How to Win the Global Cooling Prize
Agenda

The Cooling Dilemma

Prize Criteria

Evaluation of the participating technologies

Testing Protocol

Using the Global Cooling Prize website

Next Steps
The Cooling Dilemma…..

Increasingly seen as a Social Need but at an Environmental Cost we cannot afford
Cooling in the rear view mirror has not captured much attention. Looking to the road ahead, cooling needs to be on everyone’s agenda.
In addition to today’s unmet needs major future demand accelerators are at work

**POPULATION GROWTH**
Population is growing by over 80 million people/year, with 97% of growth in developing countries.

**INCOME GROWTH**
GDP growth for non-OECD countries will exceed 4.5% through 2025, making comfort economical for millions of new consumers.

**URBANIZATION**
99% of population growth is occurring in urban environments, worsening heat island effects.

**A WARMING PLANET**
Global average temperatures expected to rise over 2.0°C by 2100, making summers longer and hotter.

Non-OECD Cooling Demand will increase 5x by 2050.

For many people, comfort cooling is transitioning from a perceived luxury to a vital enabler of health, productivity & prosperity.

Present day heat exposure risk

Worldwide, by 2030, extreme heat could lead to a $2 trillion loss in labor productivity. India’s economy alone stands to lose $450 billion.

Projected exposure to deadly heat

“Air conditioning was a most important invention for us, perhaps one of the signal inventions of history. It changed the nature of civilization by making development possible in the tropics. Without air conditioning you can work only in the cool early-morning hours or at dusk. The first thing I did upon becoming prime minister was to install air conditioners in buildings where the civil service worked. Prime Minister Lee, Singapore 2009

Source:
Entry level cooling is provided by the ubiquitous residential / room air conditioner (RAC) the number in operation could grow nearly fourfold by 2050.

### Expected global stock of room air conditioners, 2016-2050

**RAC units, millions**

- **PRESENT**
  - Approx. 1.2 billion RAC units in the world; sales growing at 10-15% per year in developing economies.

- **2050**
  - Approx. 4.5 billion RAC units in operation worldwide. Demand driven by non-OECD countries.

- **2100**
  - 50-fold increase in worldwide RAC energy demand from year 2000.

This growth comes with significant impacts to electricity systems.

Residential AC’s will account for over 2/3rds of cooling electricity demand and over 10% of global electricity use by 2050.

More so in this segment than any other the business as usual path for growth is for consumers to purchase the lowest first cost product.

Source: IEA Report: The Future of Cooling: Opportunities for Energy-efficient Air Conditioning (2018); RMI: Solving the Global Cooling Challenge – How to Counter the Climate Threat from Room Air Conditioners
Air conditioning demand will place significant burdens on grids where it drives peak loads and consumers pockets.

New Delhi’s grid electricity demand profile, hourly

Cooling costs as % of median household income

While existing cooling emissions & efficiency efforts are critical, they are not sufficient
Global initiatives are helping phase out damaging refrigerants associated with comfort cooling ...

The Kigali Amendment to the Montreal Protocol (2016):
- Targets the impacts of hydrofluorocarbons (HFCs)—greenhouse gases with high global warming potential, primarily utilized as refrigerants
- Commits 197 countries to phasing down HFC use by 80%+ in the next 30 years
- Has been called world’s “single largest real contribution” to meet the Paris goals, but …
- … refrigerants account for less than a third of total emissions from mechanical cooling (a fifth in non-OECD countries) – we need to do more

We are building better buildings, and being smarter in how we operate them which helps reduce cooling loads

… but the energy consumption of the equipment serving these cooling loads remains a massive and critical component
The efficiency opportunity remains largely unaddressed by the RAC industry due to lack of market and policy signals

### Industry progress toward theoretical max efficiency

<table>
<thead>
<tr>
<th>Industry</th>
<th>Retail</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>67%</td>
<td>22%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>28%</td>
<td>25%</td>
</tr>
<tr>
<td>A/C</td>
<td>14%</td>
<td></td>
</tr>
</tbody>
</table>

### Consolidated industry

- Fewer than 500 AC companies worldwide
- 70% of global RAC production in China, concentrated within a few major manufacturers

### High barriers to entry

“The threat from a new entrant is causing a negligible impact to the present players because of heavy R&D and technical requirements needed to enter into the AC market”

– 2015-2020 Global AC Market Forecast, BIS Research

Source:
.....we need transformational efficiency of RACS – but where is the innovation?

- Cooling is the fastest growing end use consumer of generated electricity.

- While we need to continue to work on better buildings more than 3 billion new RACs will be installed in the next 30 years.

- The RAC segment is subject to a massive market failure - the fixation on lowest upfront cost as opposed to lifecycle cost.....and industry responds to market signals

- Mass market innovation has largely stalled

- Emerging & innovative technologies are unable to achieve scale
Do we allow inertia to define us or do we do what humankind has done through the ages and look for innovation to move us forward

A prize has the potential to spur climate-friendly innovation and address the market failure in the cooling industry
Technology innovation is key to addressing this emerging crisis; here is our approach

- **Understand the status quo**: current mass market technology, R&D efforts, and niche/emerging technologies

- **Focus on “raising the ceiling”** to complement on-going efforts to “raise the floor” through MEPS

- **Clearly define desired performance outcomes** based on what we need to achieve in service of our climate goals, and what is feasible

- **Instead of looking for a needle in the haystack**, use a prize to incentivize the needle to find us - US$3M of incentives

- **Create a community of innovators** and researchers to raise the profile of emerging technologies with policymakers, incumbents, and investors

- **Help create ‘signals of future demand’** via a combination of policy and advance market commitments; we need scale to drive down costs, and signals of demand to drive scale
Prize Criteria
Our Prize Criteria will ensure that the next generation room air conditioners can meet the challenging conditions across all markets.

<table>
<thead>
<tr>
<th><strong>Primary criteria used to determine final award</strong></th>
<th><strong>Supplementary criteria used to shortlist finalists</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIMATE: One-fifth of the life-time climate impact (electricity and refrigerant) of the baseline AC unit</td>
<td></td>
</tr>
<tr>
<td>POWER: Consumes less than 700W from the grid at rated cooling capacity or during test period</td>
<td>EMISSIONS: Zero onsite emissions from any captive power or heat source</td>
</tr>
<tr>
<td>SCALABILITY: Usable in existing homes, no “designed in” solution; less than 2x volumetric size of the baseline unit</td>
<td>OPERATION: Designed to have 1.5 TR cooling capacity at standard outdoor conditions and Maintains below 27°C DBT and 60% RH indoors for the duration of test period</td>
</tr>
<tr>
<td>WATER (if any is used): Consumes an yearly average of 14 liters/day with daily maximum limit of 28 liters</td>
<td>REFRIGERANTS (if any is used): Zero ODP, lower toxicity, and compliance with safety standards</td>
</tr>
<tr>
<td>AFFORDABILITY: At manufacturing scale of 100,000 units, costs no more than twice the cost of the baseline AC unit to consumers</td>
<td>MATERIALS: Minimal usage of high embodied carbon or rare earth materials</td>
</tr>
</tbody>
</table>
Defining the baseline AC unit for the competition

Explanation

- A 1.5 TR, fixed speed, EER 3.5 W/W room air conditioner (RAC) using an R410A refrigerant that…

- Operates in a typical apartment with a 90 square meter area in a composite climate like New Delhi, India over a full year temperature and humidity seasonal profile and…

- Consumes 2,969 kWh/year based on maintaining indoor conditions below 27°C DBT and 60% RH and...

- Has an installed cost of about US $546 to consumers (excluding any standard installation labor costs and taxes)

Selection of the baseline

- Most commonly-sold RAC in the Indian market in the year 2018 and also amongst the most popular units globally.

- Expected building type where the cooling technologies participating in this competition will be tested under real-world conditions.

- Installed cost of the most commonly-sold RAC sold in India by the market player with highest share
## Primary Criteria for the Prize

**Climate Impact:** Solution must achieve at least 5X lower climate impact than the climate impact of the baseline AC unit.

### What we mean by 5X
- Responsible for one-fifth or 80% lower climate impact than the climate impact of baseline AC unit...
- Through a combination of 4-5x reduced grid electricity consumption and low GWP refrigerant (if any is used) considering...
- 80:20 weighting for electricity and refrigerant respectively, to arrive at the overall climate impact

### And why we think it’s achievable
- Current best-in-class units are already ~2.5x more efficient and when combined with a low GWP refrigerant can have ~3.5x lower climate impact.
- Emerging technologies have shown potential in their prototype stages for lower energy consumption and increasing cost-effectiveness.

### Evaluation of the Technical Application
- Provide the solution’s grid electricity consumption analysis that meets the hourly sensible and latent load provided.
- Provide the refrigerant characteristics, if any is used, of your cooling solution.
- Provide a detailed description of analysis on the solution’s climate impact reduction w.r.t. the baseline.
- Points will be awarded ratably between 0 – 100 based on level of reduction achieved from the baseline i.e. 0 points for no reduction and 100 points for 100% reduction.
- Minimum 80 points will be required to compete in the competition
Example evaluation of the climate impact

**Climate Impact:** Solution must have 5x less climate impact than the baseline unit

Consider a proposed cooling solution that has:
ISEER 5.2 W/W (6.5 to 7.0 SEER) using 1196 kWh/yr and R290 (Propane) refrigerant with a GWP of 3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Proposed Cooling Solution</th>
<th>% reduction achieved</th>
<th>Assigned Weight</th>
<th>Weighted Score</th>
<th>Total Achieved reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Electricity Consumption (kWh/yr)</td>
<td>2969</td>
<td>1196</td>
<td>60%</td>
<td>80%</td>
<td>48%</td>
<td>68%</td>
</tr>
<tr>
<td>Refrigerant GWP</td>
<td>2088</td>
<td>3</td>
<td>100%</td>
<td>20%</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>
Primary Criteria for the Prize

Affordability: Solution must cost the consumer no more than 2X the baseline AC unit cost at an assumed manufacturing scale of 100,000 units

What we mean by 2X

- Installed cost to consumers must be no more than two times the baseline cost where...
- Bill of materials will be assessed at a manufacturing scale of 100,000 units
- And the baseline cost, taken as US $546 for reference, will be reassessed by the technical review committee during evaluation in the year 2019

And why we think it’s achievable

- RMI analysis shows that even at 2X price point, a 5X cooling solution brings significant savings over the life-cycle of operation.
- Innovative financing mechanisms by utilities and energy companies will further reduce the burden on consumer pockets.

Evaluation of the Technical Application

- Provide the estimated bill of material cost of AC components and materials required for installation.
- A fixed factor for “other costs and margins” at 60% of total installed cost is added for all applications.
- Provide a detailed description of analysis including evidence for cost estimation.
- Points will be awarded ratably between 0 (5x baseline cost) – 40 (zero cost) based on the level of cost achieved.
- Minimum 24 points will be required to compete in the competition.
## Supplementary Criteria for the Prize

### Power Draw: Solution should consume no more than 700 W of power from the grid

<table>
<thead>
<tr>
<th>What we mean</th>
<th>And why this is important</th>
<th>Evaluation of the Technical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consume no more than 700 W of power from the grid at…</td>
<td>• Reducing power demand is critical to avoid huge spending on new generation capacity and grid infrastructure</td>
<td>• Provide the solution’s power draw analysis for the hourly sensible and latent load provided.</td>
</tr>
<tr>
<td>• Rated cooling capacity or any outdoor conditions during test period when…</td>
<td>• RMI analysis and literature review suggests that a 5X reduction in electricity could achieve about 60% reduction in power demand</td>
<td>Provide a detailed description of specific technology innovation and methodology adopted in the analysis to verify the power draw claim.</td>
</tr>
<tr>
<td>• Determined over any 15-minute interval</td>
<td>•</td>
<td>• Pass / fail criteria with failure leading to a likely disqualification.</td>
</tr>
</tbody>
</table>

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**Global Cooling Prize**
Supplementary Criteria for the Prize

Water: Solution should consume no more than 14 liters of water per day when averaged over a year with maximum limit of 28 liters per day

**What we mean**
- Consume no more than an yearly average of 14 liters/day of water if...
- any is required for daily operation of the unit onsite and subject to...
- A maximum daily limit of 28 liters

**And why this is important**
- Need to ensure that the cooling solution does not consume large quantity of water, especially in regions where water scarcity is going to become a critical issue in the future
- Need to balance the energy-water nexus
- Not create a burden on consumer bills

**Evaluation of the Technical Application**
- Provide the solution’s water usage analysis, if any is used, for the hourly sensible and latent load provided.
- Provide a detailed description of specific technology innovation and methodology adopted in the analysis to verify the water usage claim.
- Pass / fail criteria with failure leading to a likely disqualification.
Supplementary Criteria for the Prize

Onsite Emissions: Solution should have zero onsite emissions from any fossil fuel based captive power source or heat source

What we mean

- Does not use any combustion sources onsite when...
- such energy source is required to generate a heating medium or electricity for operation of the unit

And why this is important

- Including distributed combustion sources possesses potential safety concerns for residential applications
- Undermines the impact of increasing penetration of renewables in the electricity grid and the corresponding reduction in grid emissions intensity

Evaluation of the Technical Application

- Provide a schematic that shows the power source and any combustion source used in operation of the cooling solution.
- Declare that no fossil fuel based power source or heating medium is used.
- Pass / fail criteria with failure leading to a likely disqualification.
### Supplementary Criteria for the Prize

**Refrigerant compliance:** Solution should use a refrigerant that has a zero ozone depleting potential (ODP), lower toxicity and complies with international standards on refrigerant safety.

<table>
<thead>
<tr>
<th>What we mean</th>
<th>And why this is important</th>
<th>Evaluation of the Technical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>If any refrigerant is used, it should have…</td>
<td>Develop synergy with international agreements and standards to ensure environmental safety</td>
<td>• Provide the refrigerant characteristics, if any is used, of your cooling solution.</td>
</tr>
<tr>
<td>- Zero ODP,</td>
<td>Should not pose risk to the health and safety of the occupants from its operation</td>
<td>• Declare that refrigerant, if any is used, complies with the environmental and safety standards for use in residential application.</td>
</tr>
<tr>
<td>- lower toxicity (class A) according to ISO 817,</td>
<td>Reducing the warming impact from refrigerants that are potent greenhouse gases</td>
<td>• Pass / fail criteria with failure leading to a likely disqualification.</td>
</tr>
<tr>
<td>- comply with ISO 5149 or IEC 60335-2-40 or any local standard (if stricter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge quantity not materially different from baseline unit¹</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ A 1.5 ton air conditioner unit has a typical R410A charge quantity of 1.65 kg.
Supplementary Criteria for the Prize

**Scalability:** Solution should be usable in existing homes, rather than requiring a "designed in" engineering solution

### What we mean

- Does not have a total volumetric size of more than 0.42 cubic meters\(^1\) which includes...
- Size of the cooling unit, any external component and any integrated renewable energy source such that...
- Installation does not need any major structural, electrical or plumbing upgrades

### And why this is important

- Should be able to scale in same market conditions as conventional vapor compression based units
- Should be easy to install in existing buildings as well as new buildings

### Evaluation of the Technical Application

- Provide technical drawings of the cooling solution clearly showing dimensions of all components.
- Provide a detailed description on the solution’s installation in an existing apartment building.
- Pass / fail criteria with failure leading to a likely disqualification.

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\(^1\) The baseline AC unit has the volumetric size of indoor and outdoor unit as 0.075 and 0.135 cubic meters.
Supplementary Criteria for the Prize

**Materials:** Solution should be developed with regard to minimal usage of rare earth materials and embodied carbon

<table>
<thead>
<tr>
<th>What we mean</th>
<th>And why this is important</th>
<th>Evaluation of the Technical Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Should carefully consider the quantity and type of materials used for producing the components of the cooling solution</td>
<td>• A solution might not be sustainable if it uses materials having high embodied carbon or are rare earth</td>
<td>• Provide the estimated bill of materials of AC components and materials required for installation.</td>
</tr>
<tr>
<td></td>
<td>• Mitigate the risk of unintended consequences in the future by use of such materials</td>
<td>• Provide a description on the type and quantity of any rare-earth materials used.</td>
</tr>
</tbody>
</table>
<pre><code>                                                                             |                                                                                         | • The Technical Review Committee may conduct a life cycle impact assessment study if needed.          |
                                                                             |                                                                                         | • Pass / fail criteria with failure leading to a likely disqualification.                              |
</code></pre>
Supplementary Criteria for the Prize

**Operation:** Solution should be designed to have 1.5 TR cooling capacity at standard outdoor conditions and maintain below 27°C DBT and 60% RH indoors for the duration of test period.

### What we mean
- Ability to meet a cooling load (sensible + latent) of 1.5 TR at outdoor conditions of 35°C DBT and 24°C WBT
- Maintain the indoor conditions below 27°C DBT and 60% RH under varying outdoor weather conditions of test and simulated markets

### And why this is important
- Humidity and temperature control are key to human comfort and productivity
- Improper humidity levels can result in mold growth in buildings
- These conditions are increasingly used as standards for indoor set-points to optimize energy use and thus allows to scale in other markets

### Evaluation of the Technical Application
- Provide the solution’s cooling capacity for the hourly outdoor weather conditions while meeting hourly sensible and latent cooling load.
- Provide the unmet hours for which solution cannot meet the indoor conditions of below 27°C DBT and 60% RH.
- Pass / fail criteria with failure leading to a likely disqualification
Evaluation of the participating technologies
Technology evaluation will occur across three stages

1. **Application Review & Screening**
   - Applicants will submit design documents detailing how they meet the technical criteria
   - Initial assessment of solution cost (at manufacturing scale) will be completed alongside
   - Score will be given based on achievement of climate impact and affordability criteria
   - Up to 10 finalists will be selected for interim award and testing

2. **Lab & Field Testing**
   - A combination of lab and real world testing will allow further filtering and evaluation of each cooling solution based on performance against the prize criteria

3. **Final Assessment**
   - Results from field and lab testing will be used to update the score of competing solutions in order of performance on technical criteria
   - The winner will be selected based on updated score on the climate impact and affordability criteria
Phase 1 of the Global Cooling Prize is underway…

• **REGISTER AND COMPLETE PROFILE**
  ✓ Register at www.globalcoolingprize.org/apply for applying to the Prize
  ✓ Stay informed about application deadlines, get useful resources and participate in forums

• **SUBMIT PARTICIPANT “INTENT TO APPLY” FORM- June 30, 2019**
  ✓ Complete a simple online form to showcase your intent to participate
  ✓ What we ask is a few simple questions to know:
    ➢ your team
    ➢ your innovative cooling technology
    ➢ your understanding of the Prize Criteria

• **SUBMIT DETAILED TECHNICAL APPLICATION FORM- August 31, 2019**
  ✓ Comprehensive information about the innovative cooling technology along with a detailed schematic, design calculations, technical drawings, showcasing the achievement of the Prize Criteria
Phase 2: Selected finalists will be required to ship two prototypes to India by May 2020 for testing

- Finalists announced in **November 2019** after evaluation of the Detailed Technical Applications by the Technical Review Committee
- Finalists will be eligible to receive an interim award of up to **US $200,000**
  - US $100,000 on announcement of finalists
  - US $100,000 on delivery of prototypes
- Finalists will undertake prototype development and production between **November 2019** and **April 2020**
- Finalists will ship two prototypes to India by **May 2020** for testing
Phase 2: Field and lab testing will be conducted in parallel for all finalist technologies

- Selection of ~10 most promising technologies
- Application Evaluation
  - Prototype 1: ISEER testing
  - Prototype 2: Lab simulated full-year testing (up to 12 days)
- Field testing (up to 60 days)
- Exception to ISEER testing made for alternative technologies
- Screen solutions with ISEER <7
- Final evaluation: Testing results combined with final cost assessment
Indian Seasonal Energy Efficiency Ratio (ISEER) test (1/3)

- Performance test of variable capacity systems based on vapor compression technology

**Test Parameters**

- **Cooling Capacity**
  - Cooling at full capacity
  - Cooling at 50% capacity

- **Power Consumption**
  - Power consumption at full capacity
  - Power consumption at 50% capacity

- **ISEER rating**
  - Annual seasonal cooling load
  - Annual seasonal energy consumption

**Test conditions**

- Outdoor Conditions – 35°C DBT and 24°C WBT
- Indoor Conditions – 27°C DBT and 19°C WBT

**Standard followed**

- IS 1391: Part 1 – 2017 (unitary air conditioners)
- IS 1391: Part 2 – 2018 (split air conditioners)
- ISO 16358-1: 2013

Outdoor temperature varying from 24-43°C
Indian Seasonal Energy Efficiency Ratio (ISEER) test (2/3)

• Determining the ISEER rating of the cooling solutions

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Average annual hours</th>
<th>Fraction</th>
<th>Bin hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>527</td>
<td>9.1%</td>
<td>146</td>
</tr>
<tr>
<td>25</td>
<td>590</td>
<td>10.2%</td>
<td>163</td>
</tr>
<tr>
<td>26</td>
<td>639</td>
<td>11.1%</td>
<td>177</td>
</tr>
<tr>
<td>27</td>
<td>660</td>
<td>11.4%</td>
<td>183</td>
</tr>
<tr>
<td>28</td>
<td>603</td>
<td>10.4%</td>
<td>167</td>
</tr>
<tr>
<td>29</td>
<td>543</td>
<td>9.4%</td>
<td>150</td>
</tr>
<tr>
<td>30</td>
<td>451</td>
<td>7.8%</td>
<td>125</td>
</tr>
<tr>
<td>31</td>
<td>377</td>
<td>6.5%</td>
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<td>32</td>
<td>309</td>
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<td>33</td>
<td>240</td>
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<td>67</td>
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<td>34</td>
<td>196</td>
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<tr>
<td>35</td>
<td>165</td>
<td>2.9%</td>
<td>46</td>
</tr>
<tr>
<td>36</td>
<td>130</td>
<td>2.3%</td>
<td>36</td>
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<tr>
<td>37</td>
<td>101</td>
<td>1.7%</td>
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<td>38</td>
<td>79</td>
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<td>16</td>
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<tr>
<td>40</td>
<td>44</td>
<td>0.8%</td>
<td>12</td>
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<tr>
<td>41</td>
<td>31</td>
<td>0.5%</td>
<td>9</td>
</tr>
<tr>
<td>42</td>
<td>20</td>
<td>0.3%</td>
<td>6</td>
</tr>
<tr>
<td>43</td>
<td>10</td>
<td>0.2%</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>5774</td>
<td>100%</td>
<td>1600</td>
</tr>
</tbody>
</table>

• 1600 Annual cooling hours divided into bin hours for a outdoor temperature range of 24 – 43 °C.

• Determining the cooling seasonal total load (CSTL) and cooling seasonal energy consumption (CSEC) based on the bin temperature range and hours of operation.

• Determining the ratio of CSTL and CSEC to evaluate the ISEER value.

• For more information about this testing method, visit https://www.beestarlabel.com/content/files/inverter%20ac%20schedule%20final.pdf
Indian Seasonal Energy Efficiency Ratio (ISEER) test (3/3)

- Protocol to be followed for ISEER test

  ➢ One prototype of each finalist sent to a NABL (National Accreditation Board for Testing and Calibration Laboratories) accredited lab for evaluation of standard test parameters.
  
  • Prototypes should have a standard cooling capacity of 1.5 TR (5.3 kW).
  
  • Prototypes should have an ISEER rating of greater than 7.

  ➢ Prototypes that cannot be assessed under IS 1391 standard or cannot be given an ISEER rating will be considered on a case-by-case basis by the Technical Review Committee.
  
  • If the prototype meets all the prize criteria during the other two testing methods i.e. lab simulated year-round test and field test, the Technical Review Committee may allow such prototype to compete in the competition.
Field test (1/5)

- Following the ISEER test, prototypes will be installed in actual residential apartments

• Newly built mid to high rise residential apartment building in a heat stressed city in India.

• Selected apartment units to occupy middle floors of the building.

• Selected apartment units to be materially equivalent in size, envelope characteristics, solar heat gain, shading etc.

• Selected apartment units to have cooling loads that can be met by the baseline AC unit of 1.5 TR (5.3 kW) cooling capacity under standard conditions i.e. outdoor conditions 35°C DBT and indoor conditions 27°C DBT/60%RH.

Disclaimer – The actual apartments during the field test may not resemble this apartment building
Field test (2/5)

- **Measures will be taken to verify that apartment units are materially equivalent**

  - Apartment units to remain unoccupied to limit variation in loads due to human behavior.
  
  - Thermal imaging to be performed to ensure similar envelope characteristics across the apartment units.
  
  - Blower door test to be conducted to ensure an equivalent air tightness.
    
    - Wherever necessary, envelope will be properly sealed or leaked to ensure that air tightness characteristics are equivalent across all the apartment units.
  
  - Airflow measurements to be taken for kitchen and exhaust fans, and adjustments be made to ensure even flow rates across the apartment units.
Field test (3/5)

- **Protocol to be followed during the field test**
  - Prototypes to be installed and tested for a period of up to 60 days in residential apartment units.
    - A team member can be present on site to support the installation and observe the performance of the prototype.
  - Baseline AC unit to be installed and tested in parallel with the prototypes—ensuring similar conditions during testing.
  - Prototypes with integrated PV panels to be installed such that the panels uniformly face between a southwest or southeast orientation—no rooftop access allowed.
  - Internal load profiles to be simulated based on the typical daily sensible and latent gains observed in a home from lighting, infiltration, occupants etc. using electric resistance and humidifier.
  - Prototypes and baseline AC unit to be operated continuously for all the test days i.e. up to 60 days.
  - Performance parameters of the prototypes and baseline AC unit to be recorded at every 15-minute interval.
    - Grid electricity consumption, Power demand, Water usage etc.
    - Indoor conditions where the prototype is installed - below 27°C DBT and 60% RH at all times
    - Indoor conditions in adjacent rooms - below 27°C DBT and 60% RH to the extent possible
Field test (4/5)

• Allowance and other consideration for the prototypes during the field test

➢ Unmet hours allowance for not maintaining the indoor conditions will be considered:
  • To the extent of the number of hours the baseline AC unit does not maintain the indoor conditions below 27°C DBT and 60% RH
  • Additional allowance of up to 3.4% of test hours that the prototype operates i.e. a maximum of 49 unmet hours allowed if it operates for all 60 days of the field test

➢ Use of existing plumbing line will be allowed, but without any major modifications to the piping network of the apartment unit.

➢ Structural modification to the apartment unit or electrical upgrades may be allowed if it is not materially different from that required for installation and operation of the baseline AC unit.

The decision of the Technical Review Committee will be final when qualifying any modification or upgrade as “major” and thus violating the “Scalability” criteria of the Prize.
Field test (5/5)

- **Addressing a component failure of the prototype during the field test**
  
  - Global Cooling Prize team communicates the issue to the concerned finalist’s team leader and/or its onsite representative.
  
  - Opportunity to either replace or perform necessary repairs to the prototype at own discretion and cost.
  
  - Up to a maximum of three on site replacements or repair opportunities provided.
    
    - **Each repair opportunity** will be for a duration of **up to 5 days** following notification
    - Failure to do so within the 5 day window will count as one lost opportunity
    - If repair takes more than 15 days from notification, this will be counted as all three opportunities lost.
  
  - Once all the three opportunities are lost and the failure is not addressed or a component fails again -
    
    - **Has the prototype been successfully tested for at least 72 hours in continuous operation mode?**
      
      - **YES**
        
        - Provide Technical Review Committee with the performance analysis for the successful test days and a brief write-up on failure analysis.
      
      - **NO**
        
        - Assess possibility of any further attempts based on prize timelines and provide Technical Review Committee with a brief write-up on failure analysis.

The decision of the Technical Review Committee will be final.
Lab simulated year-round performance test (1/8)

• Second prototype of each finalist will be tested at CEPT University’s state-of-the-art facility

- Designed to assess energy use, demand, and water use for a wide variety of air conditioning system technologies - traditional and low energy cooling systems

- Design comprises of External and Internal rooms (Room within a room) to simulate energy use in buildings

- External Chamber maintains a wide range of daily outdoor condition profiles (5 to 45 °C, 20 to 80% Relative Humidity)

- Internal Chamber maintains accurate indoor conditions (15 to 35 °C, 10 to 90% Relative Humidity)
Lab simulated year-round performance test (2/8)

- Capability to simulate real world environmental conditions as well as internal heat gains

- Fully integrated with Building Management System (BMS) for flexible programming of building operations, chamber interactions, and artificial heat loads

- Accurate monitoring of air temperatures, relative humidity, carbon dioxide level, PM 10 and PM 2.5 levels inside the facility

- Simulates interaction between indoor and outdoor rooms through controlled air exchange rates

- Comfort stations and thermal mannequin to scientifically understand thermal comfort in the facility
Lab simulated year-round performance test (3/8)

- Testing the prototypes for 10 continuous days under varying outdoor conditions to estimate the full-year performance

- Selected 10 typical daily profiles representing all climate zones of India under which a cooling technology is expected to be operated in India.

<table>
<thead>
<tr>
<th>Warm and Dry day</th>
<th>Warm and Humid day</th>
<th>Hot and Dry day</th>
<th>Hot and Humid day</th>
<th>Extreme humid day</th>
<th>Extreme hot and dry day</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph of Warm and Dry days" /> Day 1</td>
<td><img src="image2.png" alt="Graph of Warm and Dry days" /> Day 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Graphs**

- **Dry bulb temperature**
- **Relative humidity**
Lab simulated year-round performance test (4/8)

<table>
<thead>
<tr>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm and humid days</td>
<td>Hot and humid days</td>
<td>Hot and dry days</td>
<td>Extreme humid day</td>
</tr>
</tbody>
</table>

- **Dry bulb temperature**
- **Relative humidity**

Day 7:

```
<table>
<thead>
<tr>
<th>44.0</th>
<th>39.0</th>
<th>34.0</th>
<th>29.0</th>
<th>24.0</th>
<th>19.0</th>
<th>14.0</th>
<th>9.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>5.5</td>
<td>10.5</td>
<td>15.5</td>
<td>20.5</td>
<td>25.5</td>
<td>20.0</td>
<td>15.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
```

Day 8:

```
<table>
<thead>
<tr>
<th>44.0</th>
<th>39.0</th>
<th>34.0</th>
<th>29.0</th>
<th>24.0</th>
<th>19.0</th>
<th>14.0</th>
<th>9.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>5.5</td>
<td>10.5</td>
<td>15.5</td>
<td>20.5</td>
<td>25.5</td>
<td>20.0</td>
<td>15.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
```

Day 9:

```
<table>
<thead>
<tr>
<th>44.0</th>
<th>39.0</th>
<th>34.0</th>
<th>29.0</th>
<th>24.0</th>
<th>19.0</th>
<th>14.0</th>
<th>9.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>5.5</td>
<td>10.5</td>
<td>15.5</td>
<td>20.5</td>
<td>25.5</td>
<td>20.0</td>
<td>15.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
```

Day 10:

```
<table>
<thead>
<tr>
<th>44.0</th>
<th>39.0</th>
<th>34.0</th>
<th>29.0</th>
<th>24.0</th>
<th>19.0</th>
<th>14.0</th>
<th>9.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>5.5</td>
<td>10.5</td>
<td>15.5</td>
<td>20.5</td>
<td>25.5</td>
<td>20.0</td>
<td>15.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
```

- Hot and dry days
- Hot and humid days
- Warm and humid days
- Extreme humid day
- Extreme hot and dry day

Global Cooling Prize

Dry bulb temperature

Relative humidity
Lab simulated year-round performance test (5/8)

- **Protocol to be followed during the lab test**
  - Prototypes to be installed and tested for up to 12 days in the simulated lab environment.
    - A team member can be present on site to support the installation and observe the performance.
  - Prototypes to be operated for 10 days in continuous operation mode i.e. all 24 hours, excluding time for stabilization and transition.
  - **External** (envelope heat gains and infiltration) and **internal gains** (lighting and occupants) will be simulated in the chamber.
  - Performance parameters of the prototypes to be recorded at every 15-minute interval.
    - Grid electricity consumption, Power demand, Water usage etc.
    - Indoor conditions of the internal chamber - below 27°C DBT and 60% RH at all times.

**Disclaimer** – The layout and exact location of any equipment or any instrument may be different in the actual lab set-up.
Lab simulated year-round performance test (6/8)

- Weighting factors are assigned to each of the 10 test days to evaluate the year-round performance of the prototypes
  - Weighting factors represent the fraction of days in a year in New Delhi, India that are similar to each of the selected day for testing

<table>
<thead>
<tr>
<th>Day Type</th>
<th>Sequence of days</th>
<th>Weighting factor*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm and Dry</td>
<td>Day 1</td>
<td>8%</td>
</tr>
<tr>
<td>Warm and Dry</td>
<td>Day 2</td>
<td>12%</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>Day 3</td>
<td>5%</td>
</tr>
<tr>
<td>Warm and Humid</td>
<td>Day 4</td>
<td>18%</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>Day 5</td>
<td>1%</td>
</tr>
<tr>
<td>Hot and Dry</td>
<td>Day 6</td>
<td>10%</td>
</tr>
<tr>
<td>Hot and Humid</td>
<td>Day 7</td>
<td>4%</td>
</tr>
<tr>
<td>Hot and Humid</td>
<td>Day 8</td>
<td>6%</td>
</tr>
<tr>
<td>Warm and Extreme Humid</td>
<td>Day 9</td>
<td>6%</td>
</tr>
<tr>
<td>Extreme Hot and Dry</td>
<td>Day 10</td>
<td>2%</td>
</tr>
</tbody>
</table>

Example calculation - Using weighting factor to determine annual performance

<table>
<thead>
<tr>
<th>Test day</th>
<th>Operating hours [hours/day]</th>
<th>Measured cooling electricity consumption [kWh/day]</th>
<th>Weighting factor*</th>
<th>Annualized energy consumption [kWh/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 10 - Extreme Hot and Dry</td>
<td>24</td>
<td>25</td>
<td>2%</td>
<td>200 [25* (2%*365)]</td>
</tr>
</tbody>
</table>

Sum of the weighting factors: 72% after eliminating the days when the prototype is not expected to operate in New Delhi, India

*Note: The above weighting factors can be used by the participants for estimating the annual performance of their cooling solution during the lab simulated year-round performance test. In an unlikely scenario where any changes are made, all the participants will be updated about the same. These weights will also be updated on the Global Cooling Prize website and shared with the participants.
Lab simulated year-round performance test (7/8)

• **Allowance and other consideration for the prototypes during the lab test**

  ➢ Unmet hours allowance for not maintaining the indoor conditions will be considered:
    
    • To the extent of the number of hours the **baseline AC unit does not maintain** the indoor conditions below 27°C DBT and 60% RH
    
    • **Additional allowance of up to 3.4% of test hours** that the prototype operates

  ➢ Credit will be given to the prototypes that have integrated renewable energy technology
    
    • Evaluating the energy generation using test day weather profile data and standard component efficiencies.

  ➢ Structural modification to the lab, electrical upgrades, piping modifications may be allowed if it is not materially different from that required for installation and operation of typical room air conditioner unit.

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The decision of the Technical Review Committee will be final on any modification or upgrade which they consider to be “major” and thus violating the “Scalability” criteria of the Prize.
Lab simulated year-round performance test (8/8)

- **Addressing a component failure of the prototype during the lab test**
  - Global Cooling Prize team provides a 30 day advance notice of the dates over which prototype will be tested.
  - Opportunity to either replace or perform necessary repairs to the prototype at own discretion and cost.
  - Up to a maximum of **three on site replacements or repair opportunities provided**.
    - **Each repair opportunity** will be for a duration of **up to 24 hours** following notification.
    - Failure to do so within the 24 hour window will count as one lost opportunity.
    - If repair takes more than 72 hours from notification, this will be counted as all three opportunities lost.
  - Once all the three opportunities are lost and the failure is not addressed or a component fails again -

Has the prototype been successfully tested for a cumulative period of **at least 72 hours**

- **YES**
  - Provide Technical Review Committee with the performance analysis for the successful test days and a brief write-up on failure analysis.
- **NO**
  - Assess possibility of any further attempts based on prize timelines and provide Technical Review Committee with a brief write-up on failure analysis.

The decision of the Technical Review Committee will be final.
Phase 3: Final evaluation of the prototypes and selection of winner

- After consideration of the full suite of test results Technical Review Committee will provide an updated score to the prototypes following the same scoring methodology as the Detailed Technical Application and provide a rank to each solution.
  - Performance of the prototypes will be recorded against each testing method.
  - Final score of the prototypes will be based on overall performance across all three testing methods.
  - Score obtained in the lab simulated full-year test and field test along with any limitations will be considered in adjusting the final score and ranking by the Technical Review Committee.

- Supervisory Board ratifies the recommendations after ensuring the winning participant(s) fully meet the intent of the Prize’s technical criteria.

- Announcement of the final winner at a day-long international award ceremony with Mission Innovation, as well as participating country ministerial and funder presence.
Using the Global Cooling Prize website
Registration and applicant dashboard

- Register at www.globalcoolingprize.org/apply for applying to the Prize
Prize Criteria details and Evaluation Tool

The Prize Criteria page provides an explanation about each criteria. Access it https://globalcoolingprize.org/prize-details/criteria/

The Prize Criteria Tool assesses the performance of your cooling solution reflect the total points scored in this competition. Access it https://globalcoolingprize.org/prize-

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### Prize Criteria

**Climate Impact**

- **Baseline AC unit - electricity consumption (kWh/yr)**
  - ZW3

- **Baseline AC unit - refrigerant GWP**
  - ZW3

- **Proposed cooling solution - electricity consumption (kWh/yr)**
  - Enter the grid electricity consumption of your cooling solution

- **Proposed cooling solution - refrigerant GWP**
  - Enter GWP of the refrigerant used in your cooling solution

- **Percentage reduction in climate impact**

**Affordability**

- **Baseline AC unit - installed cost to consumer (USD)**
  - $4,500

- **Baseline AC unit - material cost (USD)**
  - $2,000

- **Prepared cooling solution - material cost (USD)**
  - Total material cost of your proposed cooling solution (USD)

- **Affordability Points Scored (Maximum Points = 10)**

**Scored**

- **Baseline AC unit - carbon emissions (kg CO2e)**
  - 15 kg CO2e

- **Baseline AC unit - carbon emissions per charge (kg CO2e)**
  - 5 kg CO2e

**Material**

- **Baseline AC unit - weight of materials (kg)**
  - 10 kg

**Quality**

- **Baseline AC unit - critical path time (days)**
  - 1 day

**Total Points Scored (Maximum Points = 14)**
Frequently asked questions

The FAQ page provides all the necessary information on the Prize so that your questions are answered at the earliest. The page is categorized into 8 sections which include all aspects of the prize. Access it [https://globalcoolingprize.org/prize-details/faq/](https://globalcoolingprize.org/prize-details/faq/)

- About the Prize
- Apply for the Prize
- Application Process
- Applicant portal
- Technical Evaluation
- Scoring Method
- Testing Protocol
- Intellectual Property
Scan to discover additional Global Cooling Prize resources

- Informational Brochure
- Testing Protocol Document
- Details & Criteria Document
Next Steps with Global Cooling Prize
Global Cooling Prize will continue for a period of two years

- **November 12, 2018**
  - Participant portal launched and Intent to Apply form opened

- **June 30, 2019**
  - Deadline to submit Participant “Intent to Apply”

- **August 31, 2019**
  - Deadline to submit Detailed Technical Application

- **July - October, 2019**
  - Evaluation of Technical Applications and Selection of Finalists

- **November, 2019**
  - Announcement of top 10 finalists and Interim Awards

- **November, 2019 - April, 2020**
  - Prototype development phase

- **May – September, 2020**
  - Prototype testing in India

- **October - November, 2020**
  - Final Evaluation, Presentations and Award Ceremony
Adoption and scaling of a 5X solution could help mitigate up to 0.5°C by the end of century...

... even as 3.3 billion RAC units get added to the installed stock by 2050
Adoption and scaling of the 5X solution will reduce global annual emissions in year 2050 to a level we can address.

Key assumptions:
- RMI analysis assumes an adoption curve for the 5X solution as follows: market adoption starts in 2022 with a 5% share; by year 2030 it gains an 80% share of the annual sales, and by year 2040 it achieves an almost 100% share of the annual sales.
- We assume that building envelope improvements (thermal insulation driven by building codes) have the potential to achieve a 7.5% reduction in cooling demand in 2050 in developed countries. For developing countries, we assume that a 15% reduction in cooling demand can be achieved in 2050 as a significant portion of the building stock is still to be built.
Globally, this is potentially the single biggest technology-driven action we can take to mitigate climate change

- **75+ GT** CO₂eq emissions avoided through 2050
- **0.5°C** Global warming mitigation by 2100

**Equivalent Impacts**

- Avoid **over 2,000 GW of new generation capacity** globally
- Avoid **up to 5,900 TWh of electricity generation**, equivalent to electricity consumption of US, Japan, and Germany today
- Make all 28 countries in the **European Union carbon neutral tomorrow**

2018 was the third warmest year on record, with an average mean of 1.14 °C above the 1961-1990 average.

January 2019, warmest January on record.

Demand for cooling will continue to grow and operating hours will increase.

- With a 5X solution RAC consumption of electricity will reduce 20 TWh by 2050.
- 21 avoided 235 MW gas power stations.
- $15.4 Billion saved on investment.
Where we are today

Prize Support and Launch
Prize is endorsed and adopted by Mission Innovation and supported by the Government of India. Dr. Harsh Vardhan, Minister of Science and Technology, Environment, Forest, and Climate Change, Government of India, launched the prize in November 2018. The Government of China is engaged with the prize and we co-hosted a China Launch Event with the Chinese Association of Refrigeration in February 2019.

Prize Applications
Received over 1400 registrations for the prize and over 130 intent to apply forms from over 33 countries in 6 continents in just 4 months since the launch of the prize.

Outreach and Media
Over 26,000 users on the prize website from 166 countries. The Prize was featured in over 781 global publications in news outlets such as CNN, CNBC, NY Times, The Wall Street Journal, etc and recorded ~300 million impressions. The Prize has over 5,000 followers on social media. A coalition of over 20 leading organizations are supporting the prize as Outreach Partners.
Thank you to our Prize supporters

Initiated by

Lead Implementation Partner

Lead Supporting Partners

Sponsored by

Administered by

Outreach Partners
Thank You

Visit us: www.globalcoolingprize.org
Contact us at: info@globalcoolingprize.org
icampbell@rmi.org