Global Cooling Efficiency Accelerator

Super-efficient Room Air Conditioner Performance Specification Guideline for Indian Market

Developed by the Global Cooling Efficiency Accelerator

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Disclaimer: The specifications and views expressed in this report are those of the contributors.

About Global Cooling Efficiency Accelerator

Co-founded by the Clean Cooling Collaborative (CCC) and RMI, the Global Cooling Efficiency Accelerator is a coalition working to establish the necessary preconditions and scientific data-based evidence to pave the way for bringing super-efficient ACs to the marketplace. The Global Cooling Efficiency Accelerator comprises of partners with deep technical and policy expertise and brings together policymakers, manufacturers, industry and market experts, and buyers to shape the market for commercialization and adoption of super-efficient ACs.

1. Introduction

1.1 Purpose:

This Performance Specification Guideline (hereafter referred to as "Guideline") document outlines the performance attributes for super-efficient room air conditioners (hereafter referred to as "super-efficient AC").

1.1.1 Background: Room air conditioners are most commonly deployed in India's residential sector and in certain commercial applications including banking, small offices and hotels. As the country faces extreme temperatures and higher humidity levels, more people will explore the market for air conditioners. India is expected to have over 1 billion room AC units in operation by 2050 — making it the world's fastest-growing AC market. Operating 1 billion ACs would require approximately 600 gigawatts of new power generation capacity — 1.5 times more power than India's total grid capacity today. This demand for space cooling will account for 45 percent of India's peak electricity demand — the demand that is often the most expensive and polluting to meet. It's a vicious cycle in which meeting the rising need for cooling results in further pollution and overheating of our planet.

1.1.2 Need for super-efficient ACs: Today, air conditioners users turn down the thermostat or the AC setpoint significantly to manage humidity in the air. This results in overcooling of the air and consequently significantly higher energy consumption. This is true even when operating high-efficiency ACs on the market. Although the AC industry has continuously optimized efficiency levels of their products to meet these efficiency standards in the country, these improvements have been focused on efficiently managing the temperature (or sensible load) and not much attention has been given to addressing the humidity (or latent load) in the indoor spaces. As the planet gets warmer, the frequency and intensity of high heat and humidity events will further increase. Additionally, as the buildings use better materials, windows and shades, the contribution of latent load in the space will gradually increase (as sensible load will likely decrease) requiring ACs to get better at removing moisture and consequently provide comfort. This requires a shift in how ACs handle temperature and humidity both effectively and efficiently.

1.1.3 Definition of super-efficient AC: An air conditioner that has key attributes of the Global Cooling Prize (Prize) winning technologies.[1] These products use high efficiency components and are designed and optimized for real-world conditions resulting in dramatically lower energy use while providing significantly better comfort and reduced electricity bills for consumers. Specifically, when operating in warm and humid climates, these products can deliver effective and efficient dehumidification without significantly overcooling the space as typically observed with today's products. A superefficient AC, when tested and normalized for

1 Global Cooling Prize was an international innovation challenge by RMI; Department of Science and Technology, Government of India; and Mission Innovation, to identify and demonstrate residential air conditioning solutions with five-times lower climate impact compared to the typical products sold in the Indian market. For more details, check out https://globalcoolingprize.org/

performance relative to the Prize baseline unit (fixed-speed, ductless single split type room AC unit[2] with an Indian Seasonal Energy Efficiency Ratio or ISEER of 3.5 W/W and using R22 refrigerant) and refrigerant global warming potential of winning solutions, meets the "5X" lower climate impact criteria of the Prize.

1.2 Scope:

The Guideline document prescribes the technical performance and other functional requirements for ductless single split super-efficient AC of

- rated cooling full capacity of 5,300 Watts (with tolerance of ±5% as specified in section 9.9.5 of IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners),
- rated voltage of 240 Volts for single phase / 415 Volts for three phase, and
- rated frequency of 50 hertz.

This Guideline document is **not applicable** to following products:

- ductless split air conditioners of other types [like cassette or floor mounted]
- window air conditioners
- ducted heat pumps

1.3 Intended Use:

This Guideline document is for use by buyers including but not limited to procurement departments, engineers, contractors, and consultants for specifying purchase of super-efficient ACs that significantly reduce the cooling energy use, total cost of ownership, and lifecycle emissions while providing better comfort for occupants.

The super-efficient AC specifications outlined in this Guideline document are based on measured performance data in the lab following a full-year simulated test in a state-of-the-art laboratory at CEPT University, India[3] and validated in the field following a 9-month field testing in India.[4]

By using the Guideline document and specifications outlined herein for purchasing of super-efficient ACs, buyers can expect:

- Approx. **75% energy use reduction per year** and **550 Watts of avoided peak power draw** relative to the Prize baseline unit (as defined in section 1.1.3) and
- Approx. **65% energy use reduction per year** and **350 Watts of avoided peak power draw** relative to the typical 3-star AC [ISEER 3.8 – 4.39] in the India market in 2024

2 Single split type room AC unit is a split air conditioner having single indoor and outdoor unit as defined in 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners).

3 The full-year simulated test protocol can be found here https://globalcoolingprize.org/prize-details/testing-protocol/

4 Kalanki, Ankit *et al.* Paving the Way for Super-efficient Room Air Conditioners: Insights from Field Testing in India. Global Cooling Efficiency Accelerator, November 6, 2024, https://rmi.org/event/webinar-field-testing-of-super-efficient-room-air-conditioner-results-and-learnings/

while avoiding significant overcooling of the space and ensuring comfort conditions for the occupants by maintaining temperature and relative humidity conditions at or below 27 degrees Celsius and 60% respectively.[5]

This Guideline document focuses on providing performance specifications for super-efficient AC products and **does not** provide estimate or indications of price of such products. The final price of a product is influenced by various factors, including but not limited to procurement volumes, warranties, brand, and specific buyer requirements. Pricing is typically negotiated between the buyer and the manufacturer or supplier based on these variables. Additionally, factors such as the power supply source and logistics can affect the operating costs for each buyer. We encourage each buyer to use this Guideline document to obtain quotations from manufacturers/suppliers and conduct their own economic analysis (e.g., payback period) before making final procurement decisions. Appendix A lists key input parameters (though not exhaustive) to assist buyers in their analysis.

It is important to recognize that while updates to AC performance metrics and testing standards will be a key to scaling widespread adoption of super-efficient ACs, demand-side actions are equally vital to jumpstart adoption of such products. This Guideline document serves as a bridge for buyers and producers who are ready to move forward during this critical transition period, helping accelerate the adoption of super-efficient ACs. By following this guideline, we hope that buyers will be able to demand products that significantly reduce cooling energy use, lower total cost of ownership, reduce lifecycle emissions, and enhance occupant comfort.

2. General Requirements

2.1 Construction:

The construction of the super-efficient AC, including provision of suitable protective coating for corrosion prevention of all metal and metal alloy pipes, parts and components, shall conform to the requirements as given in Section 5 of the Indian Standard IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners).

2.2 Safety:

The super-efficient AC shall meet the requirements of IS 659 (Safety code for air conditioning) and IS 302 - Part 1 (Safety of household and similar electrical appliances: Part 1 General Requirements).

2.3 Brand and Model:

5 Indoor conditions of at or below 27°C and 60% relative humidity is in alignment with thermal comfort conditions under ASHRAE 55 standard "Thermal Environmental Conditions for Human Occupancy." It specifies the combinations of reasonable indoor environmental factors (air temperature and relative humidity) and personal factors (metabolic rate and clothing level) to achieve acceptable thermal comfort for occupants in buildings.

This Guideline document encourages open procurement and is agnostic of any brand or model provided the desired energy performance and specifications are demonstrated satisfactorily by the supplier.

2.4 Warranty:

- Comprehensive product warranty (including all spares, replenishing the refrigerant, bimonthly servicing and any other site visits if failure occurs during warranty period) – minimum 1 year
- Compressor – minimum 10 years
- Optional extended warranty should be available

3. Technical Performance Requirements

3.1 Total Cooling capacity:

3.1.1 Total cooling capacity

- Rated cooling full capacity of 5,300 Watts at standard test conditions (with tolerance of ±5% as specified in section 9.9.5 of IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners)
    - Standard test conditions are defined as outside air-dry bulb temperature of 35 degrees Celsius and wet bulb temperature of 24 degrees Celsius; indoor air dry bulb temperature of 27 degrees Celsius and wet bulb temperature of 19 degrees Celsius.
- Rated cooling half capacity of 2,650 Watts or higher at standard test conditions [as defined above].

3.2 Power consumption:

The maximum power consumption of super-efficient AC at standard test conditions [as defined in section 3.1.1] shall not exceed values in the table below.

- The manufacturer shall provide the performance test data – including delivered sensible and latent cooling capacity and power draw - for super-efficient AC at standard test conditions [as defined in section 3.1.1] as per table below.

% Nominal Capacity (of 5,300 Watts)	Nominal Cooling Capacity (Watts)	Sensible Cooling Capacity (Watts)	Latent Cooling Capacity (Watts)	Maximum Power Draw (Watts)*
25%	1325	835	490	170
50%	2650	2014	636	410
75%	3975	3538	437	650

100%	5300	4876	424	880

* Power values have been normalized for outdoor temperature 35 degrees Celsius as per the calculations provided in IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners).

3.3 Humidity control:

The super-efficient AC shall operate to provide humidity control without significantly overcooling the space [or reducing the room dry bulb temperature significantly below 27 degrees Celsius]. The unit shall have integrated dehumidification capabilities that allow it to modulate its latent cooling capacity to 20% of the total cooling capacity for achieving better humidity control and may include, but not limited to, separate temperature and humidity sensors that optimize operation based on real-time conditions and provide better comfort and higher energy savings. With smart sensing and control capabilities (as defined in section 4.4) the AC unit shall respond to real-world conditions and operate such that the indoor relative humidity is always maintained at or below 60%.[6]

3.4 Compressor technology:

The super-efficient AC shall have a variable-speed compressor with DC motor for precise speed (and consequently temperature) control, reduced power use and quieter operation.

3.5 Maximum operating temperature condition:

The super-efficient AC shall satisfactorily operate and provide cooling at outside air dry bulb temperature of up to 46 degrees Celsius without tripping of the compressor in any operating mode as specified in sections 8.1.2 and 9.4 of the Indian Standard IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners).

4. Other Functional Requirements

4.1 Refrigerant:

4.1.1 Global warming potential (GWP)

Uses a lower global warming potential (GWP) refrigerant that has a GWP value not exceeding 800 (according to refrigerant GWP value provided in IPCC AR6 report).

4.1.2 Other criteria

- Refrigerant used must be non-ozone depleting.

6 Indoor conditions of at or below 27°C and 60% relative humidity is in alignment with thermal comfort conditions under ASHRAE 55 standard "Thermal Environmental Conditions for Human Occupancy." It specifies the combinations of reasonable indoor environmental factors (air temperature and relative humidity) and personal factors (metabolic rate and clothing level) to achieve acceptable thermal comfort for occupants in buildings.

- Refrigerant used must belong to toxicity class A as prescribed under the relevant ISO 817 standard (Refrigerants – Designation and Safety Classification).
- Refrigerant used shall belong to flammability class A2L or lower flammability as prescribed under the relevant ISO 817 standard (Refrigerants – Designation and Safety Classification).
    - If using flammable refrigerants i.e., class A2 or A3, the charge quantity in the super-efficient AC will comply with the levels prescribed under the relevant ISO 5149 standard along with provision of suitable safety features.

4.2 Dimensions and Weight

4.2.1 Indoor unit

Total volumetric size (length X width X depth) of the indoor unit shall not exceed 0.08 cubic meters.

4.2.2 Outdoor unit

Total volumetric size (length X width X depth) of the outdoor unit shall not exceed 0.25 cubic meters.

4.2.3 Weight

- Total net weight of the Indoor unit shall not exceed 14 kilograms.
- Total net weight of the Outdoor unit shall not exceed 50 kilograms.
- The supplier shall provide the necessary mounting and supporting mechanisms for the indoor unit and outdoor unit to handle the weights without compromising on stability and safety.

4.3 Noise level

4.3.1 Indoor unit:

- <20 dBA [at lowest fan speed]
- Not to exceed 58 dBA at full speed

4.3.2 Outdoor unit:

- <55 dBA

4.3.3 Noise test:

The test will be undertaken as prescribed in section 9.10 of the Indian Standard IS 1391 (Part 2): 2023 (Room Air Conditioners Specifications: Part 2 Split Air Conditioners).

4.4 Smart sensing and controls capability:

The super-efficient AC shall offer smart sensing and controls capability to ensure that the AC unit responds to actual cooling loads in the space and has a sustained performance over its lifetime.

- Sensors:
    - Indoor temperature and relative humidity sensors for real-time sensing of indoor comfort conditions and optimizing of super-efficient AC operation. Both temperature and relative humidity conditions of the indoor space shall be displayed on the panel of the indoor unit.
    - Occupancy sensor is recommended to be included to detect presence and adjust operation that can result in additional energy savings.

- Maintenance Alerts:
    - Give alerts for filter cleaning and replacement to ensure sustained high performance of super-efficient ACs.

5. Additional Requirements [optional]

5.1 Voltage stabilizer:

The super-efficient AC can be supplied with a voltage stabilizer to ensure reliable operation (depending on specific need of a buyer, although it is not a required component in a super-efficient AC product). If seeking a voltage stabilizer, it must be rated to handle the full load of the AC unit. The supplier shall provide the stabilizer with a capacity of 3-5 kVA. The voltage stabilizer must also comply with relevant safety standards and regulatory requirements, including IS 302 (for safety of household and similar electrical appliances) and IS 9815 (automatic voltage stabilizers).

Appendix A: Guidance on Evaluating the Payback Period of Super-efficient Air Conditioners

When evaluating the economic viability of purchasing super-efficient air conditioners, it is essential to consider both the upfront price of the unit and the operating costs over its lifetime. Since these products are not commercially available in the market today, it is important to note that multiple factors could influence the initial price of these products. As such, each buyer is encouraged to conduct their own economic analysis based on the following parameters.

1. First Cost (Price) Considerations

Several factors will influence the upfront price of the AC unit. While pricing is negotiated between the buyer and the manufacturer or supplier, key elements to consider include:

- **Brand**: Different brands may offer varying price points and price can vary based on perceived quality, innovation, or brand value.
- **Warranties and After-Sales Support**: The length and terms of the warranty can impact the overall price. Longer warranties or those offering extensive coverage may increase the upfront price, but they may also provide long-term savings in repair and maintenance costs.
- **Buyback or Trade-In Programs**: Some manufacturers or suppliers may offer buyback programs or discounts for replacing older units, which can reduce the upfront price.
- **Installation Costs**: The complexity of installation like additional work for special ducts or electrical requirements can also affect the upfront price.
- **Features**: Optional features, such as specialized filters, air purifiers, smart control may add to the upfront price.

2. Operating Cost Considerations

The operating cost of an AC, which includes electricity consumption and maintenance, is an essential factor when calculating the total cost of ownership. Key inputs to consider include:

- **Energy Efficiency**: Super-efficient ACs will translate to lower energy bills due to their use of high efficiency components and ability to deliver comfort without significant overcooling.
- **Operating hours and Electricity Tariff**: Buyers should estimate their annual usage to get a realistic sense of energy costs. Also, the cost of electricity varies by location and provider.
- **Maintenance Costs**: Maintenance, including servicing, filter cleaning, and refrigerant checks, contributes to the operating costs.

While the first cost (price) and operating cost considerations mentioned above will provide a solid foundation for evaluating a super-efficient AC's economic viability compared to typical or high-efficiency ACs available in the market today, it is recommended that buyers perform a thorough analysis based on their specific conditions and consider all relevant parameters to make informed procurement decisions.