International Energy Agency

Webinar series: Accelerating energy efficient cooling – The Global Cooling Prize

IEA SEAD Webinar, 30 January 2020

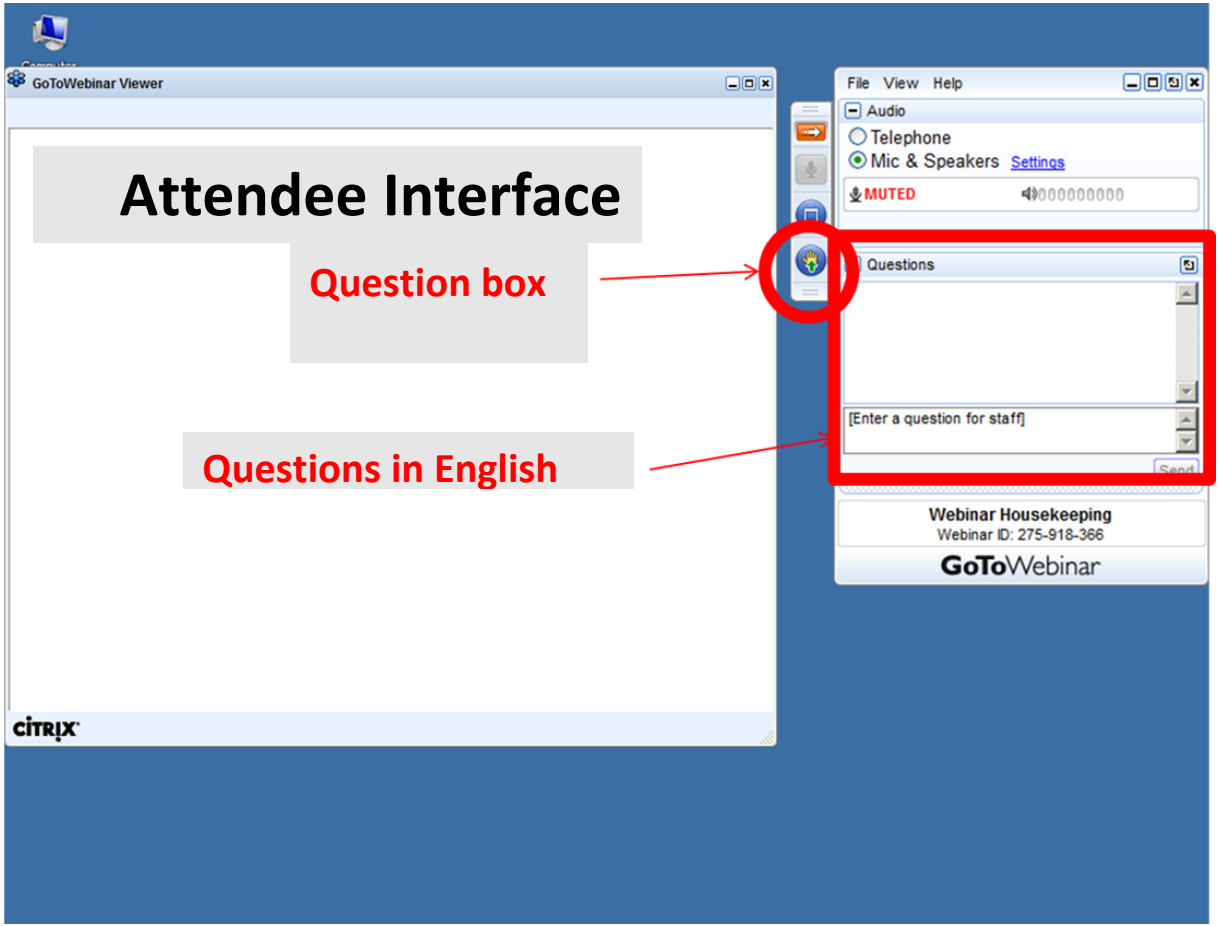
Overview

- **Introduction**
  - Vida Rozite, Energy Efficiency Division, IEA
- **The Global Cooling Prize**

Iain Campbell
Senior Fellow,
Rocky Mountain Institute

- **Questions and discussion**

How to ask questions



SEAD: Governments working together to save energy

SEAD SUPER-EFFICIENT EQUIPMENT & APPLIANCE DEPLOYMENT
AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

Governments working together to save energy, turning knowledge into action, and advancing global markets to encompass energy efficient products

Operating Agent

iea

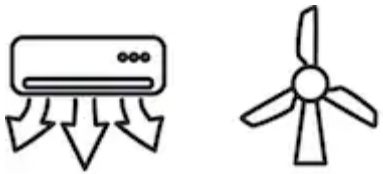
19 collaborating members

+ partners

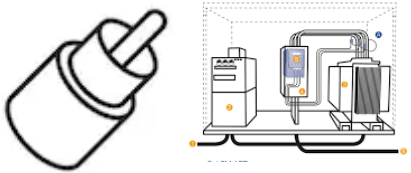
SEAD is an Initiative under the Clean Energy Ministerial

Covering a wide range of equipment and appliances…..

Cooling

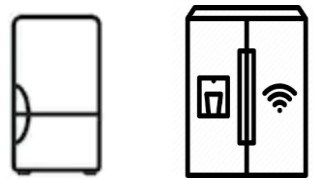


Equipment

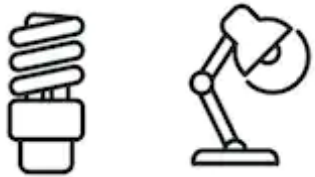


Electronics

Refrigeration



Lighting



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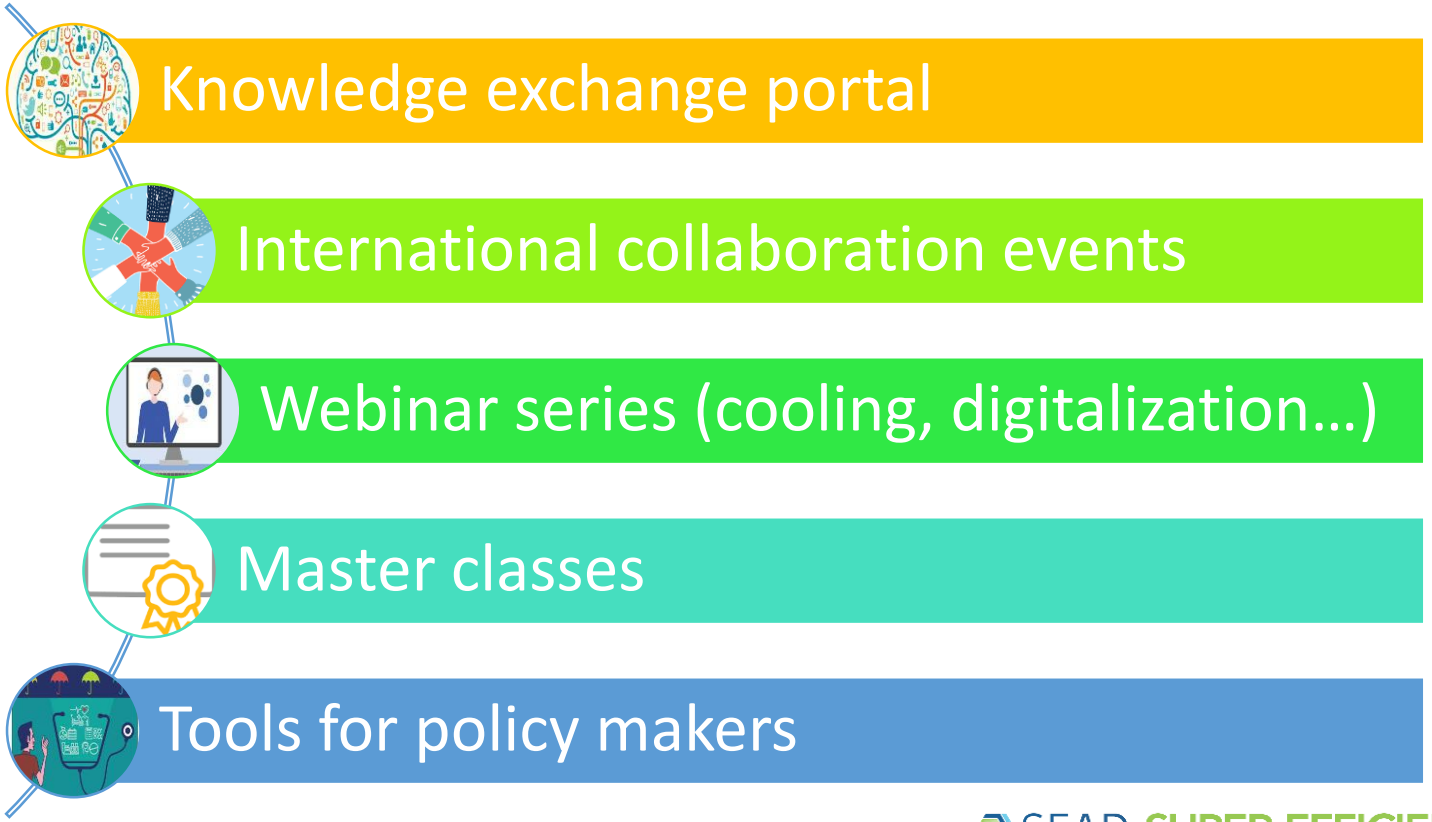
Proposed activities in the near future



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More information: vida.rozite@iea.org

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IEA – SEAD Webinar series
The Global Cooling Prize

January 30th, 2020

Global Cooling Prize

Agenda

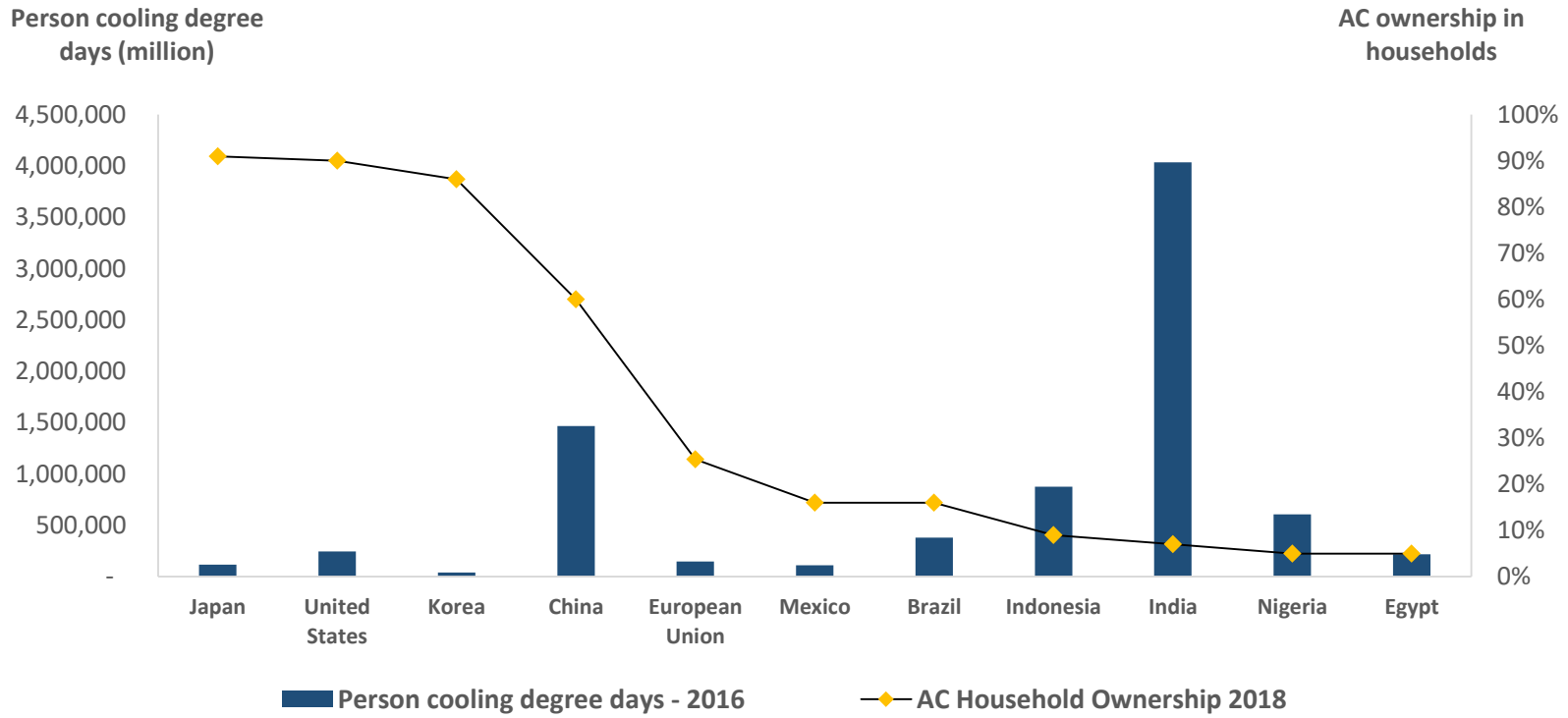
- The Cooling Dilemma
- About the Prize and our journey so far
- An overview of the innovative cooling solutions from the finalists
- Testing and Next steps regarding the Prize
- Scaling and Lessons Learned …. so far
- Questions

The Cooling Dilemma…..

Increasingly seen as a social need but at an environmental cost we cannot afford

Global Cooling Prize

Cooling in the rear-view mirror has not captured much attention .. looking to the road ahead cooling needs to be on everyone's agenda



Source: IEA Report: The Future of Cooling: Opportunities for Energy-efficient Air Conditioning (2018); United Nations, Department of Economic and Social Affairs, Population Division (2017); https://www.degreedays.net/

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

Cooling Demand will increase by almost 4x by 2050

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

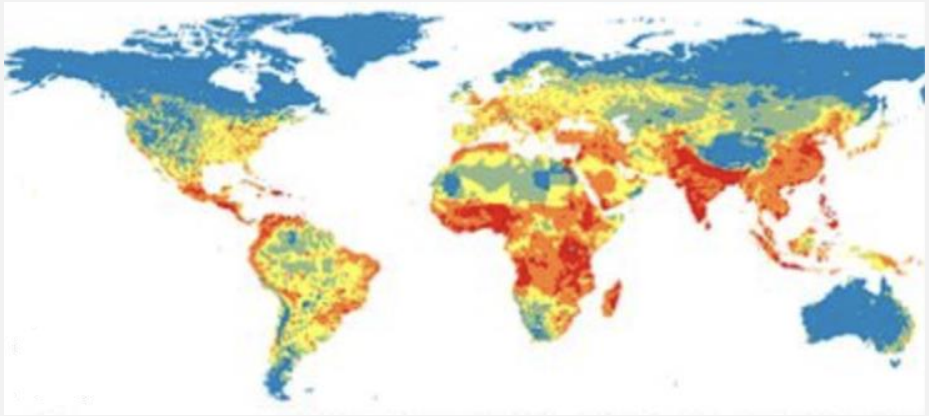
URBANIZATION
99% of population growth is occurring in urban environments, worsening heat island effects

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

Source: United Nations Sustainable Development Goals (2017), United Nations World Urbanization Prospects (2014), Population Reference Bureau World Population Data Sheet (2012), ExxonMobil Outlook for Energy (2018)

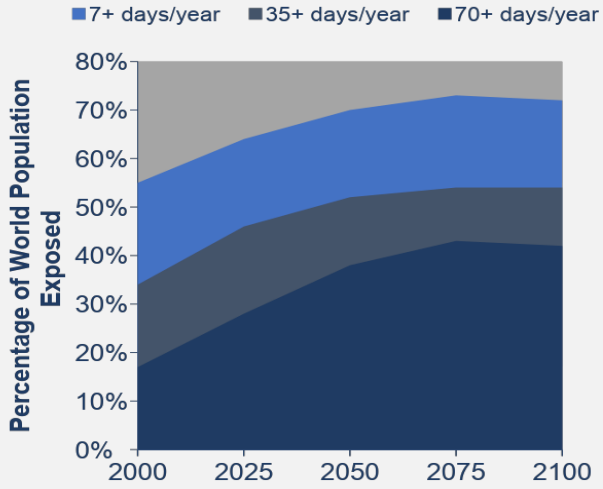
For many people comfort cooling is transitioning from a perceived luxury to a vital enabler of health, productivity & prosperity

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

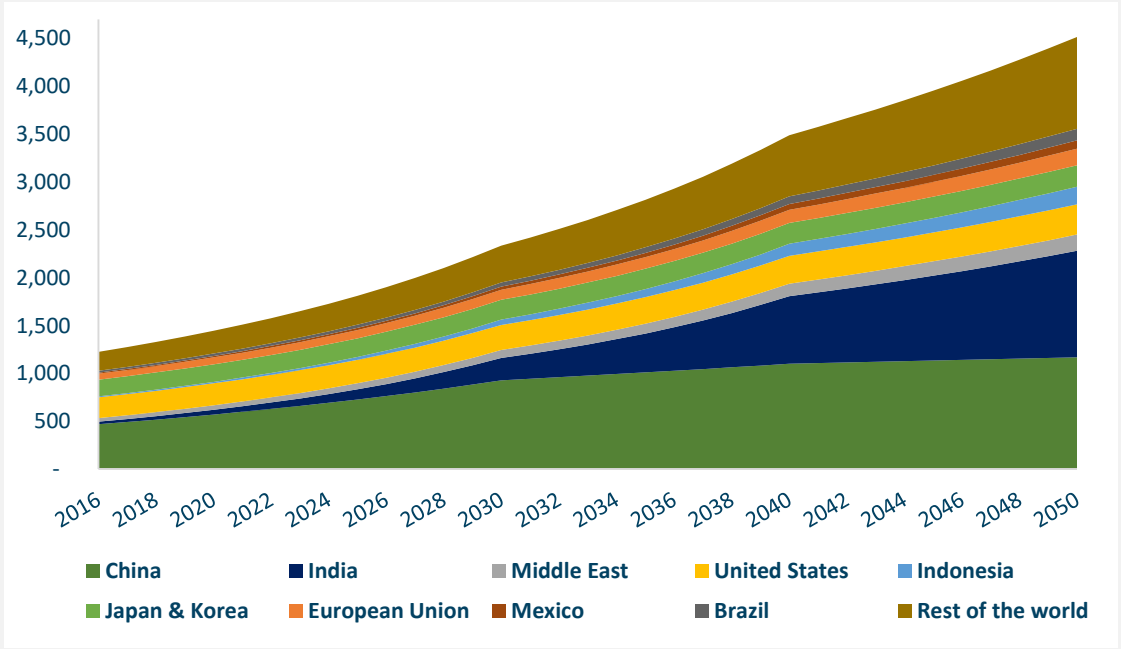


"Air conditioning was a most important invention for us, perhaps one of the signal inventions of history. It changed the nature of civilization by making development possible in the tropics. Without air conditioning you can work only in the cool early-morning hours or at dusk. The first thing I did upon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

Source: Tord Kjellstrom, PhD, Mmeng. Impact of Climate Conditions on Occupational Health and Related Economic Losses. Asia-Pacific Journal of Public Health. January 2015. Climate Change and Labour: Impacts of Heat in the Workplace. International Labor Organization (ILO). April 2016

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.

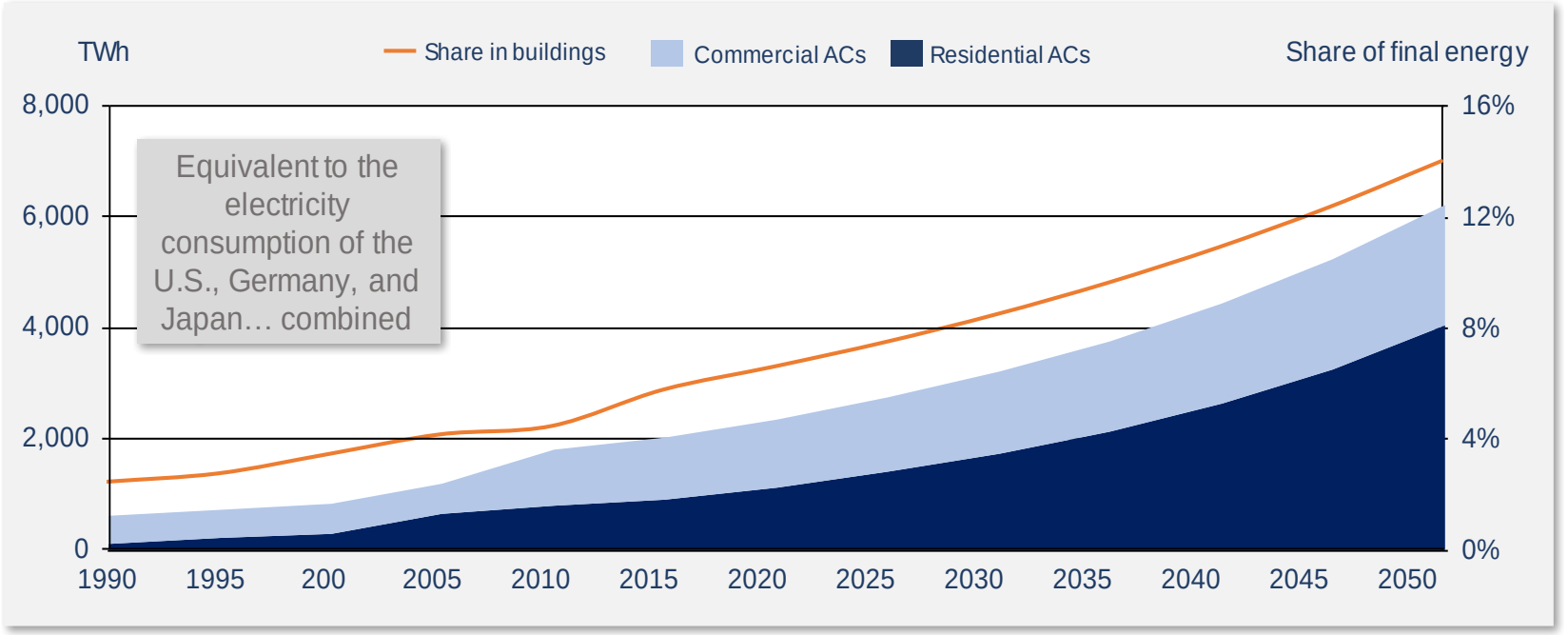
2100

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

Source: International Energy Agency (IEA) (2018), The Future of Cooling. LBNL Report: Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning (2015), IPCC, “Fifth Assessment Report”, 2014

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

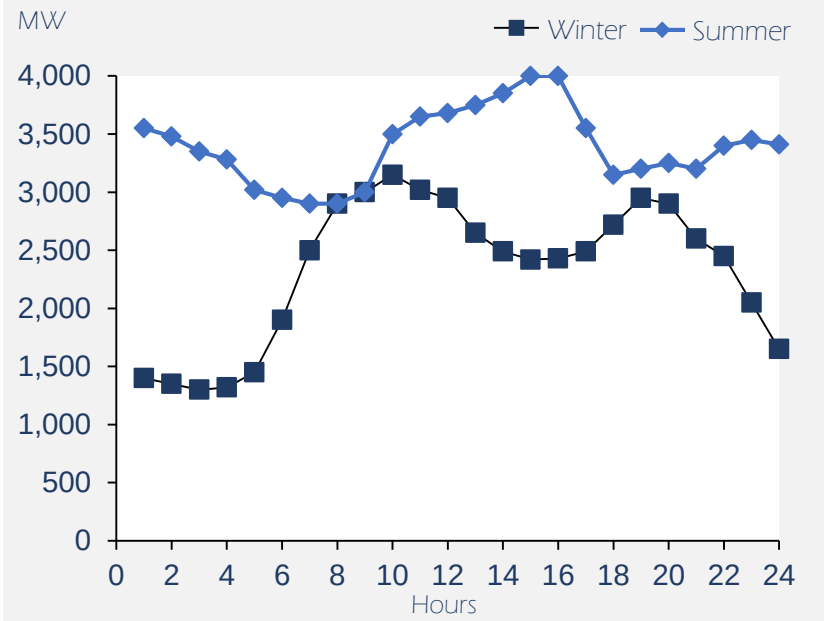
Energy consumption associated with comfort cooling, 1990-2050



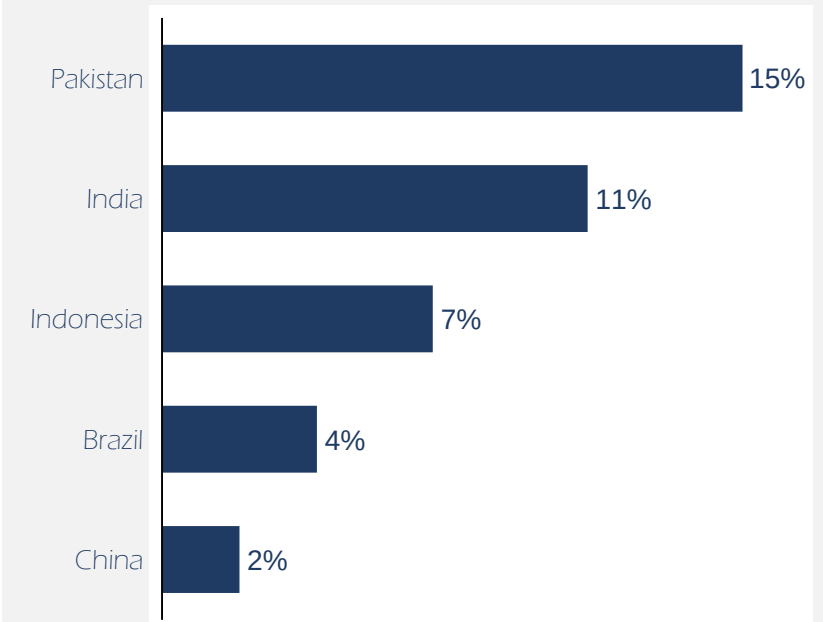
Source: IEA Report: The Future of Cooling: Opportunities for Energy-efficient Air Conditioning (2018); RMI: Solving the Global Cooling Challenge – How to Counter the Climate Threat from Room Air Conditioners

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

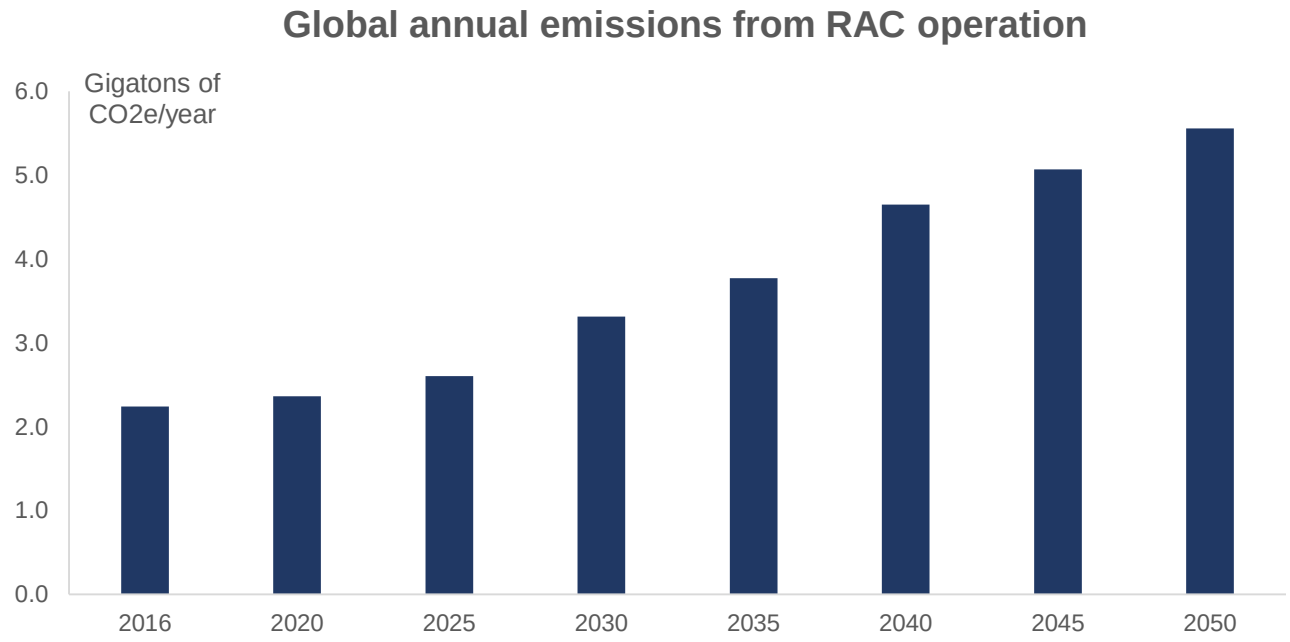


Cooling costs as % of median household income



Source: LBNL Report: Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning (2015), Global Industry Analyst Market Research, Enerdata, UCSUSA , Eco Climate Network Article, NRDC (2015), IECS and Christian Aid Report (2017); IPCC, "Fifth Assessment Report", 2014

Even projecting trends in buildings codes, equipment efficiency and grid emissions intensities – annual cooling emissions will almost triple by 2050

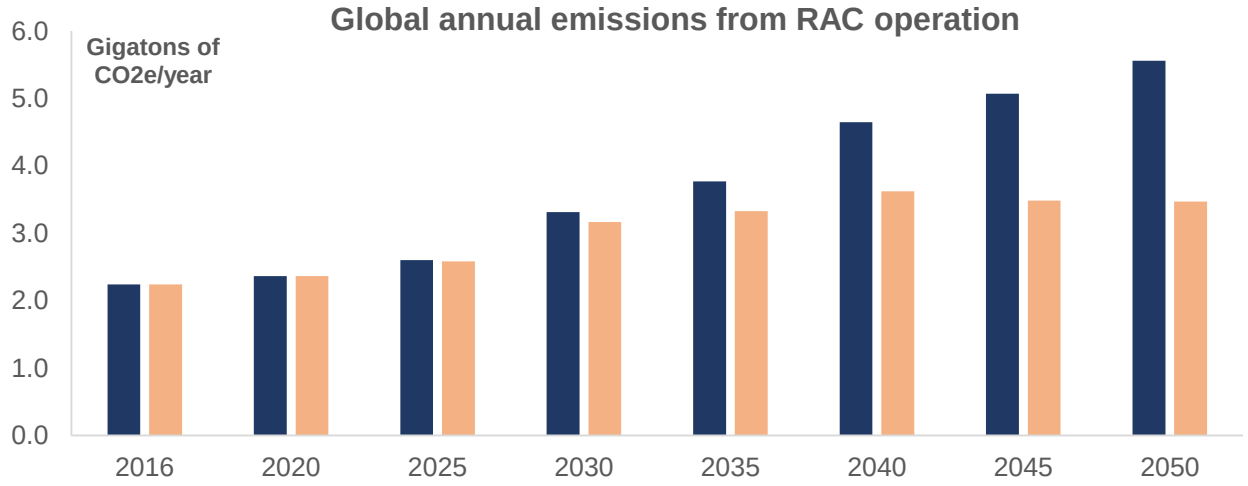


RS - Reference Scenario, or the business-as-usual RAC growth scenario, where the current adopted or committed policies and government commitments will move forward as per established timelines.

While existing cooling emissions & efficiency efforts are critical, they are not sufficient

Global Cooling Prize

Successful implementation of the Kigali Amendment will significantly reduce cooling related emissions – but we need to do more



RS - Reference Scenario, or the business-as-usual RAC growth scenario, where the current adopted or committed policies and government commitments will move forward as per established timelines.

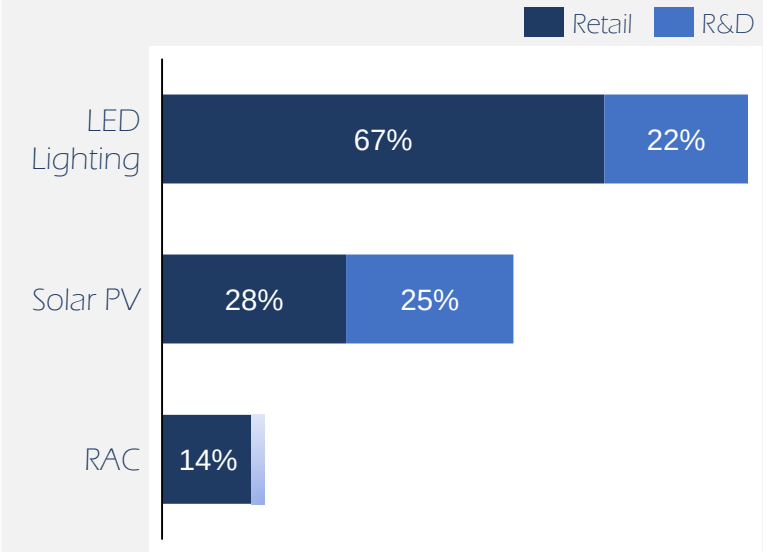
RS-K - Same as the Reference Scenario but adding in the successful implementation of the Kigali phasedown plan.

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



Consolidated industry

- RAC segment is subject to a massive market failure - the focus on lowest upfront cost…and industry responds to market signals
- Fewer than 500 AC companies worldwide

Market Analysis

- Mass market innovation has largely focused on first cost and meeting near term market requirements - not transformational efficiency
- Emerging & innovative technologies are unable to achieve scale

Source: Greentech Media, “Sunpower Again Holds Record for World’s Most Efficient Rooftop Solar Panel”, 2017; PHYS, “White LEDs with Super-High Luminous Efficacy Could Satisfy All General Lighting Needs”, 2010; Fujitsu, 2017; CLASP, “AC Challenge Program for India”, 2017; LBNL, “Addressing Air Conditioner Energy Efficiency Lost in Translation to Strengthen Policy”, 2018

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

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A prize has the potential to spur climate-friendly innovation and address the market failure in the cooling industry

Global Cooling Prize

The Global Cooling Prize Criteria has been developed to ensure that the next generation room air conditioners will deliver effective cooling at a dramatically lower environmental cost

Primary criteria used to determine final award

Supplementary criteria used to shortlist finalists

CLIMATE
One-fifth of the life-time climate impact (electricity and refrigerant) of the baseline AC unit

AFFORDABILITY
At manufacturing scale of 100,000 units, costs no more than twice the cost of the baseline AC unit to consumers

POWER
Consumes less than 700W from the grid at rated cooling capacity or during test period

EMISSIONS
Zero onsite emissions from any captive power or heat source

SCALABILITY
Usable in existing homes, no "designed in" solution; less than 2x volumetric size of the baseline unit

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

WATER (if any is used)
Consumes an yearly average of 14 liters/day with daily maximum limit of 28 liters

REFRIGERANTS (if any is used)
Zero ODP, lower toxicity, and compliance with safety standards

MATERIALS
Minimal usage of high embodied carbon or rare earth materials

The Prize is a high-profile competition with a $3M purse supported by a global coalition to spur innovation and catalyze future demand

The potential impact of a super-efficient, climate-friendly cooling solution would be profound

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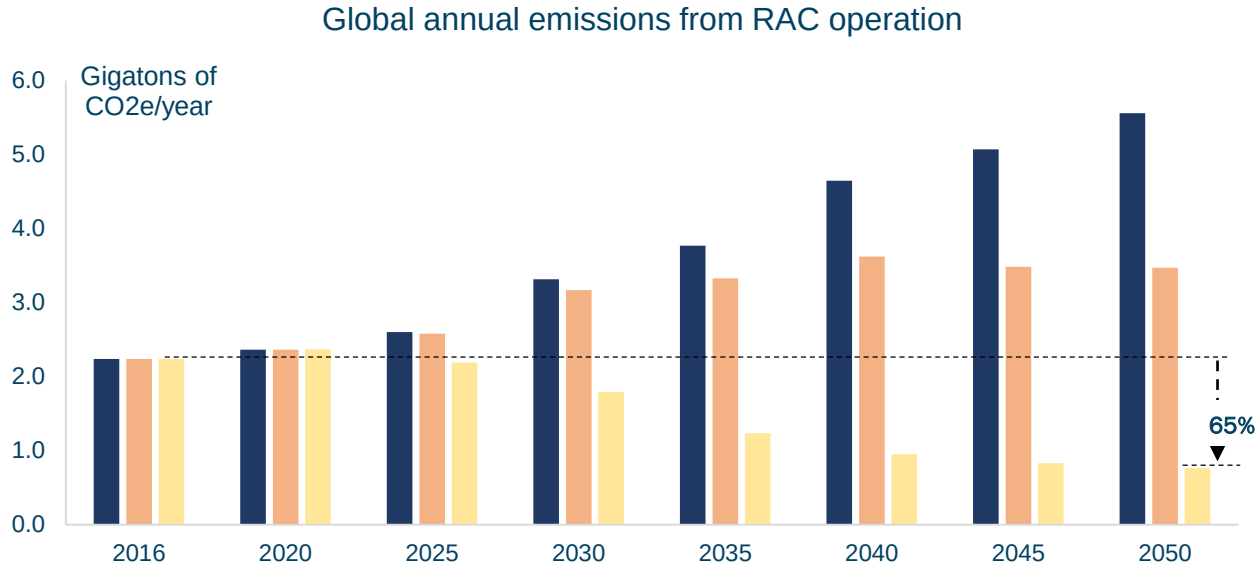
... for people, the AC industry, the power sector, and the planet

Global Cooling Prize

Globally scaling of the 5X solution will reduce RAC associated global annual emissions in year 2050 to a level that is manageable



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RS-K - Same as the Reference Scenario but adding in the successful implementation of the Kigali phasedown plan.

5X Scenario - Assumes the adoption of technology solution that will have at least five-times (5X) less climate impact than today's standard RAC units

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 may be one of the single biggest demand side actions we can take to mitigate climate change

75+ GT

CO_2eq 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 5,400 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

Source: CLASP, "AC Challenge Program for India", 2017; LBNL, "Benefits of Leapfrogging to Super efficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning", 2015; "Statistics", IEA (2018)

Where we are, the Finalists

Global Cooling Prize

Our Journey and where we are

Outreach and Media

Over 70,000 users on the prize website from 195 countries. The Prize was featured in over 1280 global publications in news outlets in over 95 countries and recorded over 2 billion impressions. The Prize has over 14000 followers on social media with 1.8 million+ impressions.

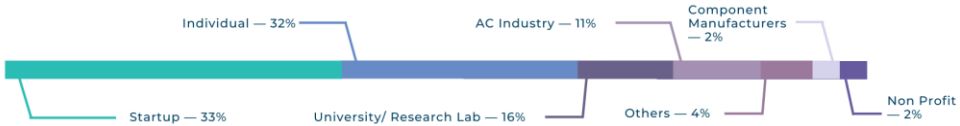
Global Application Submissions

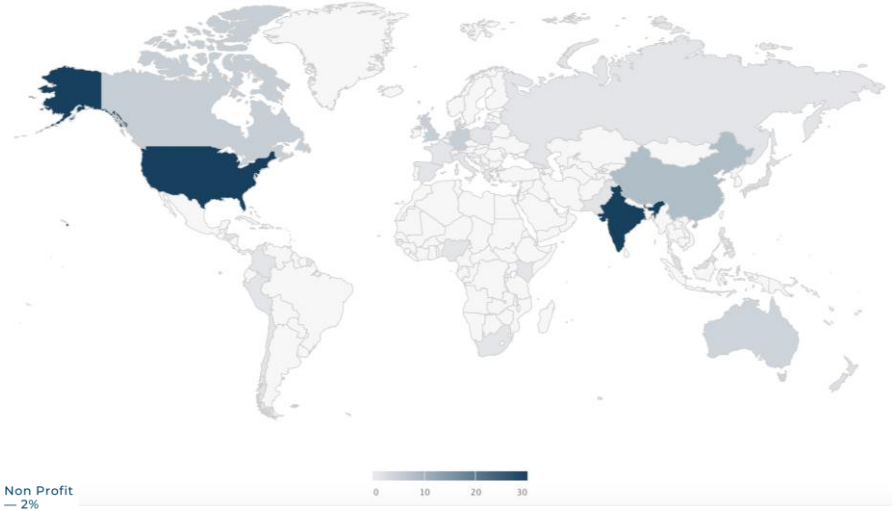
2,100+
TEAMS REGISTERED for the competition from 95 countries

445
completed the INTENT TO APPLY FORM

13
completed the INITIALED TECHNICAL APPLICATION

from **31**
COUNTRIES around the world





8 Finalist teams were selected by the Technical Review Committee

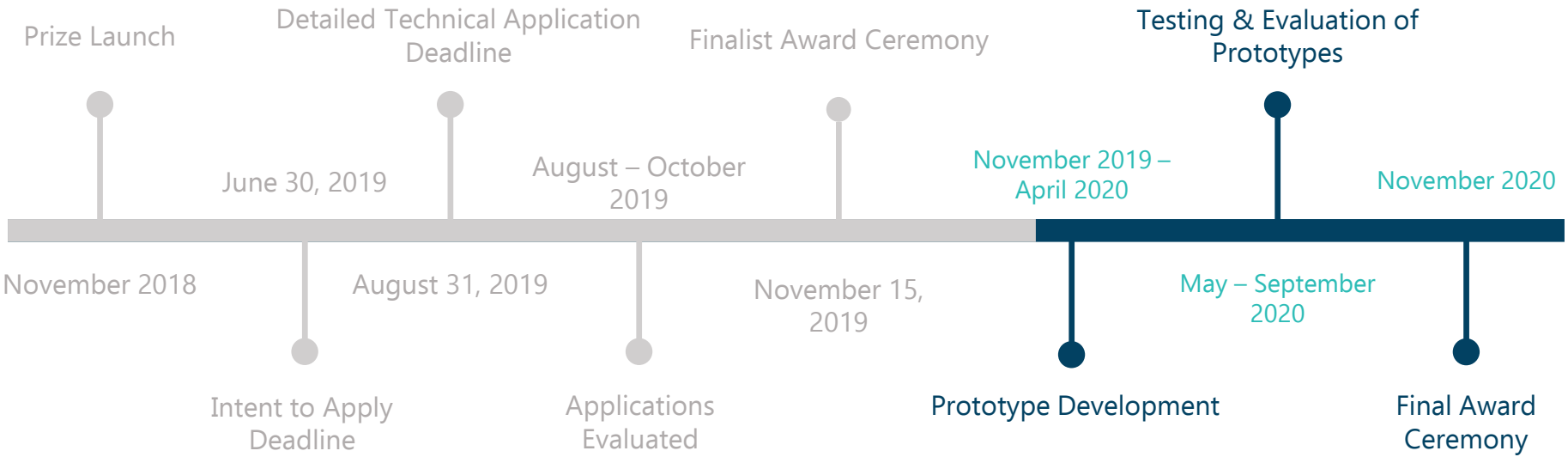
Key highlight is the diversity offered by the selected finalists

- Diversity of technology
- Diversity of geography
- Diversity of entity profile

Selected 8 breakthrough cooling solutions combine multiple innovations to meet the prize criteria

- **Climate friendly refrigerants or alternatives**
  - R152a (GWP <150)
  - R290 (GWP <3)
  - HFO 1234ze (GWP <1)
  - Solid refrigerant: 2-Bromoadamantane (GWP 0)
  - Water
- **Independent sensible and latent cooling**
  - Desiccant materials to handle latent loads
  - Novel Membrane materials to handle latent loads
  - Multiple evaporator approach to independently manage sensible and latent cooling
- **Recover and reuse condensate to reduce water consumption**
  - Direct evaporative cooling at condensing unit
  - Direct or Indirect evaporative cooling unit to handle sensible load
- **Smart controls that optimizes hybrid operation mode based on sensed condition**
  - Optimize multiple evaporator or condenser operation
  - Auto-switching between ventilation, evaporative cooling, vapor compression
- **Integrated solar PV panel on condenser unit**
  - Reduce the grid electricity consumption
  - Reduce the peak demand on the grid
  - Facilitate rainwater capture for re-use in evaporative cooling

Prize Timeline and Key Milestones



Testing and selecting a winner(s)

Global Cooling Prize

Finalists are required to ship two prototypes to India by April 15, 2020 for testing

Finalists eligible to receive an award of **US $200,000 each**

Finalists undertake prototype development and production between **November 2019 and April 2020**

Finalists ship two working prototypes to India by **April 15, 2020** for testing.

Prototypes received from finalists will undergo Testing by three different methods that complement each other

Test Method	Key Objective	Control	Relevance to Energy Use Estimate	Repeatability	Monitoring	Expected Noise
Lab-simulated test	Controlled Environment	Temp / RH conditions, Internal Loads (dynamic), External Loads (dynamic)	High	High	Extensive	Minimal
Field Test	Replicate real-world scenario with all the variables	Internal Loads (dynamic)	Moderate	Low	Moderate	High
ISEER	Alignment with reference Standards	Temp / RH conditions (static)	Low	High	As per Standard	Minimal

Lab simulated year-round performance test

Global Cooling Prize

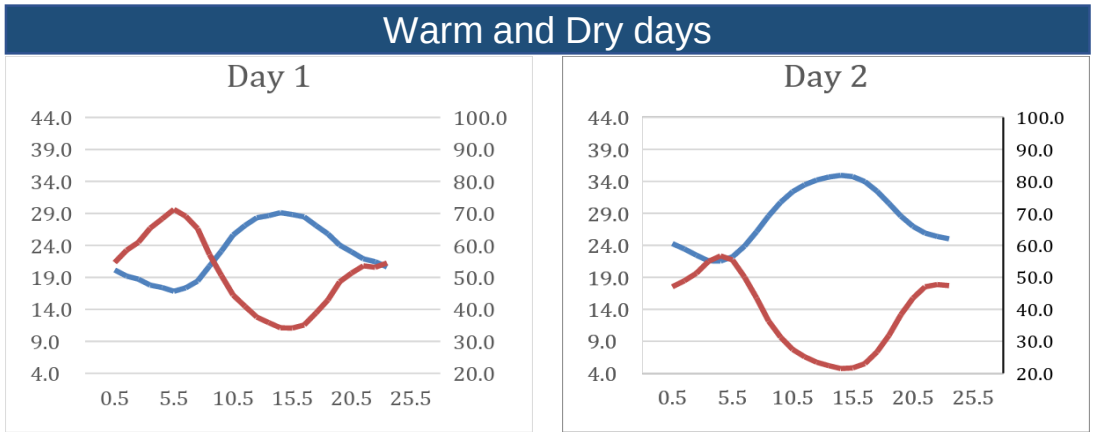
One prototype from each finalist will be tested at CEPT University's state-of-the-art facility

- 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)

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

- Selected 10 typical daily profiles represent all climate zones of India under which a cooling technology is expected to operate.

Warm and Dry day → Warm and Humid day → Hot and Dry day → Hot and Humid day → Extreme humid day → Extreme hot and dry day

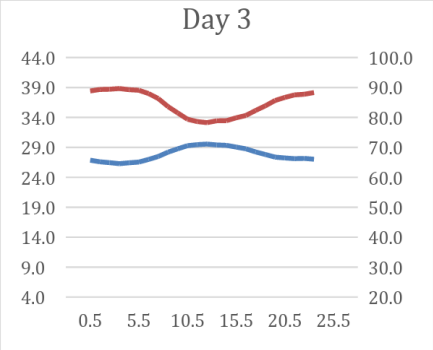


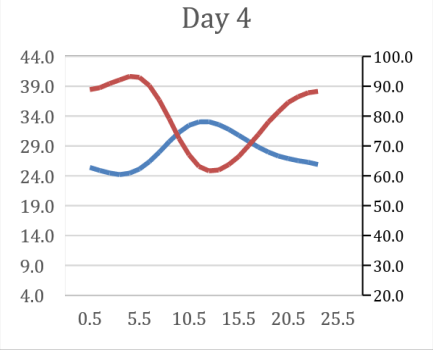
Dry bulb temperature

Relative humidity

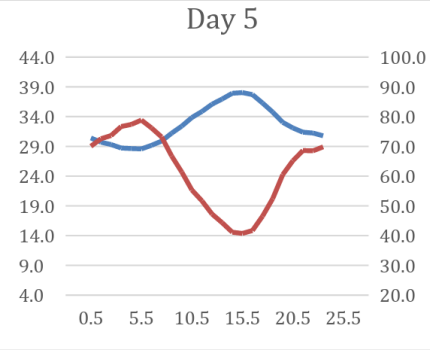
10 selected days for the lab test cont…

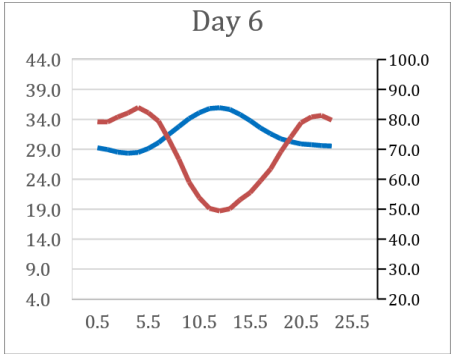
Warm and humid days



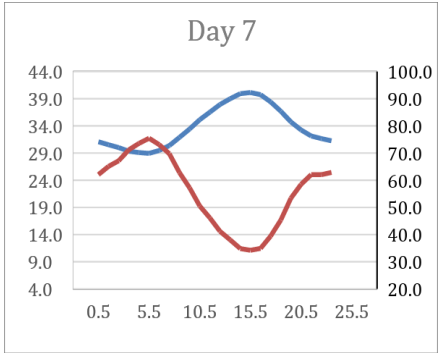


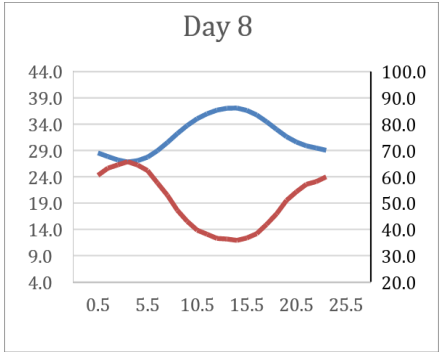
Hot and humid days



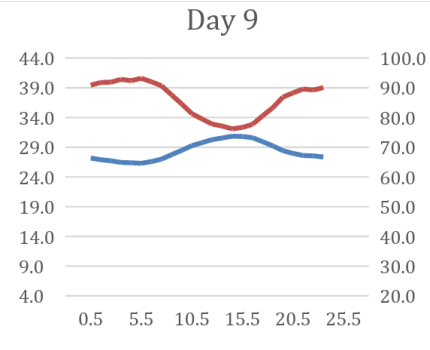


Hot and dry days

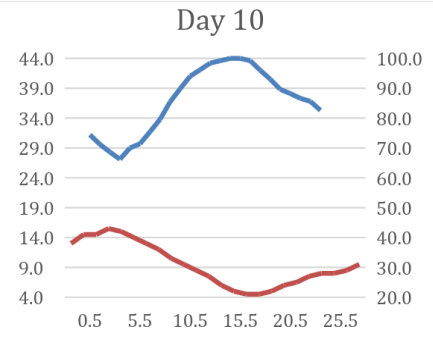




Extreme humid day



Extreme hot and dry day

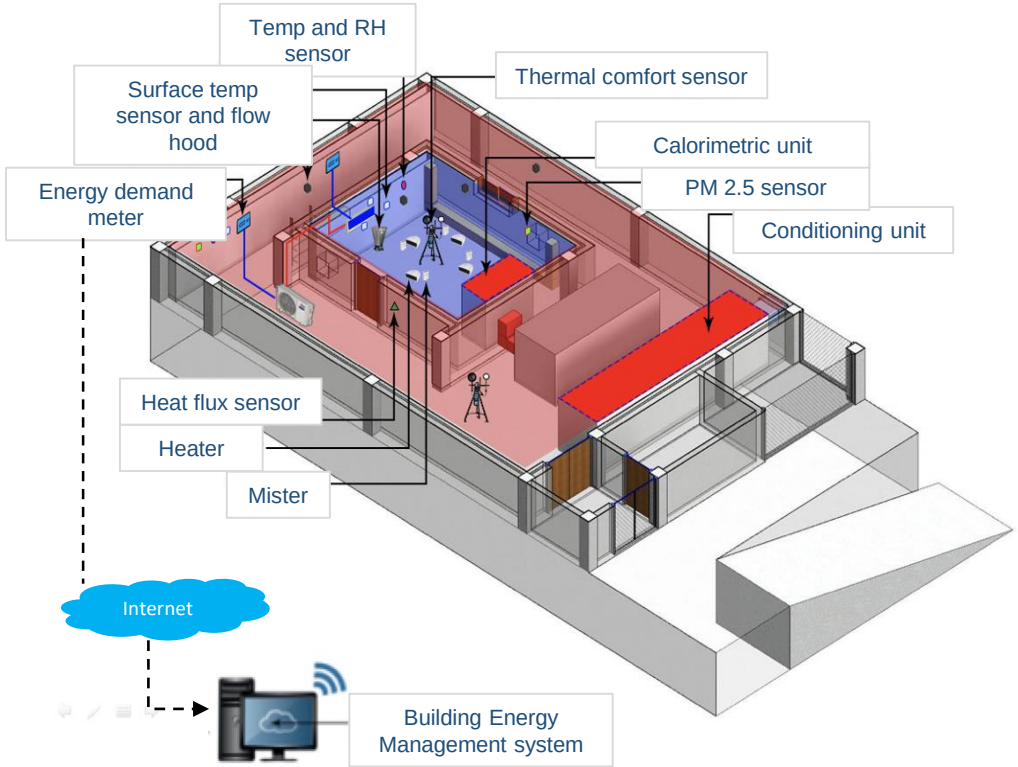


Dry bulb temperature

Relative humidity

Protocol to be followed for lab test

- Prototypes to be installed and tested for up to 12 days in the simulated lab environment.
- 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.

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

Day Type	Sequence of days	Weighting factor*
Warm and Dry	Day 1	8%
Warm and Dry	Day 2	12%
Warm and Humid	Day 3	5%
Warm and Humid	Day 4	18%
Hot and Dry	Day 5	1%
Hot and Dry	Day 6	10%
Hot and Humid	Day 7	4%
Hot and Humid	Day 8	6%
Warm and Extreme Humid	Day 9	6%
Extreme Hot and Dry	Day 10	2%

Example calculation - Using weighting factor to determine annual performance

Test day	Operating hours [hours/day]	Measured cooling electricity consumption [kWh/day]	Weighting factor*	Annualized energy consumption [kWh/year]
Day 10 - Extreme Hot and Dry	*24*	*25*	*2%*	***182.5*** *[25* (2%*365)]*

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

Scaling Interventions within the scope of the Global Cooling Prize

Global Cooling Prize

Catalyzing Scaling Interventions

- Demonstration of what is possible
- Publication of findings from prize criteria and testing protocols in comparison to equipment standards and rating systems in this sector – extracting learnings to inform future policy.
- Establishment of investor ‘marketplace’ to connect those able to commercialize and invest with innovators interested in garnering support
- Stimulate bulk procurement and AMC programs from those end users naturally motivated by lower lifecycle cost
- Stimulate the development of incentive and pay as you save programs to help overcome first cost barriers to sustainable cooling equipment

Lessons Learned .....so far

Global Cooling Prize

Lessons …. so far

- The power of amplification – A global coalition

- Specific to the prize process
  - Prize as a change model – where market failure exists
  - Establish pure outcome-based criteria, do not embed technology bias.
  - These are hard to solve problems, narrowing the focus to a single end use helps secure engagement and reduces subjectivity
  - If trying to solve a global problem running a national prize is sub-optimal, global problems deserve global prizes
  - Be sure to engage Industry and Industry associations

- The answers are out there, we just need to engage and ask the right questions – todays standards and rating systems may not be asking the right questions ?

Thank You

Visit - www.globalcoolingprize.org

Email - info@globalcoolingprize.org

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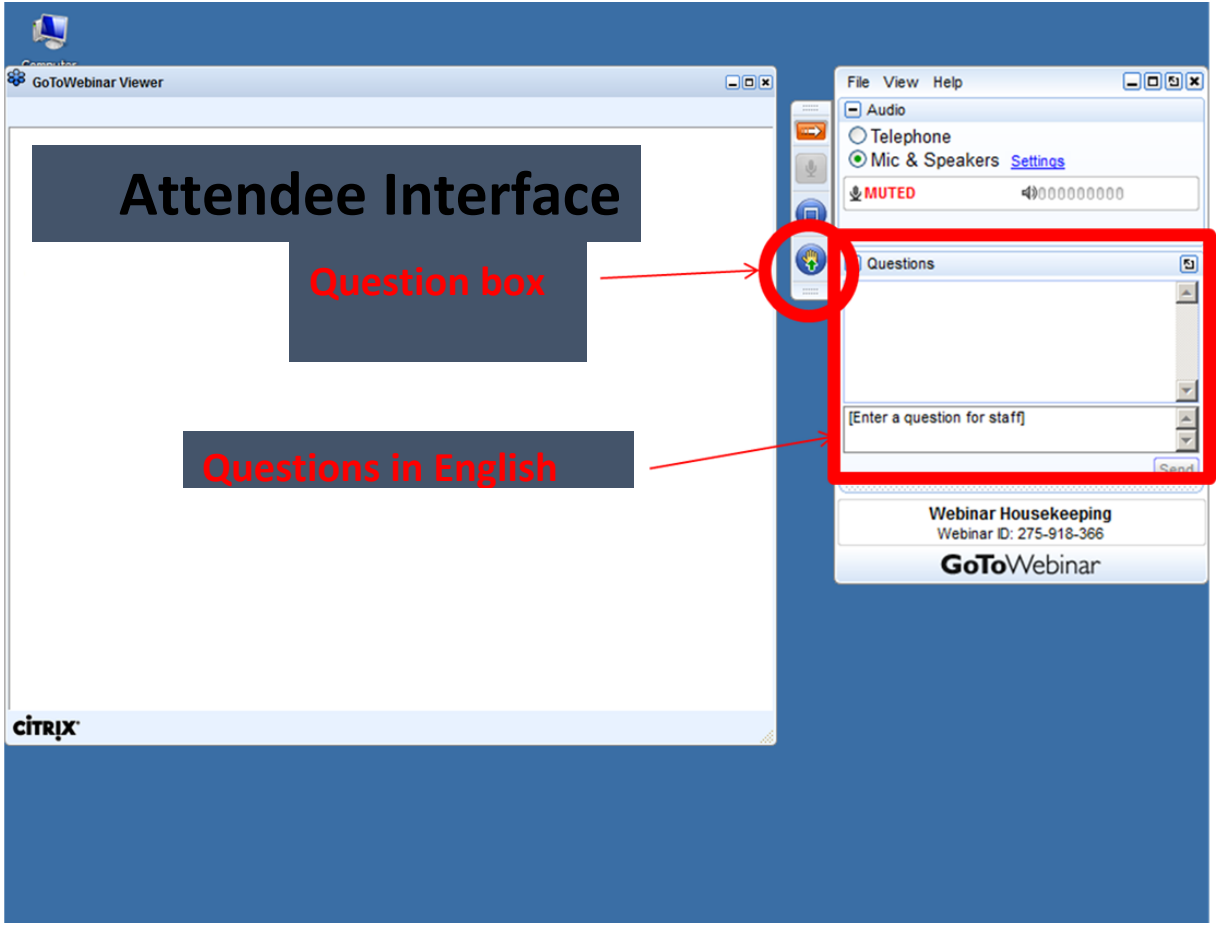
How to ask questions



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