]

Cooling Efficiency Test Conditions

In this analysis, the cooling seasonal performance factor (CSPF) or SEER calculations for variable-speed units are based on two or three sets of required test data at 35°C and another set of data points at 29°C calculated by pre-determined equations in Table 28.

Table 28: **Parameters used for the cooling efficiency calculations for variable-speed units[172]**

	Brazil	China	India	Japan	Korea
Full capacity and power input (35°C)	Required	Required	Required	Required	Required
Half capacity and power input (35°C)a	Required	Required	Required	Required	Required
Minimum capacity and power input (35°C)	Not considered	Not considered[a]	Not considered	Not considered	Required
Full capacity and power input (29°C)	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Half capacity and power input (29°C)	Optional[c]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Minimum capacity and power input (29°C)	Not considered	Not considereda	Not considered	Not considered	Calculated[b]

a The China (for units with CC > 7.1 kW) standard requires the minimum capacity test at 35°C and allow the minimum capacity test at 29°C to be calculated by using default values. This analysis does not consider the minimum-load performance since the majority of room ACs have cooling capacity less than 7.1 kW.

b Performance at the lower temperature can be calculated by using predetermined equations as below:

ISO, Brazil, China, India, Japan: ; South Korea: ;

c Under the Brazil standard, the half capacity test at 29°C is optional. This analysis uses the predetermined equations.

170 Won Young Park et al., "Lost in Translation: Overcoming Divergent Seasonal Performance Metrics to Strengthen Air Conditioner Energy-Efficiency Policies," Energy for Sustainable Development 55 (April 1, 2020): 56–68, https://doi.org/10.1016/J.ESD.2020.01.003.

171 The International Organization for Standardization (ISO) standard 5151 defines EER as the ratio of the total CC to the effective power input to the device at any given set of rating conditions, and it defines coefficient of performance (COP) as the ratio of the heating capacity to the effective power input to the device at any given set of rating conditions. We note that EER and COP have alternative definitions in certain regions.

172 Park et al., "Lost in Translation: Overcoming Divergent Seasonal Performance Metrics to Strengthen Air Conditioner Energy-Efficiency Policies."

Annual Performance Factor (APF) for Japan

The ISO heating seasonal performance factor (HSPF) and annual performance factor (APF) calculations for variable-speed reversible heat pump units are based on the above CSPF calculation and additional three sets of required test data at full- and half-capacity heating operation at 7°C and extended capacity frosting at 2°C, and other set of data points at 2°C and -7°C calculated by ISO 16358-determined equations.

Table 29: Parameters used for the APF calculation for Japan[173]

	Operating condition	Variable Speed Cooling only	Variable Speed Reversible
Cooling	Full capacity (35°C)	Required	Required
	Half capacity (35°C)	Required	Required
	Full capacity (29°C)	Calculateda	Calculated[a]
	Half capacity (29°C)	Calculateda	Calculated[a]
Heating	Full capacity (7°C)	NA	Required
	Half capacity (7°C)	NA	Required
	Extended capacity, frosting (2°C)	NA	Required
	Full capacity, frosting (2°C)	NA	Calculated[b]
	Half capacity, frosting (2°C)	NA	Calculated[b]
	Extended capacity (2°C)	NA	Calculated[b]
	Full capacity (2°C)	NA	Calculated[b]
	Half capacity (2°C)	NA	Calculated[b]
	Extended capacity, frosting (-7°C)	NA	Calculated[b]
	Full capacity, frosting (-7°C)	NA	Calculated[b]
	Half capacity, frosting (-7°C)	NA	Calculated[b]

a Refer to Table 1 for default values or predetermined equations.

b Refer to JIS C 9612: 2013 or ISO 16358-2: 2013 for default values or predetermined equations.

Outdoor Temperature Bin Hours

The seasonal efficiency metrics used in Brazil, China, India, Japan, and South Korea are consistent with ISO 16358 defined metrics (i.e., CSPF, HSPF, or APF), using the same or similar test requirements in Table 28, except they use country-specific climatic conditions and some adjustments.

Table 30: Outdoor temperature bin hours used in calculations of cooling seasonal energy efficiency[174]

	ISO 16358	Brazil	China	India	Japan	Korea
Temperature range	21—35°C	21—38°C	24—38°C	24—43°C	24—38°Ca	24—38°Ca
Total hours of outdoor temperature binb	1,817	2,080	1,136	1,600	1,569	941
Metric	CSPF	CSPF	SEER	ISEER	CSPF	CSPF

a Although JIS C 9612:2013 and KS C 9306:2017 define outdoor temperature bin hours in the range of 24—38°C, zero hours are actually assigned to 35—38°C in JIS C 9612:2013 and 38°C in KS C 9306:2017.

b Bin hours of each outdoor temperature may be calculated by multiplying the fractional bin hours by the total annual cooling hours if the fractional bin hours are applicable. ISO 16358 also provides fractional bin hours.

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Translation of Regional Energy Efficiency Metrics

The difference in seasonal efficiency metrics is primarily due to the outside temperature profiles that are used to aggregate steady-state and cyclic ratings into a seasonal efficiency value, as well as the ways of evaluating performance at part-load operation in the metric. Specific parameters to account for RAC performance at part-load and/or lower-temperature operation in the efficiency metric vary by country[175]. The paper titled 'Lost in translation: Overcoming divergent seasonal performance metrics to strengthen air conditioner energy-efficiency policies' published in 2020 established the regression equations for identifying relationships between efficiency metrics in China, the EU, India, Japan, South Korea, and the U.S., to compare efficiency of RACs available in those markets. This analysis is built up by primarily using performance data of reversible heat pumps.

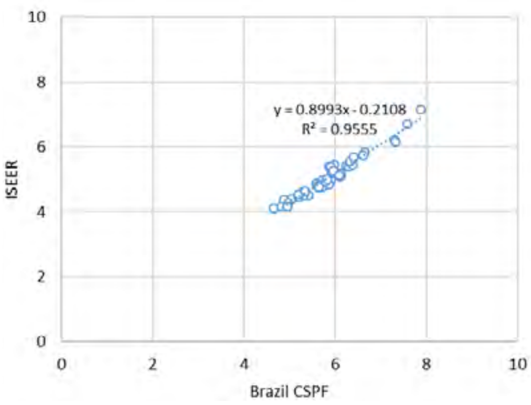
ISEER = 0.899 × *Brazil CSPF* — 0.211 (R^2 = 0.956)

ISEER = 0.998 × *China SEER* — 0.082 (R^2 = 0.989)

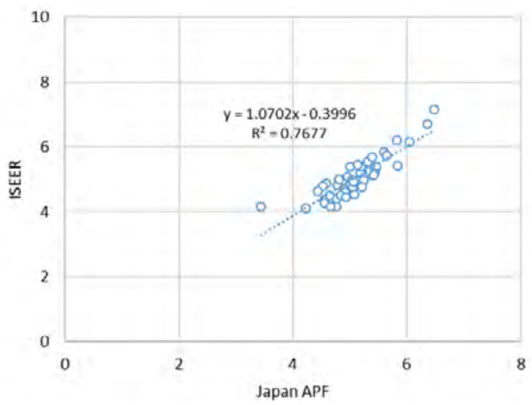
ISEER = 1.070 × *Japan APF* — 0.400 (R^2 = 0.768)

ISEER = 0.471 × *Korea CSPF* + 2.837 (R^2 = 0.791)

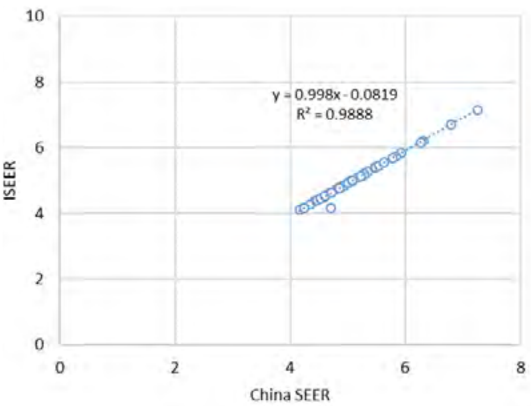
Brazil: Linear regression for 47 models



Japan: Linear regression for 47 models



China: Linear regression for 47 models



Linear regression for 14 models

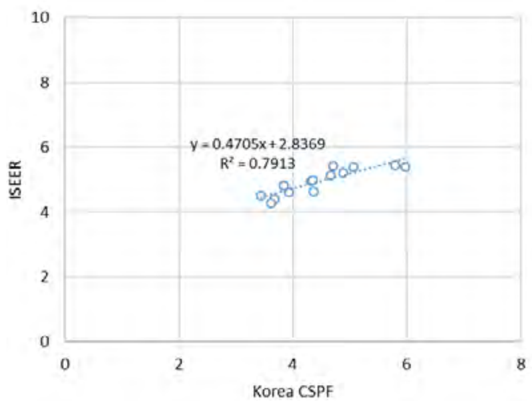


Figure 15. **Linear regression results of regional efficiency metrics**

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Bibliography

6Wresearch. “Brazil Air Conditioner (AC) Market (2019-2025) - Size, Share & Trends.” Accessed March 6, 2021. https://www.6wresearch.com/industry-report/brazil-air-conditioner-ac-market-2019-2025.

Abhyankar, Nikit, Nihar Shah, Won Young Park, and Amol Phadke. “Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies.” Lawrence Berkeley National Laboratory Working Paper, LBNL-1005798, no. April (2017): 1–30.

“About ISHRAE: HVAC Industry Standards, Education & Training Programs.” Accessed March 4, 2021. https://ishrae.in/Home/about_ishrae.

Bhaiya, Nilesh, and Pratik Singh. “Consumer Durables.” Automotive Engineer (London) 35, no. 4 (2010): 38–39. https://doi.org/10.4324/9780429043352-11.

Brian, Holuj, Won Young Park, and Nihar Shah. “MODEL REGULATION GUIDELINES. ENERGY-EFFICIENT AND CLIMATE-FRIENDLY AIR CONDITIONERS,” 2019. https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-.

BSES. “BSES Rajdhani Power Limited,” 2019. https://www.bsesdelhi.com/web/brpl/home (December, 2019).

Bureau of Energy Efficiency. “About BEE,” 2020. https://beeindia.gov.in/content/about-bee.

———. “Enforcement Machinery under Energy Conservation Act, 2001.” Accessed March 4, 2021. https://beeindia.gov.in/sites/default/files/Enforcement Machinery PPT.pdf.

———. “Guidelines for the Permittee-Standards and Labelling Program of BEE,” 2016. https://www.beestarlabel.com/Content/Files/Scheme of energy efficiency labelling.pdf.

———. “Impact of Energy Efficiency Measures for the Year 2018-19,” 2020.

BUREAU OF ENERGY EFFICIENCY. “IMPACT OF ENERGY EFFICIENCY MEASURES.” Accessed March 6, 2021. www.beeindia.gov.in.

Bureau of Energy Efficiency (BEE). “Standards & Labeling,” 2020. https://beeindia.gov.in/content/standards-labeling.

Bureau of Indian Standards. “About BIS.” Accessed March 4, 2021. https://bis.gov.in/index.php/the-bureau/about-bis.

Center for Clean Air Policy. “Minimum Performance Standards and Labeling to Improve Energy Efficiency Brazil,” 1980. http://ccap.org/assets/CCAP-Booklet_Brazil.pdf.

CLASP. “Assessment of Brazil’s Labeling Program for Air Conditioners,” 2019.

Clean Energy Ministerial. “Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative,” 2019. http://climateinitiativesplatform.org/index.php/Super-efficient_Equipment_and_Appliance_Deployment_(SEAD)_Initiative.

———. “Super-Efficient Equipment and Appliance Deployment | Clean Energy Ministerial |Super-Efficient Equipment and Appliance Deployment .” Accessed March 4, 2021. http://www.cleanenergyministerial.org/initiative-clean-energy-ministerial/super-efficient-equipment-and-appliance-deployment.

Comptroller and Auditor General of India. “Comptroller and Auditor General of India for the Year Ended March 2018,” 2020. https://cag.gov.in/sites/default/files/audit_report_files/Union_Direct_Tax_Compliance_Revenue_Report_3_2016_Department_Revenue.pdf.

Consumer Electronics and Appliances Manufacturers Association (CEAMA). “Association Overview.” Accessed March 4, 2021. https://ceama.in/AssociationOverview.html.

Cool Coalition. “Brazil Publishes New AC Energy Efficiency Label Regulation.” Accessed March 6, 2021. https://coolcoalition.org/brazil-publishes-new-ac-energy-efficiency-label-regulation/.

Department of Consumer Affairs, Ministry of Consumer Affairs Food and Public Distribution, and Government of India. “Vision and Mission,” 2020. https://consumeraffairs.nic.in/vision-and-mission.

Department of food and distribution, India. “About Us .” Accessed March 4, 2021. https://dfpd.gov.in/about-us.htm.

EESLmart. “EESL Mart.” Accessed March 5, 2021. https://eeslmart.in/#about.

Energy Efficiency Services Limited. “About Us.” Accessed March 5, 2021. https://eeslindia.org/en/about-us/.

———. “Training Program of Channel Partners IEES Model & Super-Efficient Air Conditioner Program,” 2021. https://eeslindia.org/wp-content/uploads/2021/04/SEAC-PPT_09.04.21.pdf.

Global Cooling Prize. “About The Finalists.” Accessed June 2, 2021. https://globalcoolingprize.org/about-the-finalists/.

———. “Details and criteria about the global cooling prize,” 2019.

———. “Global Cooling Prize,” 2021. https://globalcoolingprize.org/.

———. “Timeline and Milestones.” Accessed March 6, 2021. https://globalcoolingprize.org/prize-details/timeline/.

Holuj, Brian, Won Young Park, Nihar Shah, Noah Horowitz, and Alex Hillbrand. “Model Regulation Guidelines - RACs,” 2019.

Holuj, Brian, Young Park Won, Shah Nihar, Horowitz Noah, and Hillbrand Alex. “Energy-Efficient And Climate-Friendly Air Conditioners- Model Regulation Guidelines-Supporting Information,” 2019. https://united4efficiency.org/countries/country-assessments.

IEA. “Minimum Energy Performance Standards (MEPS),” n.d.

———. “PEET Efficiency Trends Analysis,” 2021.

IIFL. “RAMA Supports BEE Labelling Programme, Clarifies on Recent CSE Report.” Accessed March 4, 2021. https://www.indiainfoline.com/article/general-csr/rama-supports-bee-labelling-programme-clarifies-on-recent-cse-report-116081700626_1.html.

India Brand Equity Foundation Report. “Indian Consumer Durables Presentation.” Accessed March 5, 2021. https://www.ibef.org/industry/consumer-durables-presentation.

Innovation, Mission. “Global Cooling Prize: Finalists to Be Announced in November.” Accessed March 4, 2021. http://mission-innovation.net/2019/09/06/global-cooling-prize-finalists-to-be-announced-in-november/.

“Japan Meteorological Agency | General Information on Climate of Japan.” Accessed February 18, 2021. https://www.data.jma.go.jp/gmd/cpd/longfcst/en/tourist.html.

JICA. “Energy Efficient Air Conditioners in Brazil: Revising Energy Efficiency Standards through Public-Private Partnerships.” Accessed March 6, 2021. https://www.jica.go.jp/english/news/field/2020/20201022_02.html.

KEA. “Appliance Energy Efficiency,” 2019.

———. “KOREA ENERGY AGENCY.” energy.or.kr, 2018. http://www.energy.or.kr/renew_eng/main/main.aspx.

———. “Korea Energy Certification | Nemko,” n.d.

Krishnan, R., J. Sanjay, Chellappan Gnanaseelan, Milind Mujumdar, Ashwini Kulkarni, and Supriyo Chakraborty. Assessment of Climate Change over the Indian Region: A Report of the Ministry of Earth Sciences (MOES), Government of India. Assessment of Climate Change over the Indian Region: A Report of the Ministry of Earth Sciences (MoES), Government of India, 2020. https://doi.org/10.1007/978-981-15-4327-2.

Kubo, Kensuke, and KOJIMA Watanabe, MarikoJapan Michikazu. “Should Energy Efficiency Be Traded Off for Other Product Attributes ? An Analysis of Air-Conditioner Regulation in Japan,” no. 607 (2016). https://www.ide.go.jp/library/English/Publish/Download/Dp/pdf/607.pdf.

la Rue du Can, Stephane De, Greg Leventis, Amol Phadke, and Anand Gopal. "Design of Incentive Programs for Accelerating Penetration of Energy-Efficient Appliances." Energy Policy 72 (2014): 56—66. https://doi.org/10.1016/j.enpol.2014.04.035.

Lalit, Radhika, and Ankit Kalanki. "How India Is Solving Its Cooling Challenge." World Economic Forum, 2019. https://www.weforum.org/agenda/2019/05/india-heat-cooling-challenge-temperature-air-conditioning/.

Ministry of Economy / National Institute of Metrology, Quality and Technology. "OFFICIAL DIARY OF THE UNION ORDINANCE NO. 234, OF JUNE 29, 2020." Accessed March 6, 2021. https://www.in.gov.br/web/dou/-/portaria-n-234-de-29-de-junho-de-2020-264423659.

Ministry of Economy Trade and Industry. "Top Runner Program. Developing the World's Best Energy- Efficient Appliance and More," 2015.

Ministry of Environment Forest & Climate Change (MoEF&CC). "India Cooling Action Plan," 2019. http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf.

Ministry of Environment Forest & Climate Change Government of India. "Introduction," 2020. http://moef.gov.in/en/about-the-ministry/introduction-8/.

Ministry of Power. "Overview | Government of India," 2016. https://powermin.nic.in/en/content/responsibilities.

Ministry of Trade Industry and Energy (MOTIE). "Korea Energy Efficiency Policies: Korea's Energy Standards & Labeling," n.d.

Naturvårdsverket. "The Top Runner Program in Japan -Its Effectiveness and Implications for the EU ISBN 91-620-5515-1." Accessed February 18, 2021. www.naturvardsverket.se.

Osamu, Kimura. "The Role of Standards: The Japanese Top Runner Program for End- Use Efficiency. Historical Case Studies of Energy Technology Innovation in: Chapter 24, The Global Energy Assessment." In Chapter 24,The Global Energy Assessment, 231—43. Cambridge University Press, 2012. https://iiasa.ac.at/web/home/research/researchPrograms/TransitionstoNewTechnologies/12_Kimura_Japan_TopRunner_WEB.pdf.

Pandita, Sameer, PVN Kishore Kumar, Archana Walia, and Ashwin T.P. "Policy Measures and Impact on the Market for Room Air Conditioners in India," 2020. https://www.clasp.ngo/research/all/policy-measures-and-impact-on-the-market-for-room-air-conditioners-in-india/.

Park, Won Young, Nihar Shah, Jun Young Choi, Hee Jeong Kang, Dae Hoon Kim, and Amol Phadke. "Lost in Translation: Overcoming Divergent Seasonal Performance Metrics to Strengthen Air Conditioner Energy-Efficiency Policies." Energy for Sustainable Development 55 (April 1, 2020): 56—68. https://doi.org/10.1016/J.ESD.2020.01.003.

Phadke, Amol, Nihar Shah, Jiang Lin, Won Young Park, Yongsheng Zhang, Durwood Zaelke, Chao Ding, and Nihan Karali. "Chinese Policy Leadership Would Cool Global Air Conditioning Impacts: Looking East." Energy Research & Social Science 66 (August 1, 2020): 101570. https://doi.org/10.1016/J.ERSS.2020.101570.

"Procel Seal." Accessed March 6, 2021. http://www.procelinfo.com.br/main.asp?View=%7BB70B5A3C-19EF-499D-B7BC-D6FF3BABE5FA%7D.

ProcelInfo. "Procel Seal." Accessed March 6, 2021. http://www.procelinfo.com.br/main.asp?TeamID=%7B88A19AD9-04C6-43FC-BA2E-99B27EF54632%7D.

———. "The Program." Accessed March 6, 2021. http://www.procelinfo.com.br/main.asp?TeamID=%7B921E566A-536B-4582-AEAF-7D6CD1DF1AFD%7D.

RMI. "Global Cooling Prize: Solving the Cooling Dilemma ." Accessed June 11, 2021. https://rmi.org/insight/global-cooling-prize-solving-the-cooling-dilemma/.

Rob, Carmichael; Sarah, Widder; Nathan, Baker;, and Brychta DeWitt, Jessica; Warren, Stem; Michael. "Domestic Air Conditioner Test Standards and Harmonization," 2020. https://www.iea-4e.org/wp-content/uploads/publications/2020/03/AC_Test_Methods_Report_Final_V2_incl_JP_KO.pdf.

Shah, Nihar, Nina Khanna, Nihan Karali, Won Young Park, Yi Qu, and Nan Zhou. "Opportunities for Simultaneous Efficiency Improvement and Refrigerant Transition in Air Conditioning." Lawrence Berkeley National Lab, no. July (2017): 18.

Sharma, Srishti, Akhil Singhal, and Tarun Garg. "Decoding Evaporative Air Coolers." New Delhi, June 2021. https://aeee.in/wp-content/uploads/2021/06/Decoding-Evaporative-Air-Coolers-Report.pdf.

———. "Standard and Labelling for Evaporative Air Coolers: A Roadmap to Affordable & Sustainable Space Cooling Solutions in India," 2021. https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2021/9-products-appliances-ict/standard-and-labelling-for-evaporative-air-coolers-a-roadmap-to-affordable-sustainable-space-cooling-solutions-in-india/.

TATA Power DDL. "User Manual for AC Registration." Accessed October 14, 2021. www.tatapower-ddl.com.

TSUCHIYA M. "ROOM AIR CONDITIONERS." Toshiba Review, no. 46 (1970): 38–45. http://www.beestarlabel.com/Content/Files/AC_Notification.pdf.

United for Efficiency (U4E). "Accelerating The Global Adoption Of Energy-Efficient And Climate-Friendly Air Conditioners," 2017, 80. https://united4efficiency.org/wp-content/uploads/2017/06/U4E-ACGuide-201705-Final.pdf.

Zhou, Nan. "Status of China ' s Energy Efficiency Standards and Labels for Appliances and International Collaboration." Structure, no. March (2008).

Zhou, Nan, Nina Zheng Khanna, and David Fridley. "Development and Implementation of Energy Efficiency Standards and Labeling Programs in China : Progress and Challenges," no. January (2013). Lawrence Berkeley National Laboratory.

Zhou, Nan, Nina Zheng Khanna, David Fridley, John Romankiewicz, and Ernest Orlando Lawrence. "Development and Implementation of Energy Efficiency Standards and Labeling Programs in China: Progress and Challenges," 2013. https://china.lbl.gov/sites/all/files/china_sl_info.pdf.

Zhu, Xianli, Quan Bai, and Xiliang Zhang. "Good Practice and Success Stories on Energy Efficiency in China," 2017. https://c2e2.unepdtu.org/wp-content/uploads/sites/3/2017/06/good-practice-and-success-stories-on-ee-in-china.pdf.

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