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LEADERS IN IDEAS AND SOLUTIONS

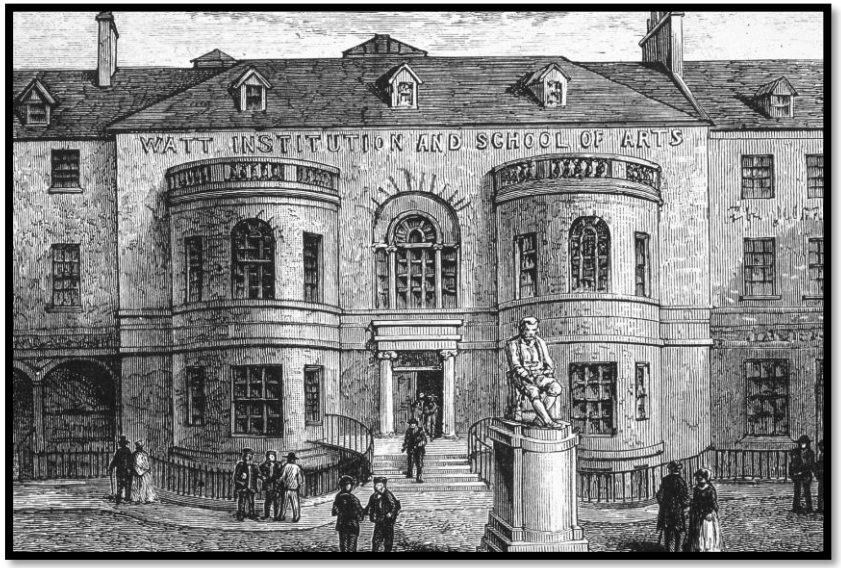
System-level thinking to meet our Cooling Demands sustainably

Professor Toby Peters

Transformational Innovation for Sustainability

Cold Economy

Mechanics Institute to Global University



- Scottish Institution, founded in 1821
- Rooted in mission to create and exchange knowledge for the benefit of society
- First Mechanics Institute, starting a worldwide movement
- Pioneer of access to education for men, women and the working classes

- c.30,000 students globally, UAE and Malaysia, including global community of PGT online learners – Edinburgh Business School

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Malaysia Campus, Putrajaya

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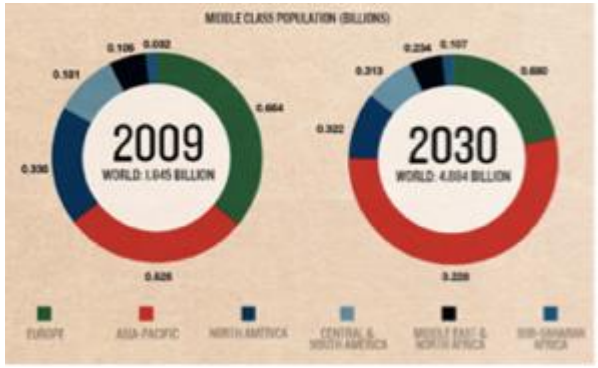
Cold sits at the nexus of this challenge

Why Cold Matters?

Artificial cooling is the backbone of our society

food, health, comfort, data

Emerging markets – Two extremes

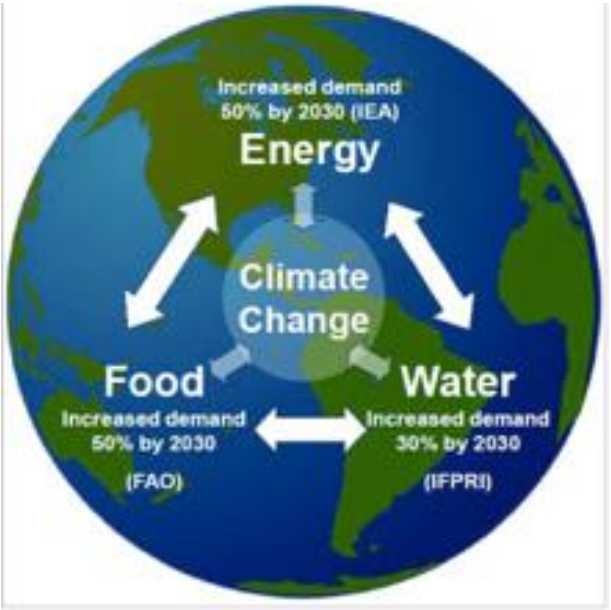


Asian Pacific middle class could grow six-fold to 3.2 billion in 2030

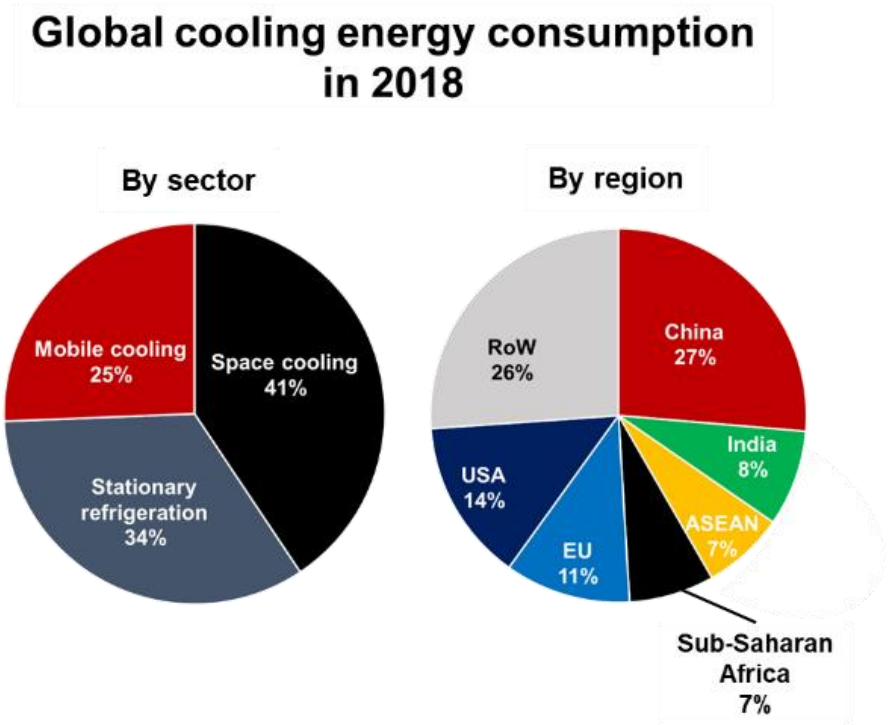
40% of food is lost post-harvest

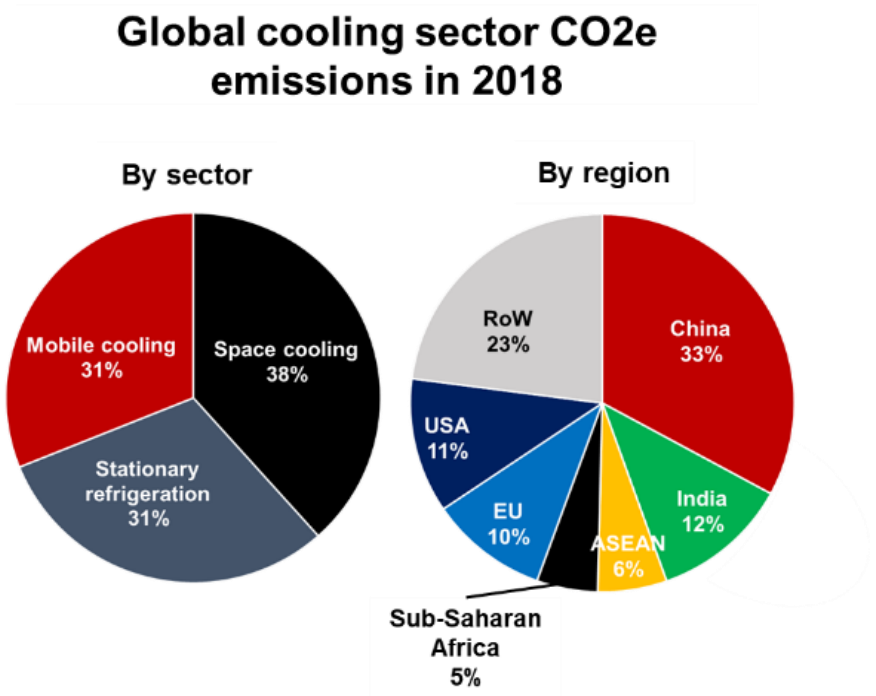
Spending power could rise from $5 trillion to $33 trillion.

Built on cooling ….

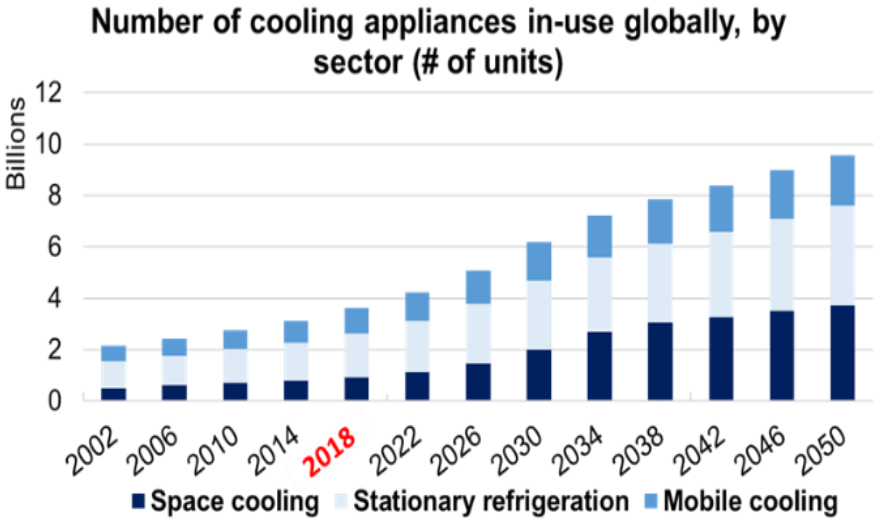


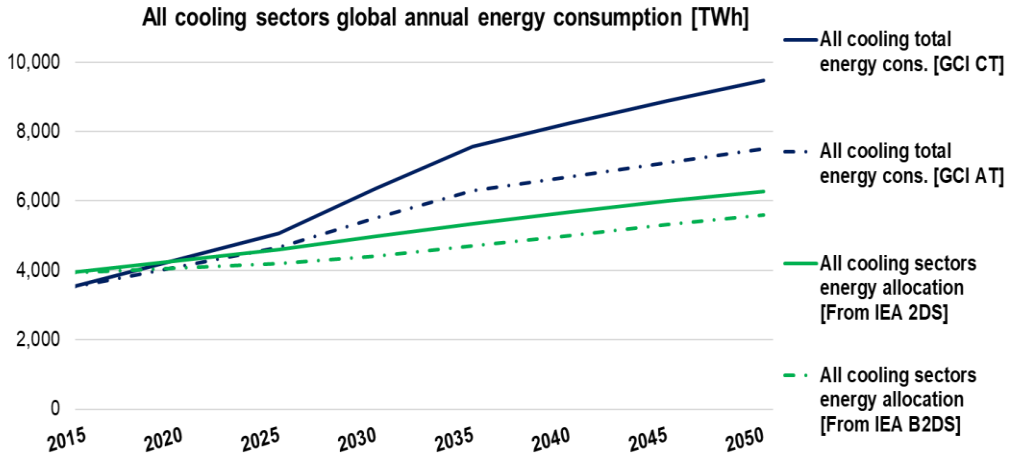
Current breakdown of energy consumption for cooling





Projected growth in cooling demand

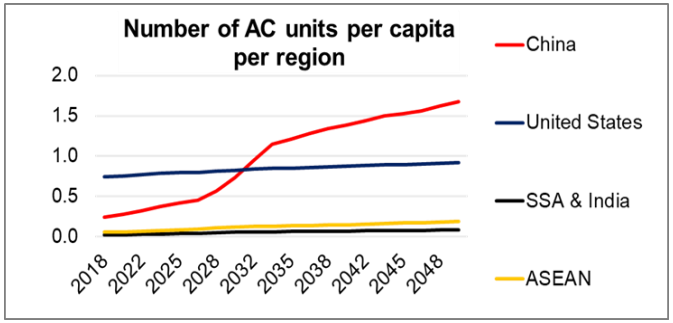


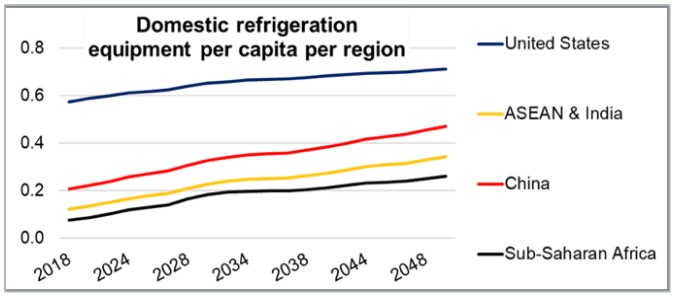


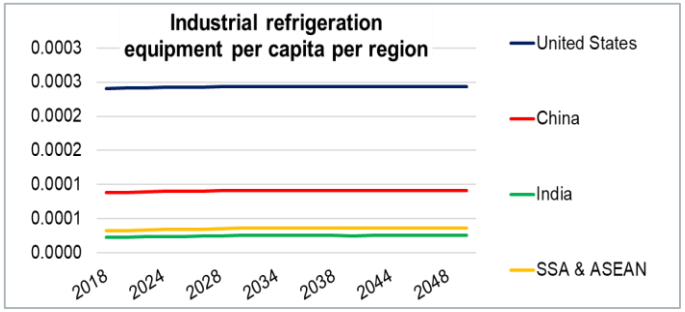
data collated from GCI, Giz Prtoklima and IEA

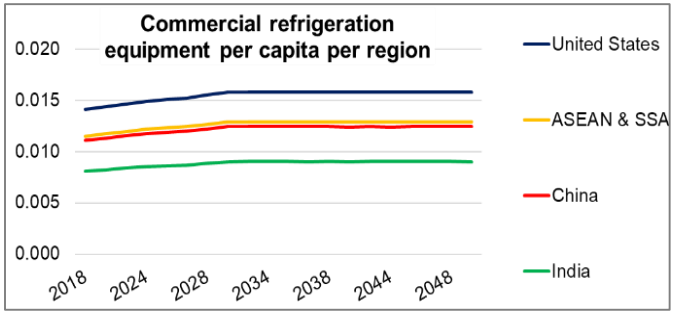
Only half the picture

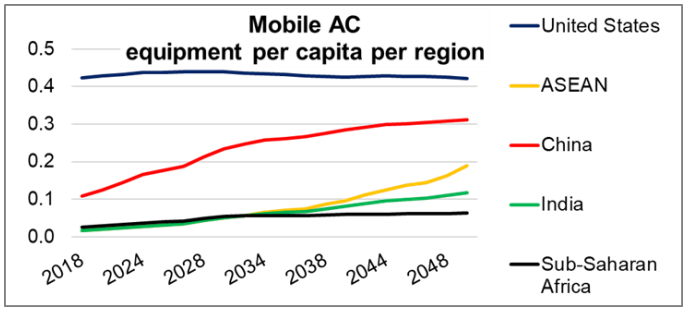
GCI projections of cooling equipment uptake still result in large portions of the world not having access to space cooling, refrigeration or cold chain even in 2050.

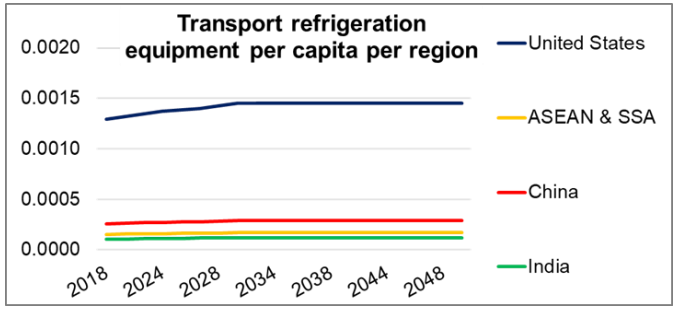




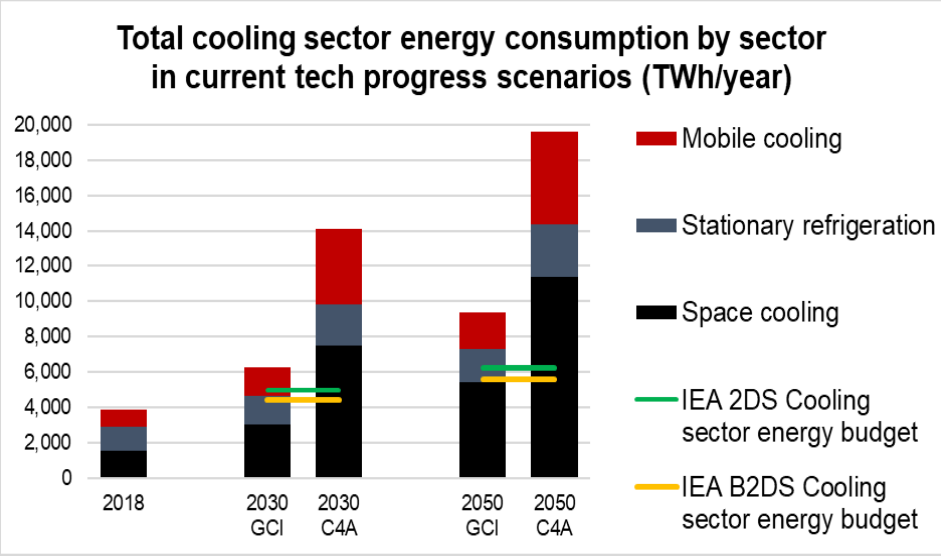


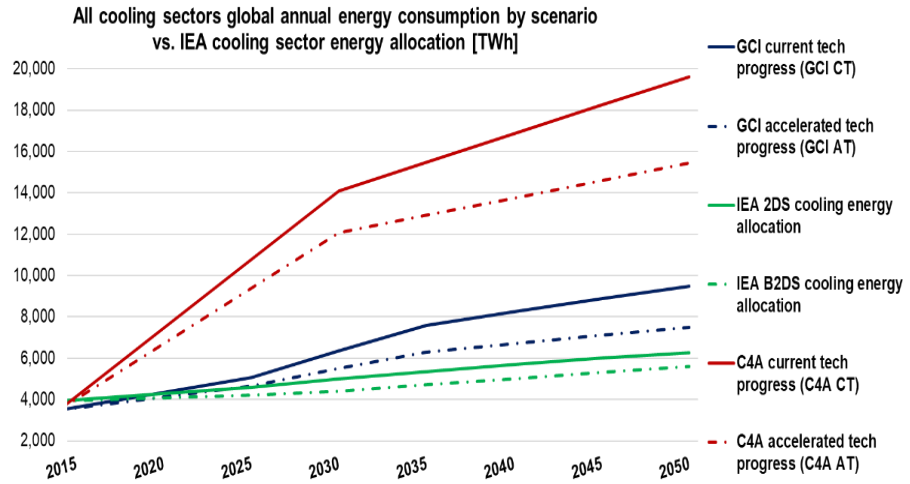






The Energy Conundrum of "Cooling for All"





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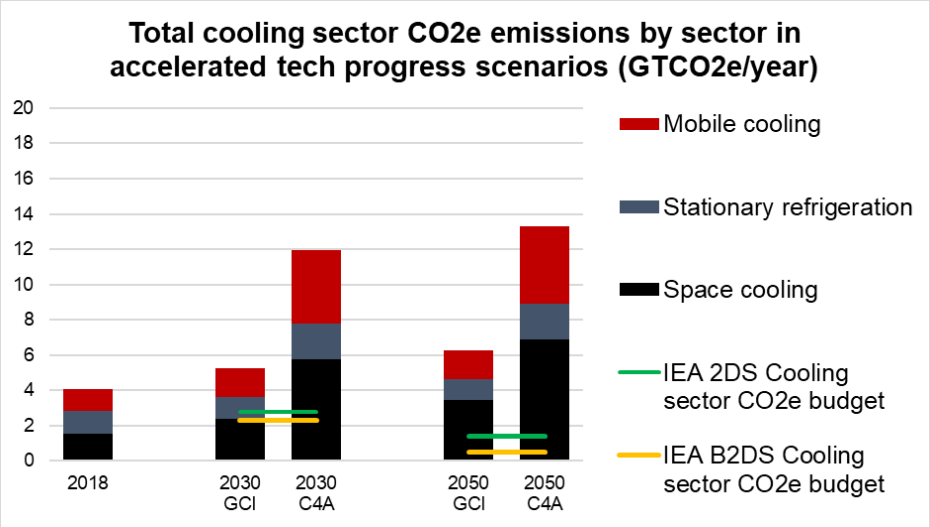

Scenario	% of IEA RTS projected renewables capacity by 2050	% of IEA 2DS projected renewables capacity by 2050
Current Technology Progress	49%	33%
Accelerated Technology Progress	39%	26%
Cooling for All - Current Technology Progress	101%	68%
Cooling for All - Accelerated Technology Progress	80%	53%

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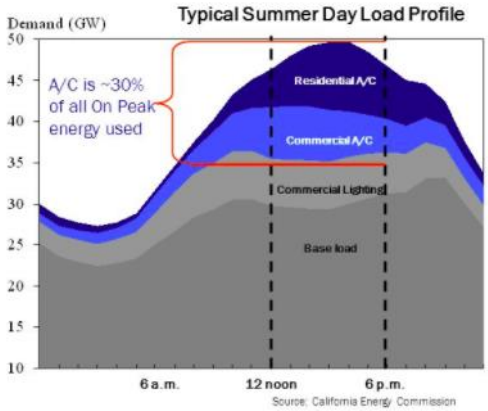
Delivering “clean cooling”

Cold sits at the nexus of this challenge

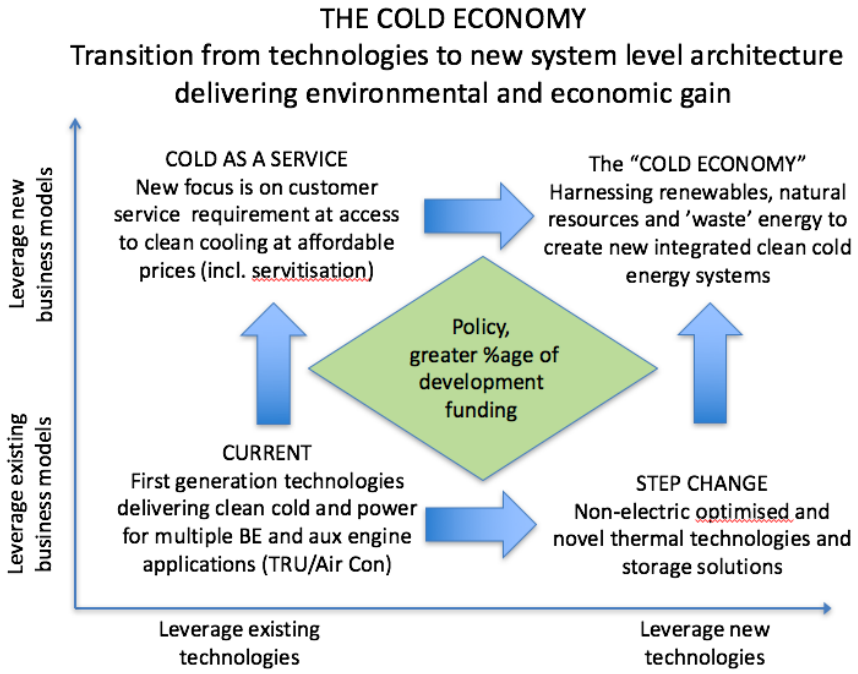
Cold Economy - Systems Approach

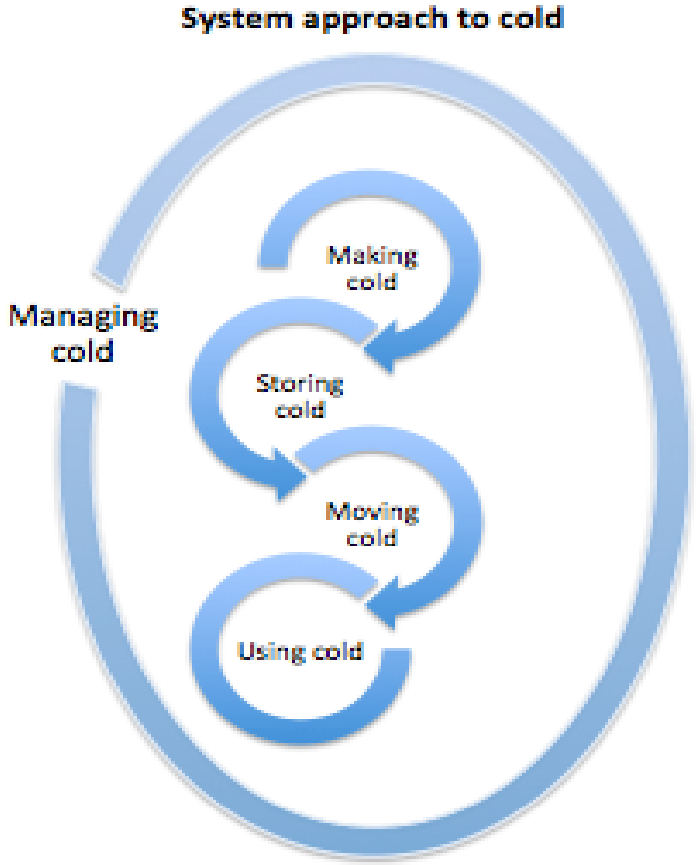
There is a need to re-shape the way we address cold needs – system approach

- We need to start with the services required, not simply the electrical demand
- We are still thinking electrons, we need to "think thermally"



Cold Economy - Systems Approach





The key 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?'*

Smart Integrated Thermal Grids

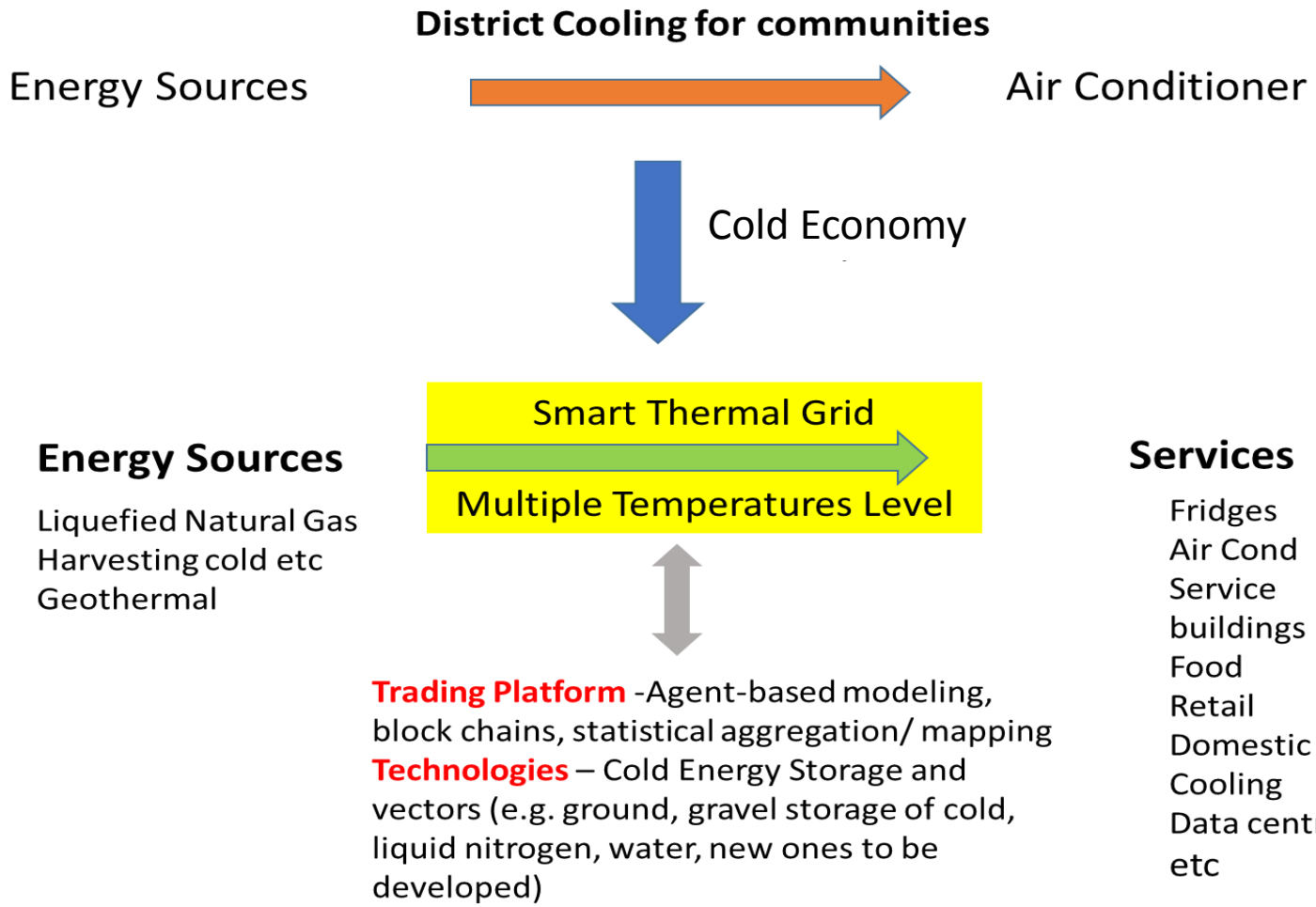
Cold Chain (food, pharmaceuticals)

Mobility

Buildings & Cities

Data

Smart Integrated Thermal Grids



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Think thermally

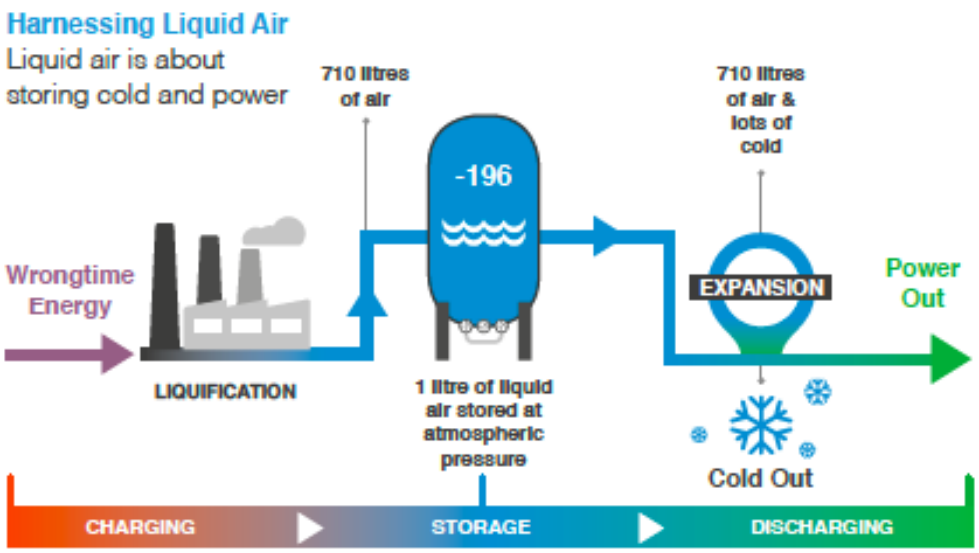
Waste Heat & Cold Usage

Heat/Cold Resource	Example Sources	Cooling Tech	Cooling Applications	Alternative Uses?
100-130°C	Process waste heat, turbine or engine exhaust gases	Absorption Chilling	Process cooling air conditioning – mainly stationary	Organic Rankine Cycle Power Generation
70-100°C	Food frying water condensate, solar thermal (vacuum tubes) and engine jacket water	Absorption and Adsorption Chilling		Process heat make up
10-12°C	The earth, water bodies like the sea	Ground Source heat pumps (cascade vapour compression cycles), underground storage	Multiple stationary applications in comfort cooling and refrigeration	N/A
4-10°C	Deep lake water	District cooling networks	Space cooling	N/A
0-4°C	Snow	Inter-seasonal snow storage	Space cooling	N/A
-164°C	LNG regasification	District cooling networks + Cryogenics	Air separation, process chilling and freezing + space cooling. Cryogenics can offer transport refrigeration too.	Direct cryogenic power cycles

Liquid Air - a novel energy vector

We need to store renewable / waste energy to use *on demand* in grid or transport applications

Liquid air is about storing cold ***and*** power



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Harnessing “Waste Cold”

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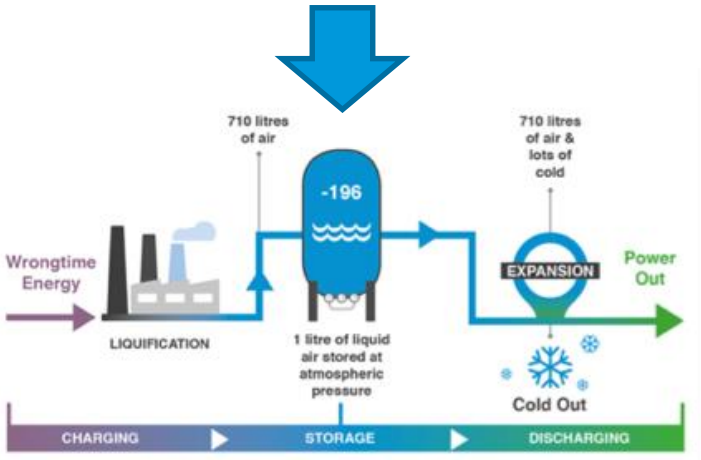
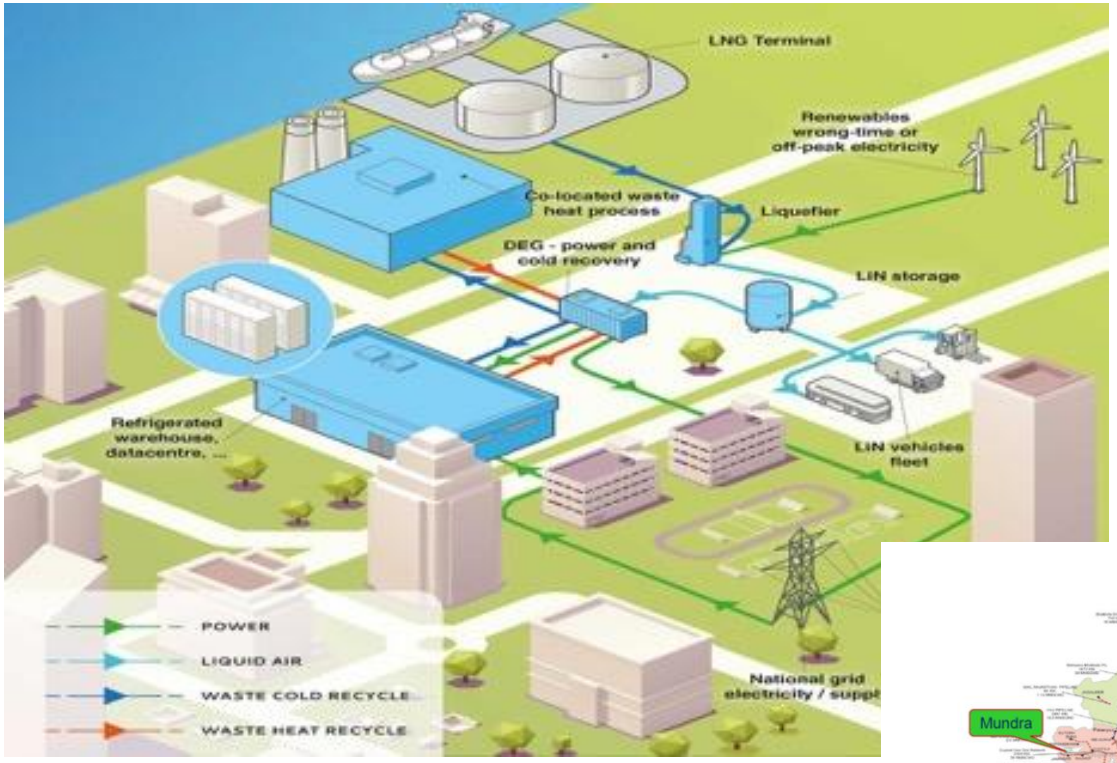
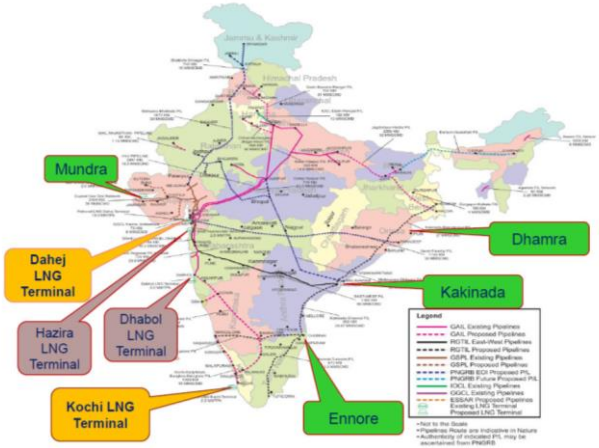


System approach to cold



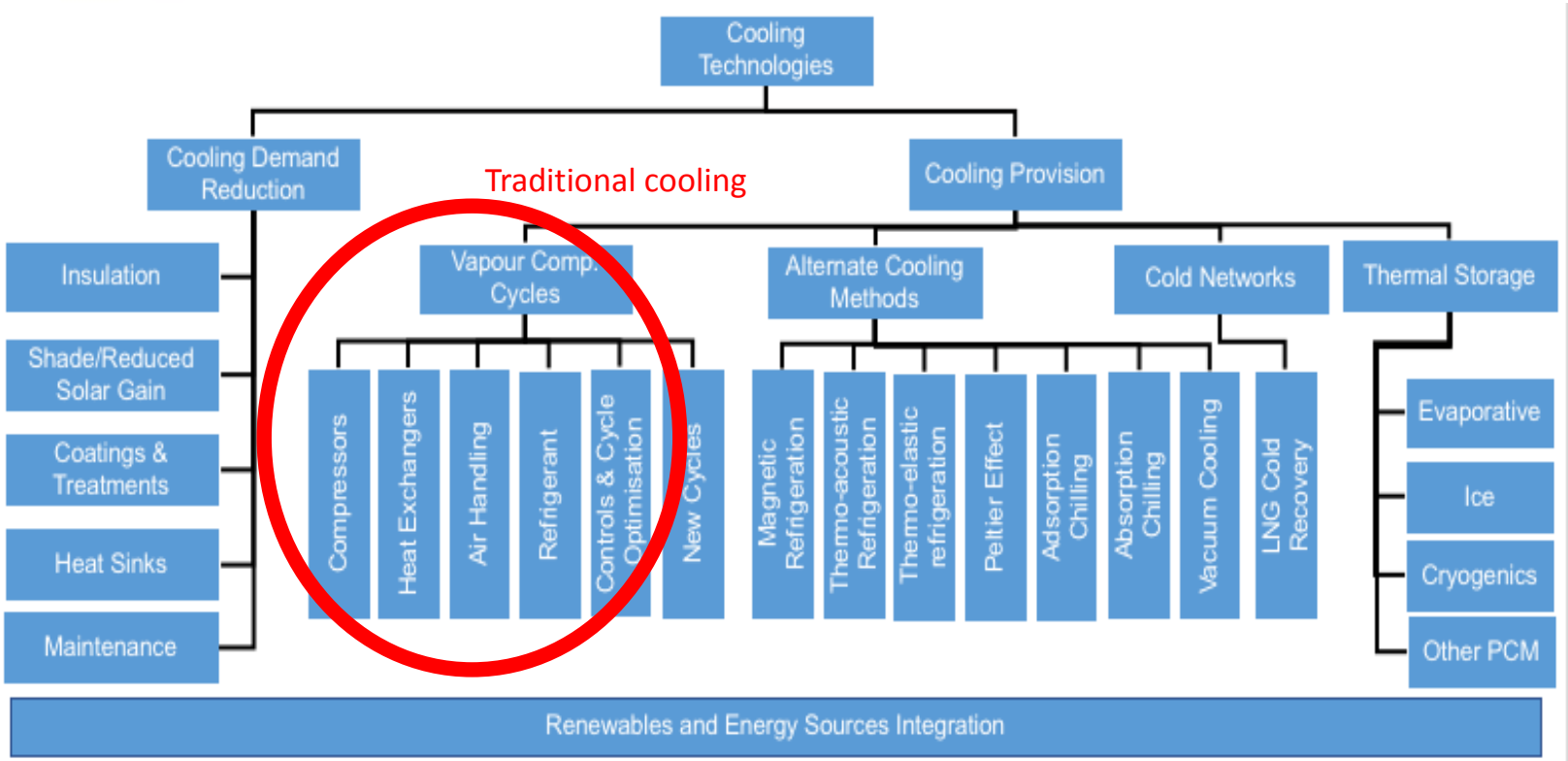


500M tonnes a year by 2025

$50 a tonne

Question is how much can we capture?

Cooling Technology – a major opportunity for innovation



PCM for air conditioner in trains, buses and EVs

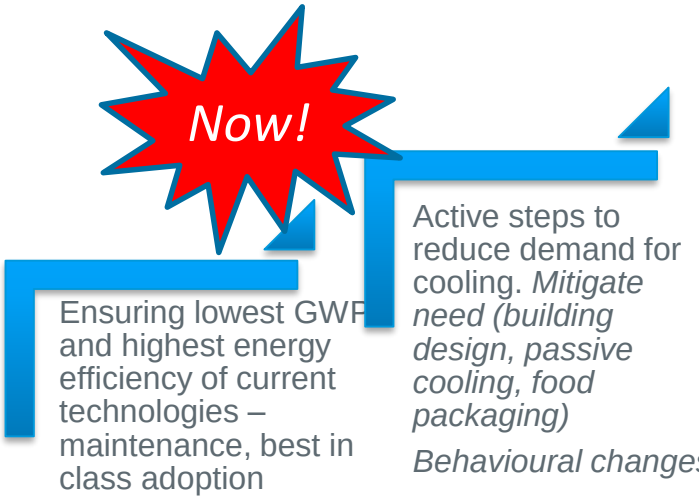
but currently very limited research and development budget

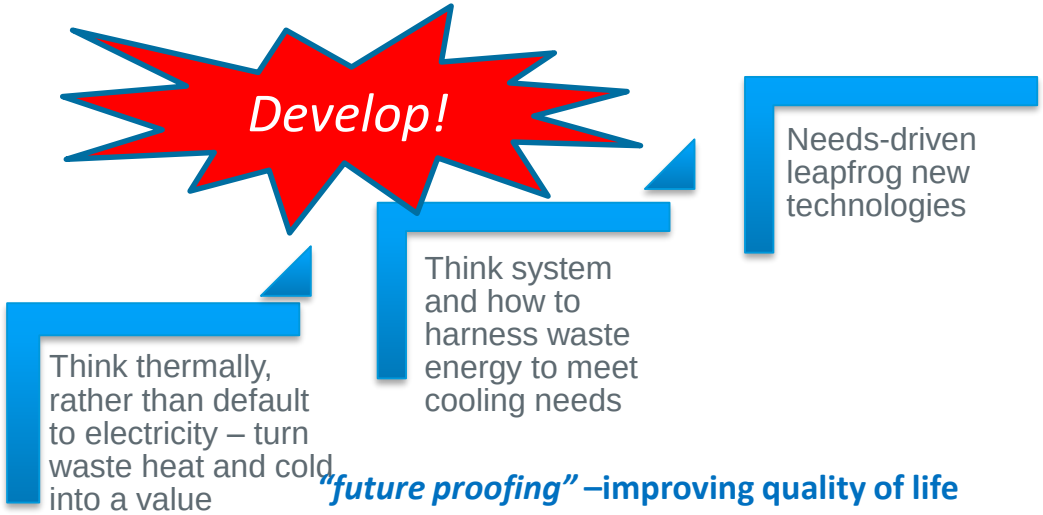
Harness waste cold of LNG

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**



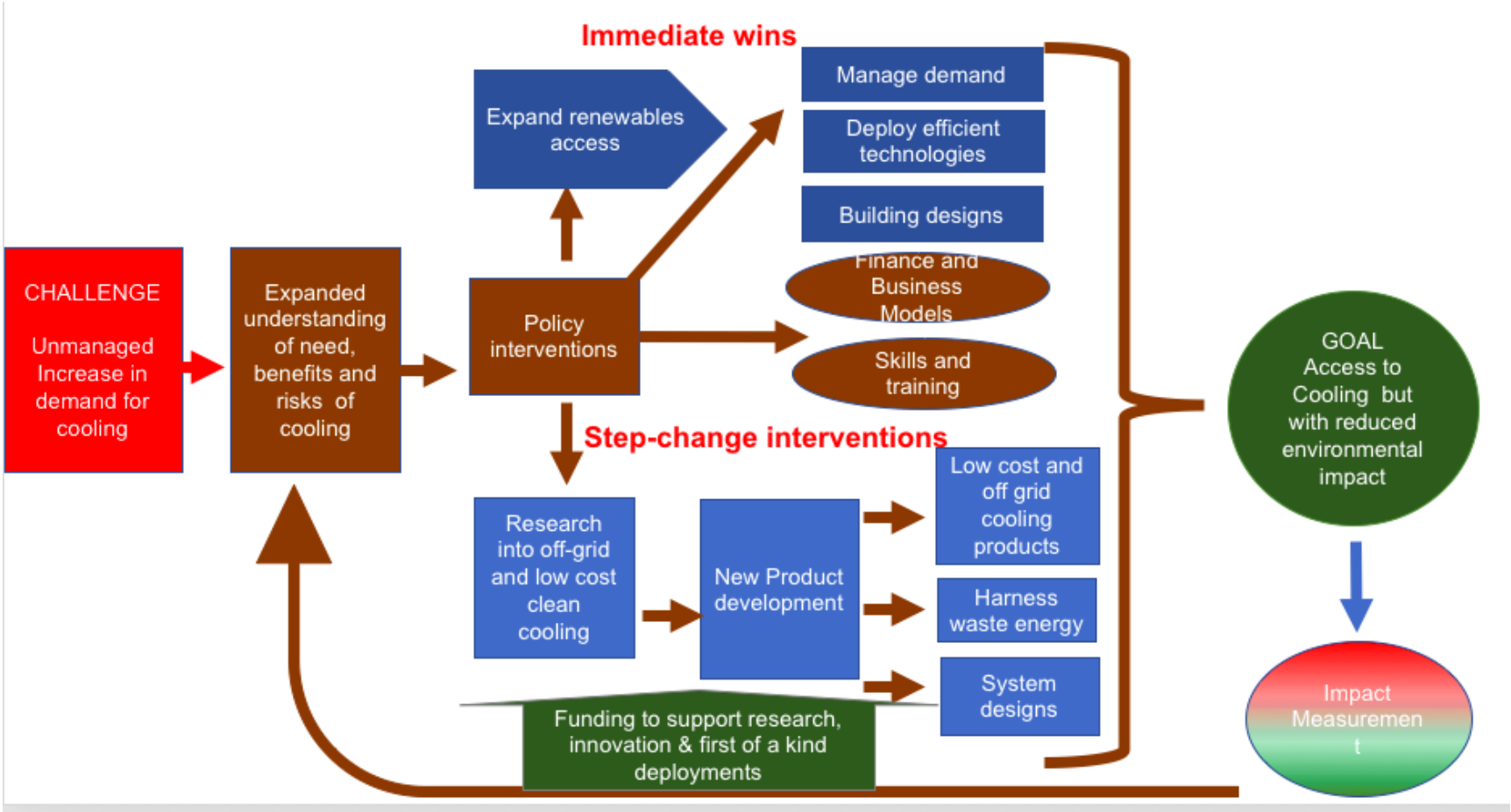


***"future proofing"* –improving quality of life for all whilst equally creating abundance from our natural resources.**

Increase efficiency

Disruptive Innovation
New business Models

What needs to happen to deliver Cooling for All sustainably?

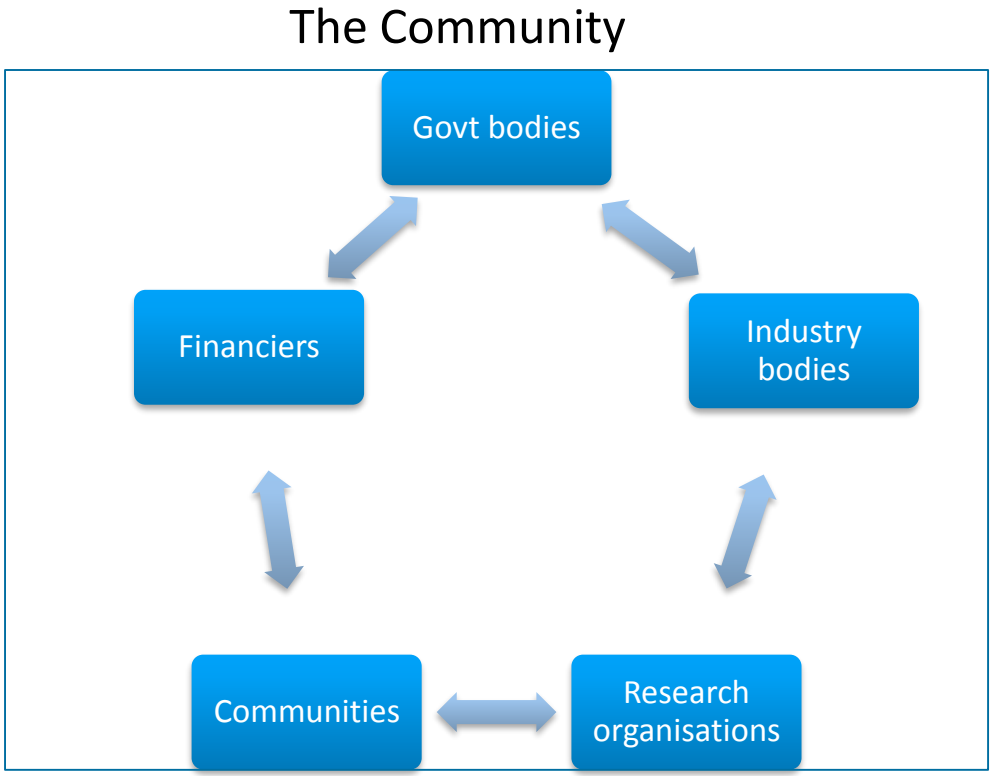


What needs to happen to deliver Cooling for All sustainably?

Phase 1 Roadmap	Phase 2 Delivery	Phase 3 Accelerate
Systems Level Problem Definition Assess Cooling for All at the systems level for alternative technologies, energy sources, business models and multi-industry resource efficiency sharing mechanisms.	**Fund Innovation development** Connect research institutes OEMs, VCs, policy makers and customers to collaborate on the delivery of high impact innovation.	**Policies to unlock finance** Create the market environment (policies and business models) to attract infrastructure investment to deliver "Cooling for All"
Multi-stakeholder Consensus Engage and drive consensus across the main stakeholder groups (policy, customers, industry, developers and financiers) on the most scalable and sustainable solutions categories	**Prove** Eliminate the performance risk and demonstrate impact through live market testing and validation in four Living Labs	**Skills** Identify the skills gap (design through to installation and maintenance) and connect educational institutes OEMs, policy makers and customers to collaborate on the delivery of accelerated solutions
Roadmap Intervention roadmap (technology, policy, finance, etc) to 70% reduction in electricity usage	**Access to Industry** Engage globaly l to scale alternative technologies	**Effective Knowledge Transfer** Use system level model, in-country living labs and manufacturing accelerator to roll out "fit for market" solutions across new geographies

Secretariat

- promote awareness of the issue
- build a community
- report on the status of relevant funding, policy, and technology,
- engage with organizations with the mandate and resources to form partnerships.



Clean Cooling Centre of Excellence

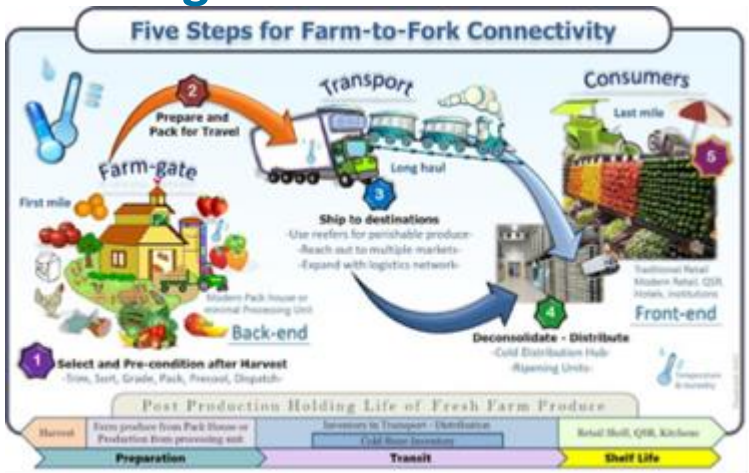
Why Clean Cold? Cold Chains

An integrated, seamless and resilient network of refrigerated and temperature controlled pack houses, distribution hubs and vehicles used to maintain the safety, quality and quantity of food, while moving it swiftly from farm gate to consumption centre.

It should enhance economic wealth, cash flow and security for farmers and improve food quality, safety and value to the customer; and achieves this with minimum environmental impact.

Increasing farmers' incomes

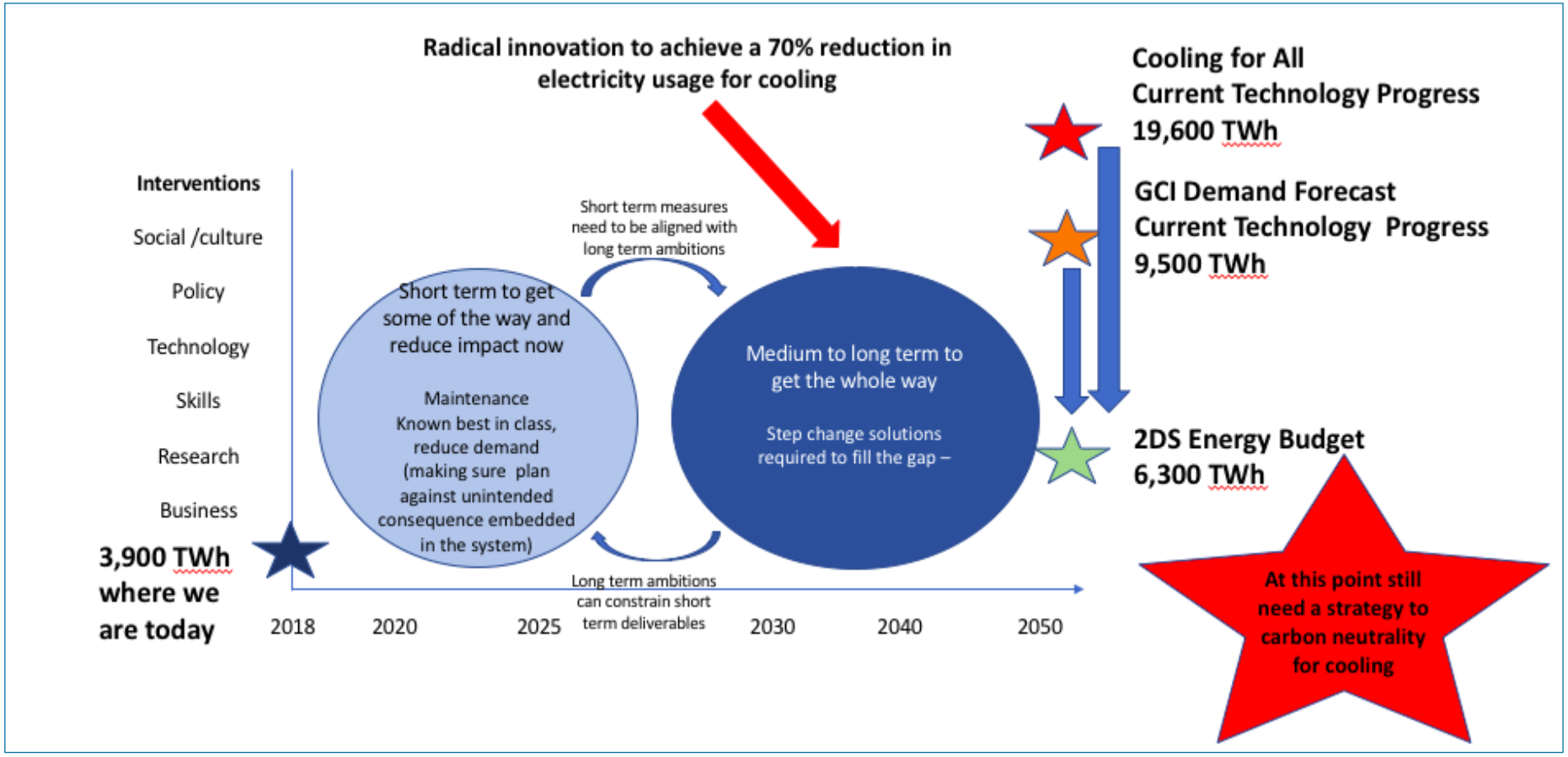
Feeding the world



We need "clean cold"

Intervention Roadmap

Meeting Cooling Demand Growth within the 2 Degrees Budget



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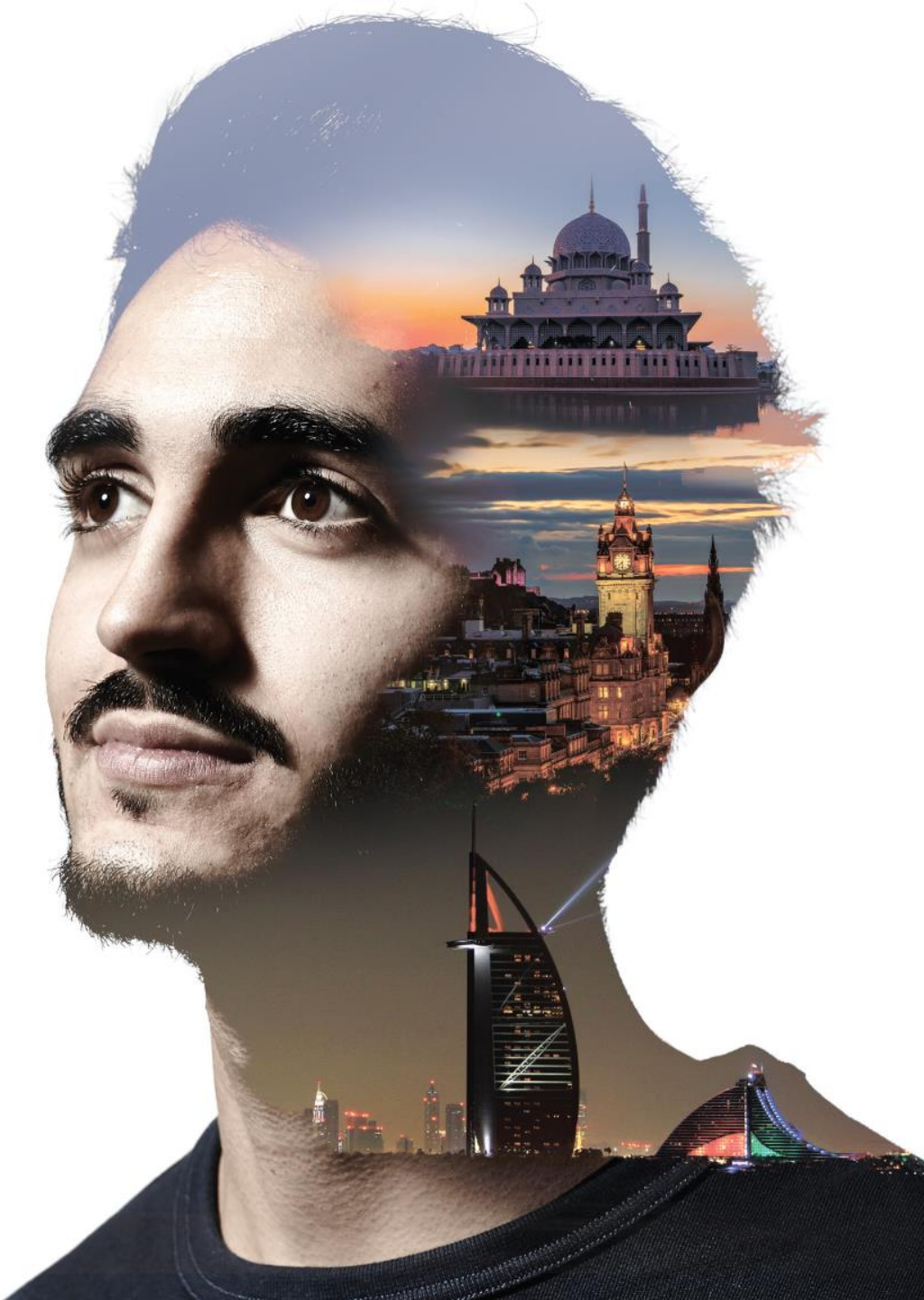

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