Delivering Low Carbon Cooling

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Why Cooling Matters?
Emerging Markets – two extremes
Cold sits at the nexus of the SDGs
Cooling is not just air-conditioning
19 cooling appliances installed every second for next 30 years

Number of cooling appliances in-use globally, by sector (# of units)

![Graph showing the increase in number of cooling appliances from 2007 to 2050, categorized as space cooling, stationary refrigeration, and mobile cooling.]

All cooling sectors global annual energy consumption [TWh]

- All cooling total energy cons. [GCI CT]
- All cooling total energy cons. [GCI AT]
- All cooling sectors energy allocation [From IEA 2DS]
- All cooling sectors energy allocation [From IEA B2DS]

Data collated from GCI, Giz Prtoklima and IEA
The Energy Conundrum of Cooling for All

Total cooling sector energy consumption by sector in current tech progress scenarios (TWh/year)

- Mobile cooling
- Stationary refrigeration
- Space cooling
- IEA 2DS Cooling sector energy budget
- IEA B2DS Cooling sector energy budget

All cooling sectors global annual energy consumption by scenario vs. IEA cooling sector energy allocation [TWh]

- GCI current tech progress (GCI CT)
- GCI accelerated tech progress (GCI AT)
- IEA 2DS cooling energy allocation
- IEA B2DS cooling energy allocation
- C4I current tech progress (C4I CT)
- C4I accelerated tech progress (C4I AT)

3,900 TWh where we are today

Radical innovation to achieve a 70% reduction in electricity usage for cooling

Interventions
- Social/culture
- Policy
- Technology
- Skills
- Research
- Business

Cooling for All
- Current Technology Progress 19,600 TWh
- GCI Demand Forecast 9,500 TWh

2DS Energy Budget 6,300 TWh

At this point still need a strategy to carbon neutrality for cooling
Thinking thermally

The question is ‘what is the service we require and how can we provide it in the least damaging way’, rather than ‘how much electricity do I need to generate?’
System approach to cooling

Making cold
Harness waste/unused resources e.g.:
‘wrong time’ renewable energy (e.g. wind),
waste cold (e.g. LNG) ambient heat & cold
(e.g. ground source)

Storing cold
Thermal energy storage to warehouse

Moving cold
New energy vectors and material to shift
cold

Using cold
Reduce cold loads
Increase efficiency and reduce GWP
of conventional technologies
New technologies to harness new
stores and vectors

Managing cold
Monitoring, controls and management

Financing Cold
How do we charge and pay for cold

There are opportunities to access thermal resources to meet cooling needs sustainably.

Cold Resources – Numerous resources exist for example:
- Waste cold of Liquefied natural gas (LNG)
- Deep Lake or sea water
- Sky cooling

Low grade heat resources
- Process waste heat
- Geothermal
- Solar
The Ladder of Opportunities

Given demand, need for both urgent intervention as well as long-term sustainable strategies, we need a roadmap and pathways based on a ladder of opportunities.

“must have” – ensure basic needs are met for all people whilst living within our natural limits and mitigating future risks to our planet

Now!

Ensuring lowest GWP and highest energy efficiency of current technologies – maintenance, best in class adoption

Increase efficiency

Active steps to reduce demand for cooling, Mitigate need (building design, passive cooling, food packaging)

Behavioural changes

Develop!

Think thermally, rather than default to electricity – turn waste heat and cold into a value

Think system and how to harness waste energy to meet cooling needs

“future proofing” – improving quality of life for all whilst equally creating abundance from our natural resources

Needs-driven leapfrog new technologies

Disruptive Innovation
New business Models
Smart Thermal Systems - What do we need to do?

Solving the cooling challenge requires a comprehensive systems approach recognising multiple interdependencies requires bundles of technologies and integrated measures and policies. These need to be fit for market and fit for finance.

1. Think how cooling demand fits into the wider electrical and energy system + opportunities to use it for demand side flexibility – energy system thinking

2. Think how cooling fits into attempts to decarbonise transport – clean transport

3. Think how waste or surplus renewable resources can be accessed via process integration or storage?
Demand-side management and behavioural change

Cooling spans many sectors. Solutions will be complex, integrated across sectors; and need to be “fit for market”

Priority Setting

Implementation Challenges

Policy Interventions

Novel business models

Partnerships for delivery
## Barriers

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<thead>
<tr>
<th>Issue</th>
<th>Description</th>
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<tbody>
<tr>
<td>Lack of Awareness</td>
<td>Cooling is a critical issue in the energy and climate change mitigation debates as an example only 83% of 1.99 Nationally Determined Contributions (NDCs) even mention refrigeration and cooling (R&amp;C), Latin America, Ghana and Vietnam are the only countries with any explicit commitments — but it is a major role in addressing socioeconomic challenges and significant impact on the energy system, climate change and pollution.</td>
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<td>Lack of research funding</td>
<td>Funding for cooling research in the EU is less than 0.2% of the total engineering research budget. EU-only spend a significantly smaller % of revenue on radical innovation than in other comparable sectors.</td>
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<td>Investment</td>
<td>The high impact and patient capital investment sectors are facing a scale at the rate required to solve pressing environmental and social challenges, including addressing the need for clean Cooling for All. UNEP has highlighted the need for new actors, coalitions and instruments to be part of the solution and help close the financing gap.</td>
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<td>Access to Finance</td>
<td>Some types of cooling equipment are too expensive for the people who would benefit from them to purchase. This seems to be especially true of pre-cooling systems that could be used to reduce food spoilage in the agricultural sector, though also relevant to domestic refrigeration and space cooling.</td>
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<td>Electricity Availability</td>
<td>The vast majority of today’s available cooling technologies are reliant on electricity access. Currently about 87% of the world has access to electricity. In sub-Saharan Africa this figure falls below 43% of the population. Lack of electricity supply prevents universal access to cooling in many developing and emerging economies. In countries that do have access to electricity the robustness of the power grid and actuality of supply can be a issue too, as for example in India where blackouts are common both in the urban and rural environments.</td>
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<td>Skills</td>
<td>The skills challenge is two-fold. Firstly, using refrigeration, and by installation, maintenance and servicing of refrigeration and space economies and deployment of equipment at scale creates a substantial National interest vs. MEPS. Minimum efficiency performance standards (MEPS) and similar initiatives can be a very effective mechanism for enhancing the efficiency of equipment sold in a market place. However, attempts to protect national producers can lead to varying efficiency standards between markets. MEPS also tend to focus on performance of traditional VRF units, rather than deployment of more radical innovations and system-based solutions for cooling.</td>
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<td>Lack of Policy Incentives</td>
<td>In many (developed) countries, mitigation-related investments remain largely untested. This indicates that there is a general lack of conducive policies to drive a carbon transition in the R&amp;C sector. Globally, numerous government incentive schemes exist. Incentives for the replacement of refrigeration technology by a reduced energy footprint are effective in both residential and commercial buildings.</td>
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<td>Split incentives</td>
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<td>Higher Purchase Prices for more efficient equipment vs. total cost of ownership savings</td>
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<td>Pipelines</td>
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<td>Proving integrated systems</td>
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<td>Culture vs. Refrigeration</td>
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<td>Lack of Market Incentives</td>
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**Novel business models … Cooling as a service**

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<th>Usage Management</th>
<th>Monitoring and Maintenance</th>
<th>Energy</th>
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<td>Buy or lease</td>
<td>In-house</td>
<td>Contract</td>
<td>3rd party or own generation</td>
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**Equipment sale**

- **Existing service based approach bringing maintenance and management into a single contract**
  - Single “lease” based contract
  - Can have a success-related payment structure linked to efficiency
  - 3rd party or own generation

**District Cooling model.**

- Single contract possibly with two elements to the bill based on RT (Refrigeration Tonnage) –
  1. **Demand charges** are associated with the system costs for infrastructure, operations, and maintenance and based on the amount of cooling your property requires.
  2. **Usage charges** are the energy costs to produce refrigeration (i.e. the chilled water in the case of District Cooling). This is metered. This could be charged as either a variable against demand or as a flat rate plus an excess fee.

**Cooling as a Service**

- Single contract **based on service provided by cooling**
  - i.e. per ton of food produce stored or moved (Coldhub model extended) or size of flat and hours of cooling – “I want temperature to be maintained between at 22-24°C” whilst I am home / from 6pm to 10pm –

_CaaS in this form could unlock integrated maintenance benefits of enhanced leases, scale benefits of district cooling and delivery system optimisation opportunities e.g. intelligent building design or insulation practices through servitization._

**ieadsm**

*energy efficiency*
Global access to sustainable, affordable and resilient cooling to
• underpin health
• habitable, safe housing and work places
• reduce post-harvest food loss - protect food volume and quality;
  ensure efficient movement from farm to consumption centre
• Enhance economic wealth and security for farmers
• Achieve nutritional security and deliver safe food to the wider population
• plus, plus, plus ….

and

ensure that the massive growth in demand for cooling is managed within the constraints of natural resources, local economies and underpins, rather than undermines
✓ CO2, Climate Change and pollution targets
✓ energy efficiency and resilience
✓ sustainable and affordable infrastructure
Doing cold Smarter

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