UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

Vienna Convention
MONTREAL PROTOCOL

Multilateral Fund for the Implementation of the Montreal Protocol

SUSTAINABLE COOLING FORUM

8-10 April 2026 | Vienna, Austria

International Institute for Applied Systems Analysis
IIASA

INSTITUT INTERNATIONAL DU FROID
INTERNATIONAL INSTITUTE OF REFRIGERATION

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Opening session

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Opening session

Mr. Ciyong Zou
Deputy Director General
Managing Director
UNIDO

Mr. Gerd Müller
Director General
UNIDO

H.E. Mr. Aiman A. Suleiman
Ministry of Environment
Jordan

H.E. Mr. Balarabe Abbas Lawal
Ministry of Environment
Nigeria

Ms. Megumi Seki
Executive Secretary
Ozone Secretariat

Ms. Tina Birmpili
Chief Officer
Multilateral Fund

Ms. Yosr Allouche
Director General
International Institute of Refrigeration

Speakers' biographies

Agenda

Photo session

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

Vienna Convention
MONTREAL PROTOCOL

Multilateral Fund for the Implementation of the Montreal Protocol

SUSTAINABLE COOLING FORUM

Rising to the Global Challenge

8-10 April 2026 | Vienna, Austria

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Introduction to the Forum

Introduction to the Sustainable Cooling Forum

Mr. Alois Mhlanga
Climate Innovation and
Montreal Protocol Division
UNIDO

Mr. Michael Eisinger
Climate Team
European Space Agency

Ms. Radhika Khosla
Associate Professor
Oxford University

Mr. Steffen Lohrey
Researcher
International Institute for Applied Systems Analysis

Scene-setting video

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Tribute to global and national efforts: Ozone recovery and climate co-benefits

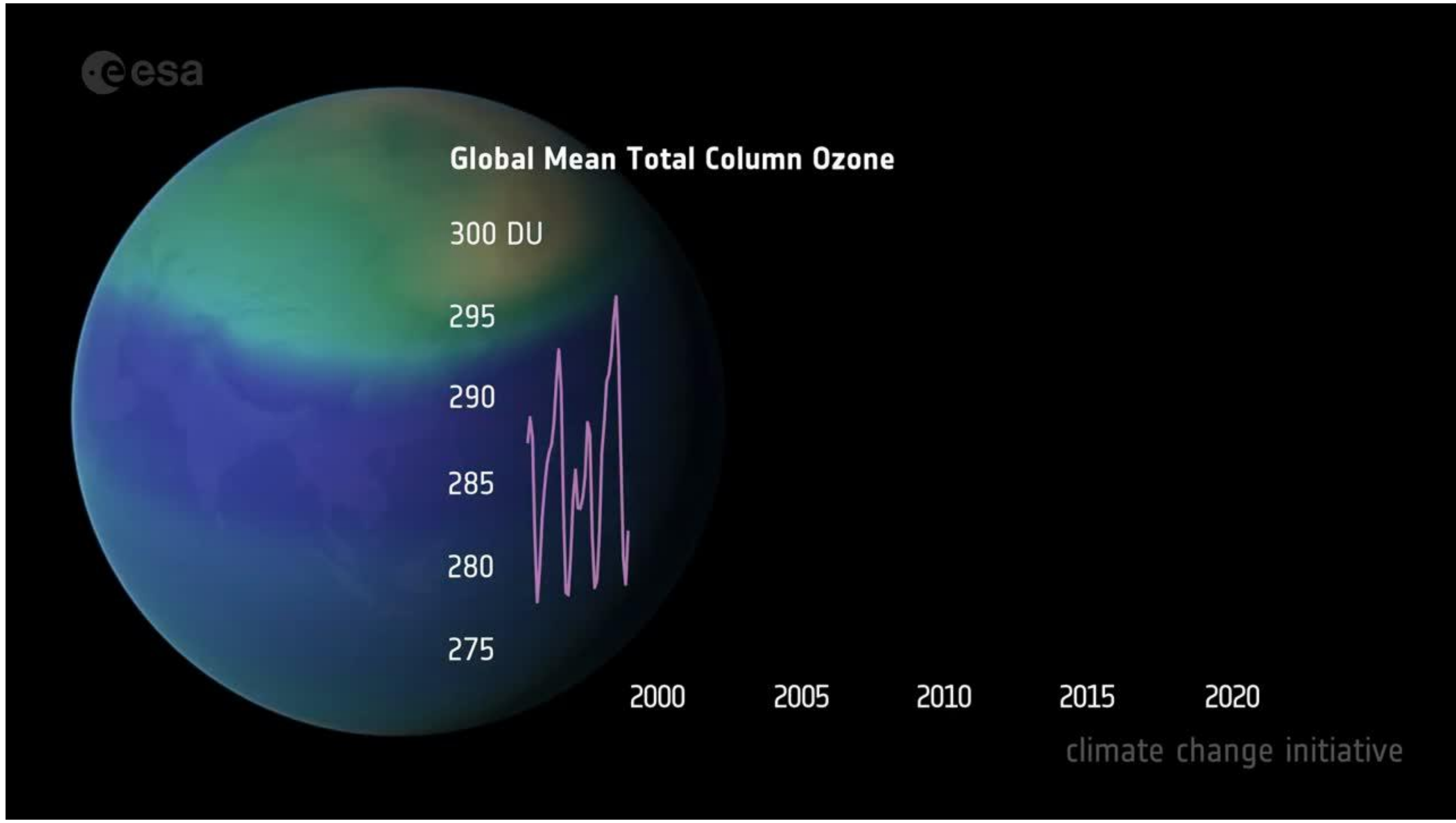
esa
THE EUROPEAN SPACE AGENCY

The power of space-based observations: Making the invisible visible

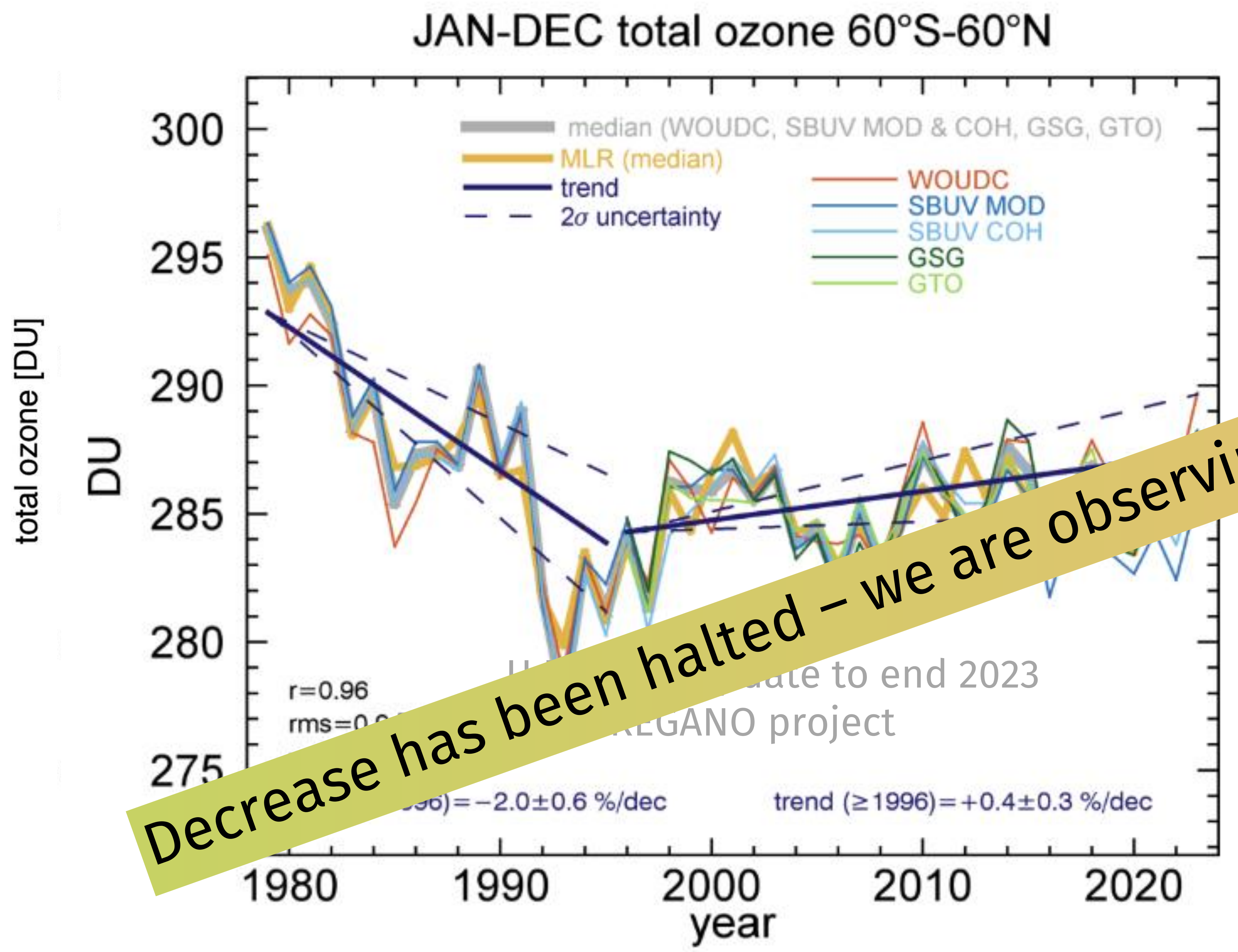
✶ European Space Agency (ESA) sensors (GOME, SCIAMACHY, GOME-2 A/B/C, Sentinels 5p/5/4, …) monitor global ozone continuously since 1996 – typically using the UV spectral range

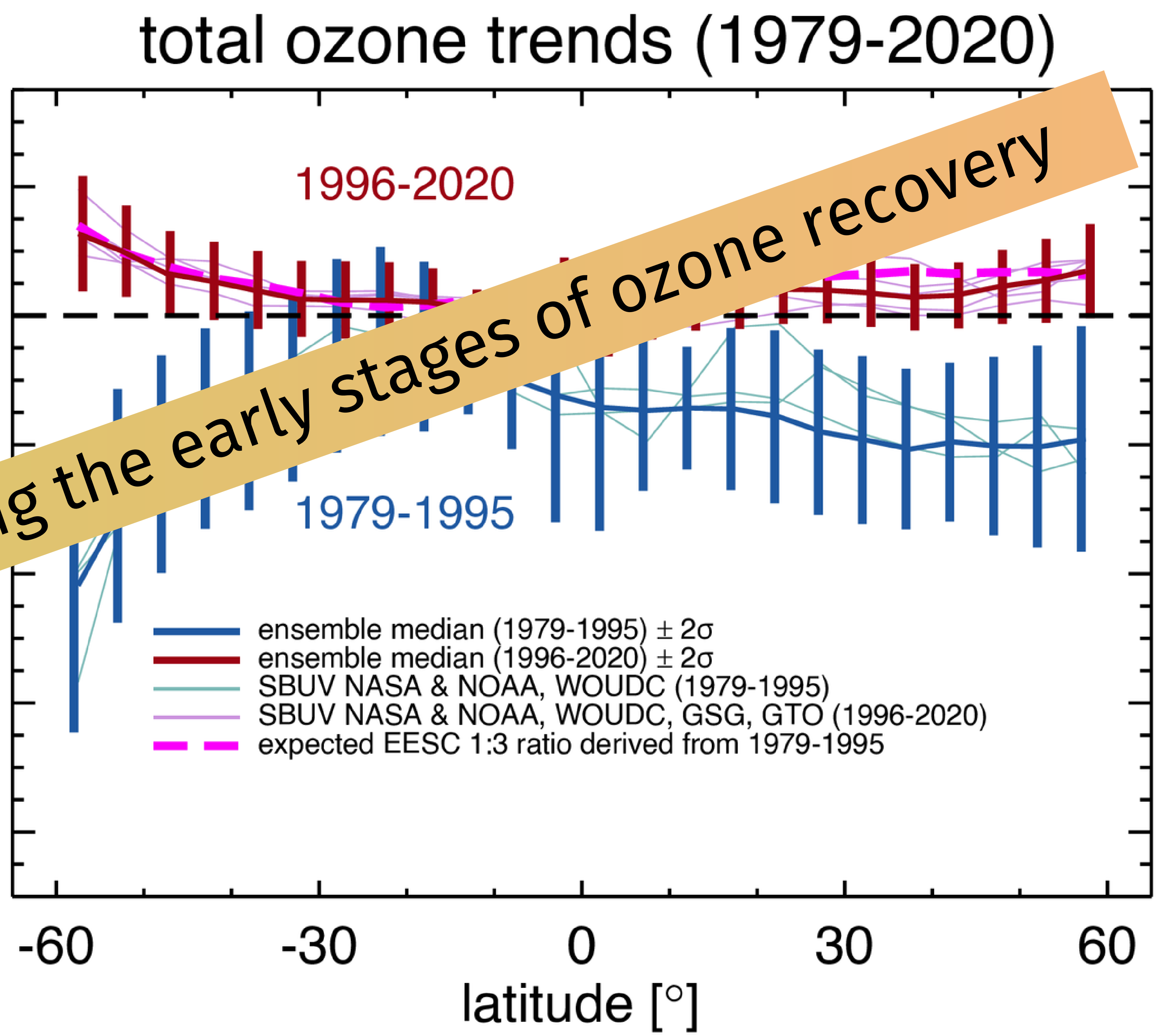
✶ The ESA Climate Space Initiative (CCI) generates long-term, high-quality, validated datasets of 28 Essential Climate Variables (ECVs), including ozone and greenhouse gases

✶ Prototype datasets, processing systems and algorithms developed by the ESA CCI have been transferred to operational service providers (EUMETSAT & Copernicus Climate Change Service) to support decision-making and inform and underpin policy action



Observed ozone trends 1: The big picture – Total ozone annual means





Decrease has been halted – we are observing the early stages of ozone recovery

ate to end 2023
EGANO project

is,
to focus on trends attributable to ODS

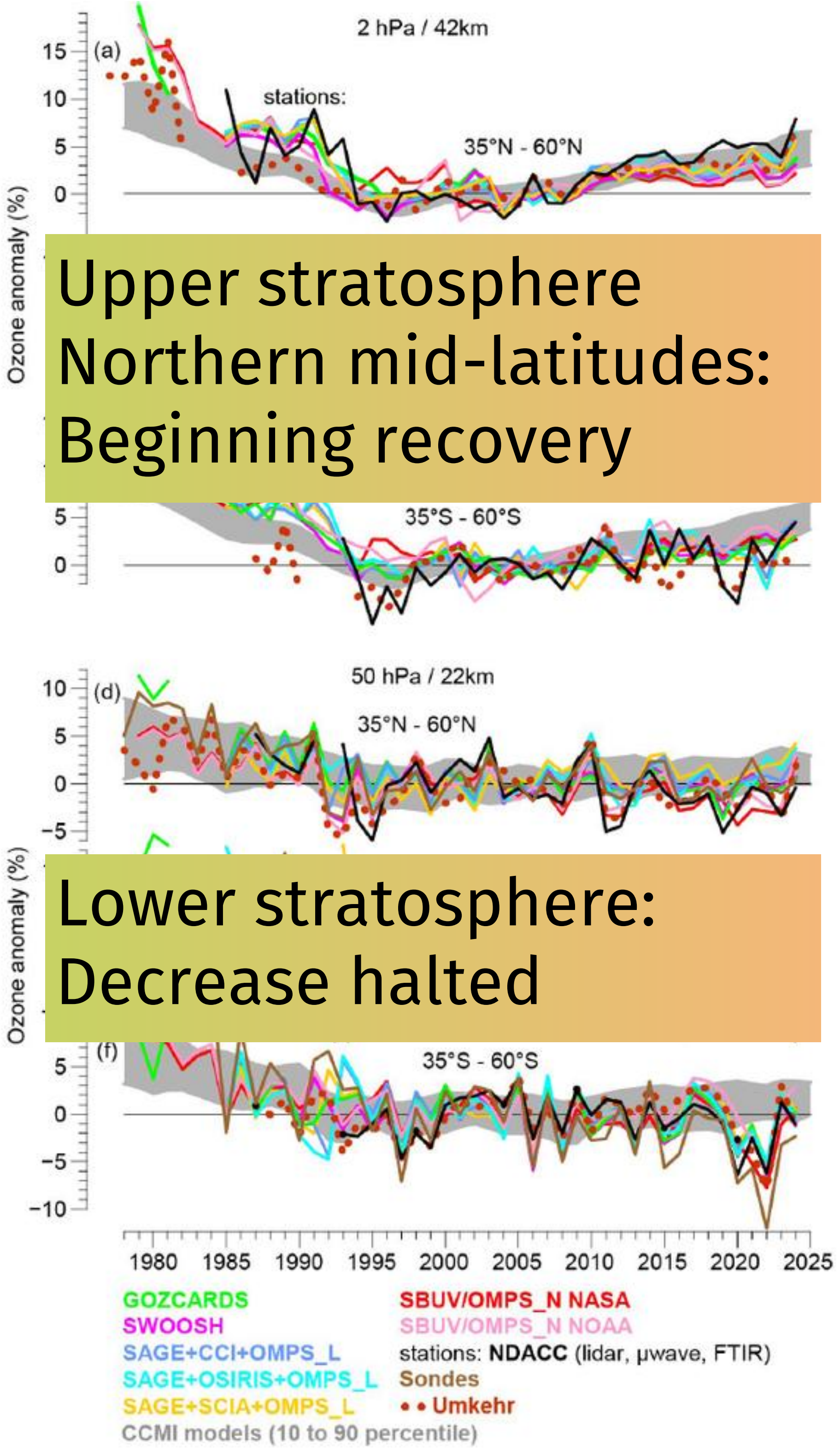
Caution: 15 or 20 years is a **short** period when deriving climate trends!

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

esa

SUSTAINABLE COOLING FORUM

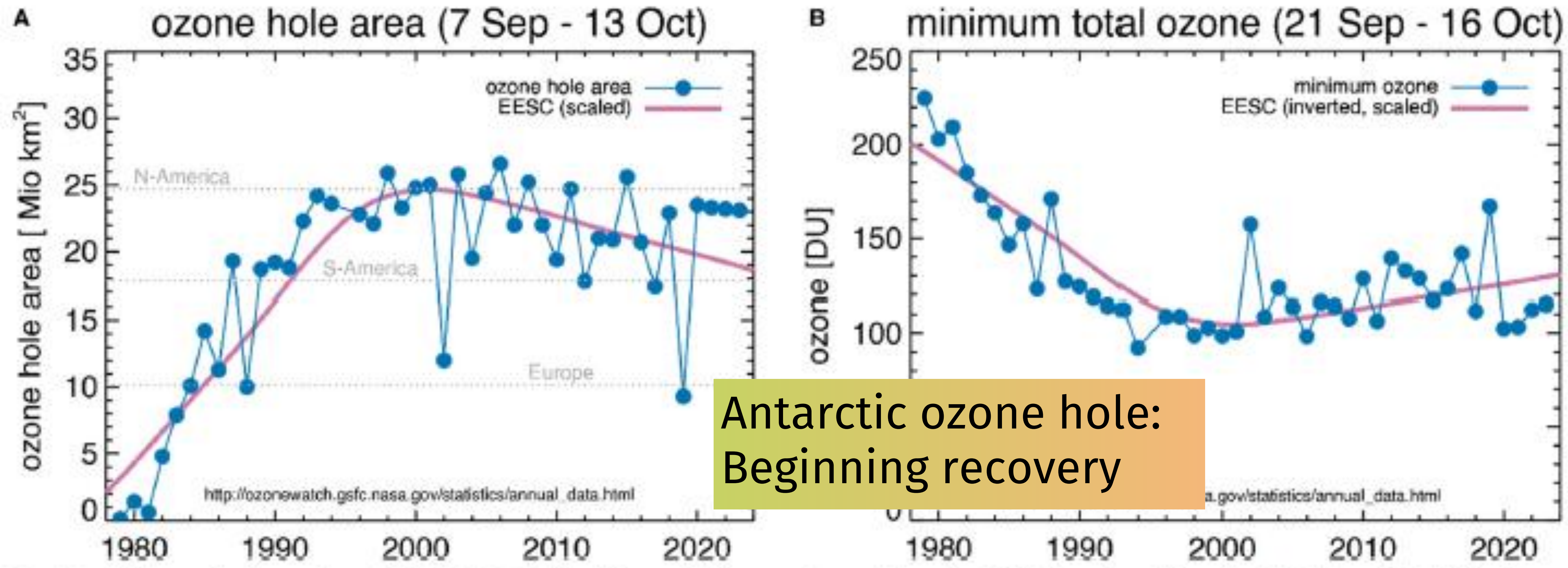
Observed ozone trends 2: A closer look – Height-resolved ozone and the Antarctic ozone hole



Upper stratosphere Northern mid-latitudes: Beginning recovery

Lower stratosphere: Decrease halted

BAMS SotC (2024)



Antarctic ozone hole: Beginning recovery

Fig. 10 (A) Ozone hole area from 1978 to 2023, (B) minimum total ozone above Antarctica. Pink lines show the polar EESC (see **Fig. 2**) fitted to the ozone hole area and total ozone minimum curve.

Weber & Chipperfield (2026)

EESC = Equivalent effective stratospheric chlorine

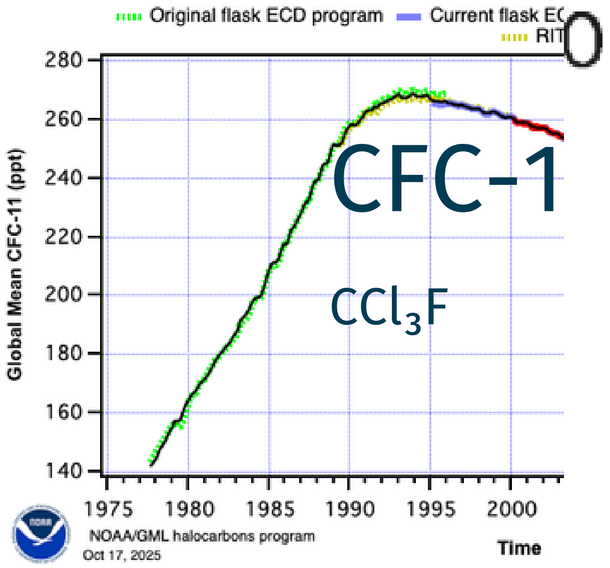
"More than 250 millions of cases of skin cancer and almost 50 millions of cases of cataracts will have been averted by the end of the century" Solomon et al. (2020)

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

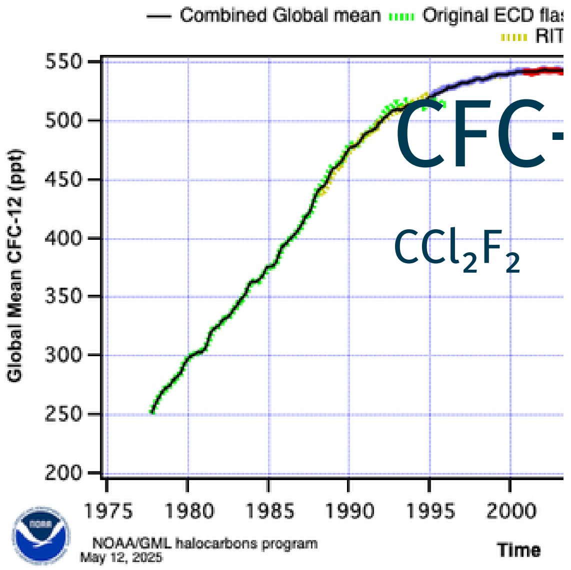
esa

SUSTAINABLE COOLING FORUM

CFC – HCFC – HFC trends, ozone projections



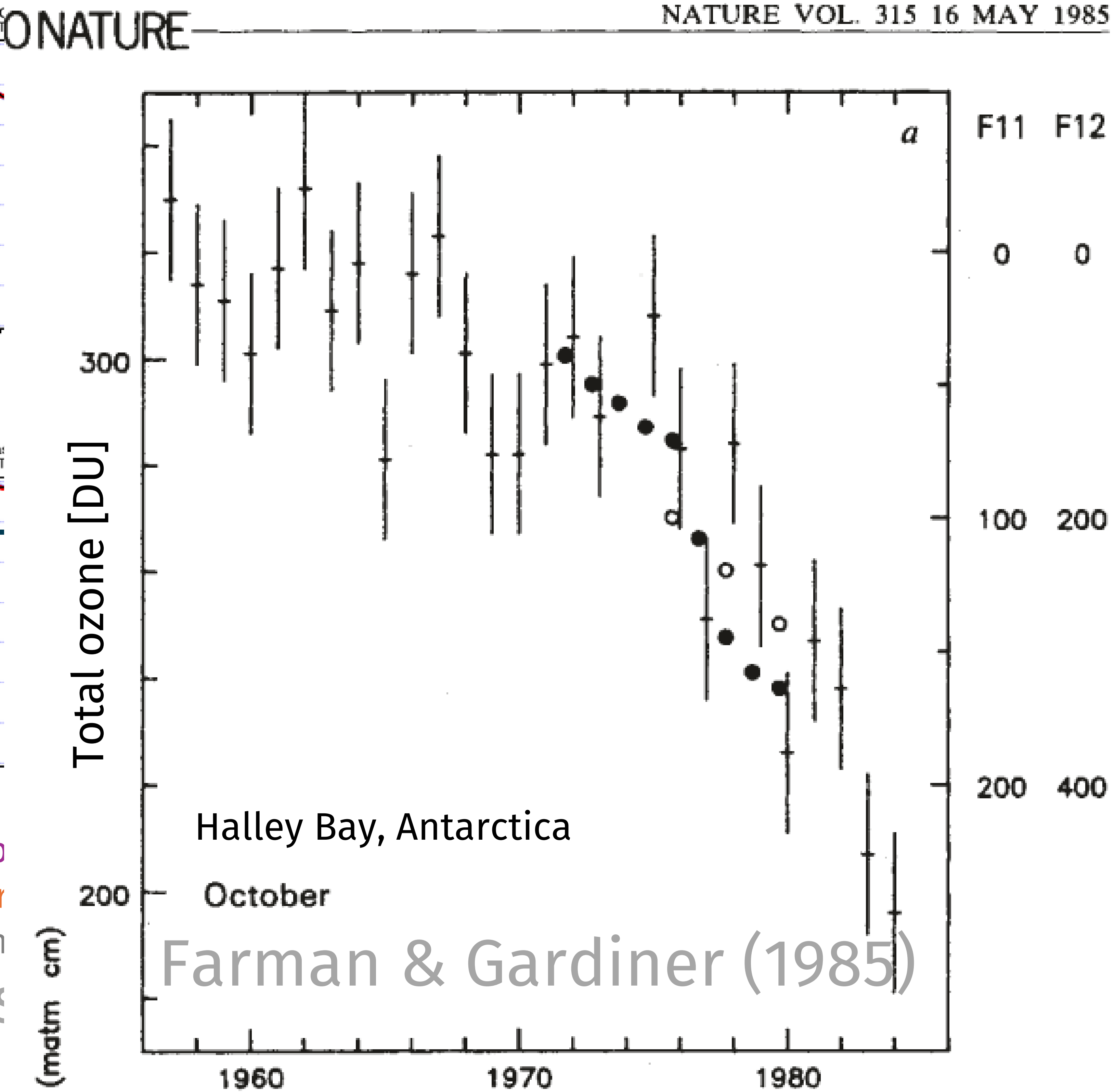
CFC-1
CCl_3F



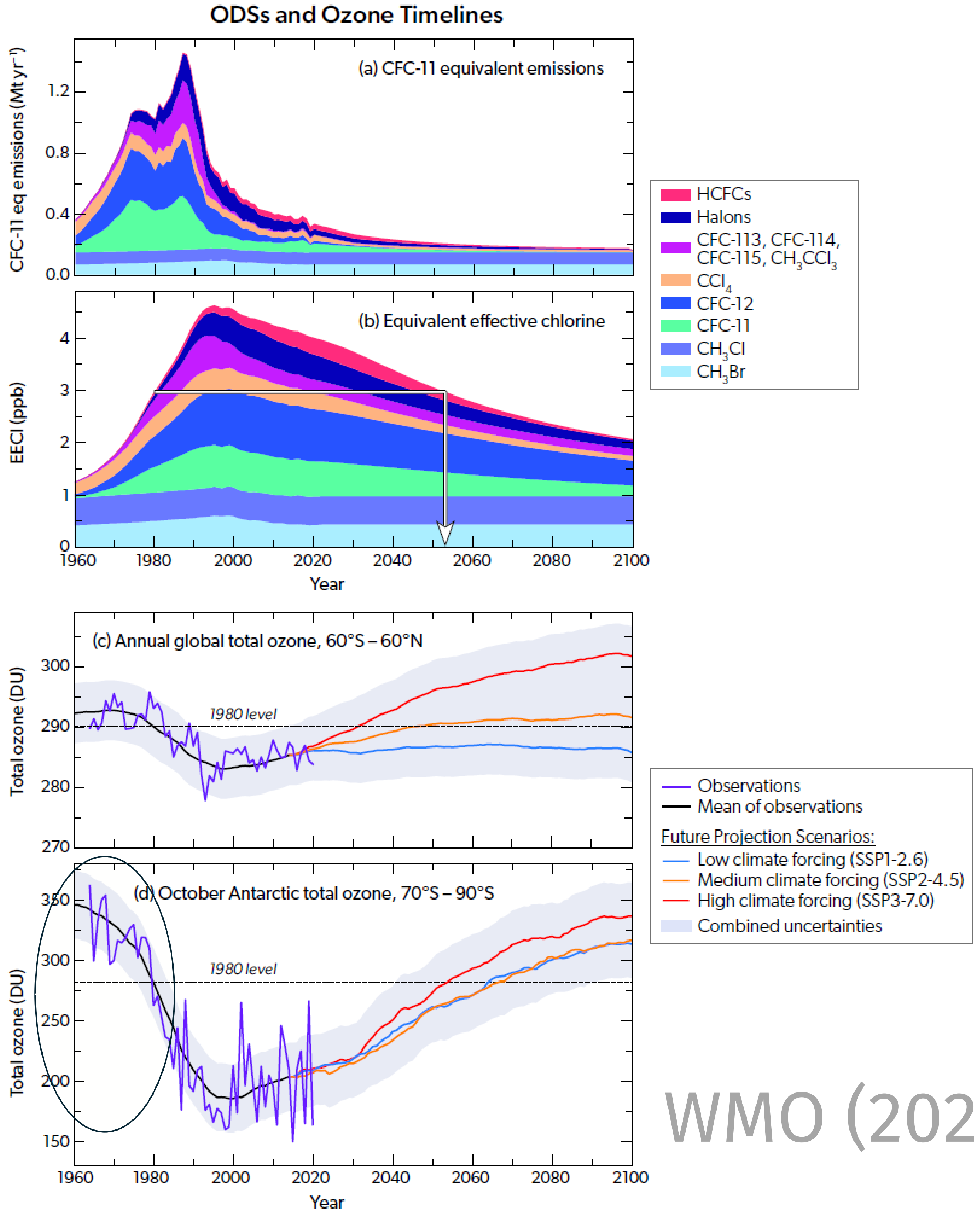
CFC-
CCl_2F_2

Ozone dep
Global war
Lifetime in

NOAA GML s



Farman & Gardiner (1985)



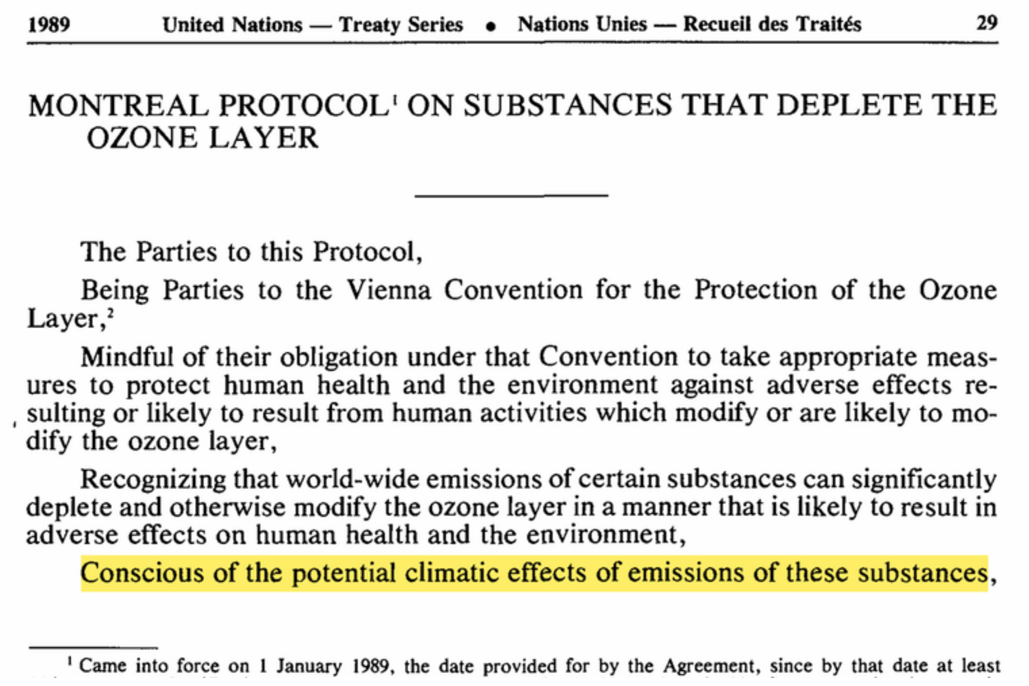
WMO (2022)

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

esa

SUSTAINABLE COOLING FORUM

Climate co-benefits of the Montreal protocol



1989 United Nations — Treaty Series • Nations Unies — Recueil des Traités 29

MONTREAL PROTOCOL[1] ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

The Parties to this Protocol,

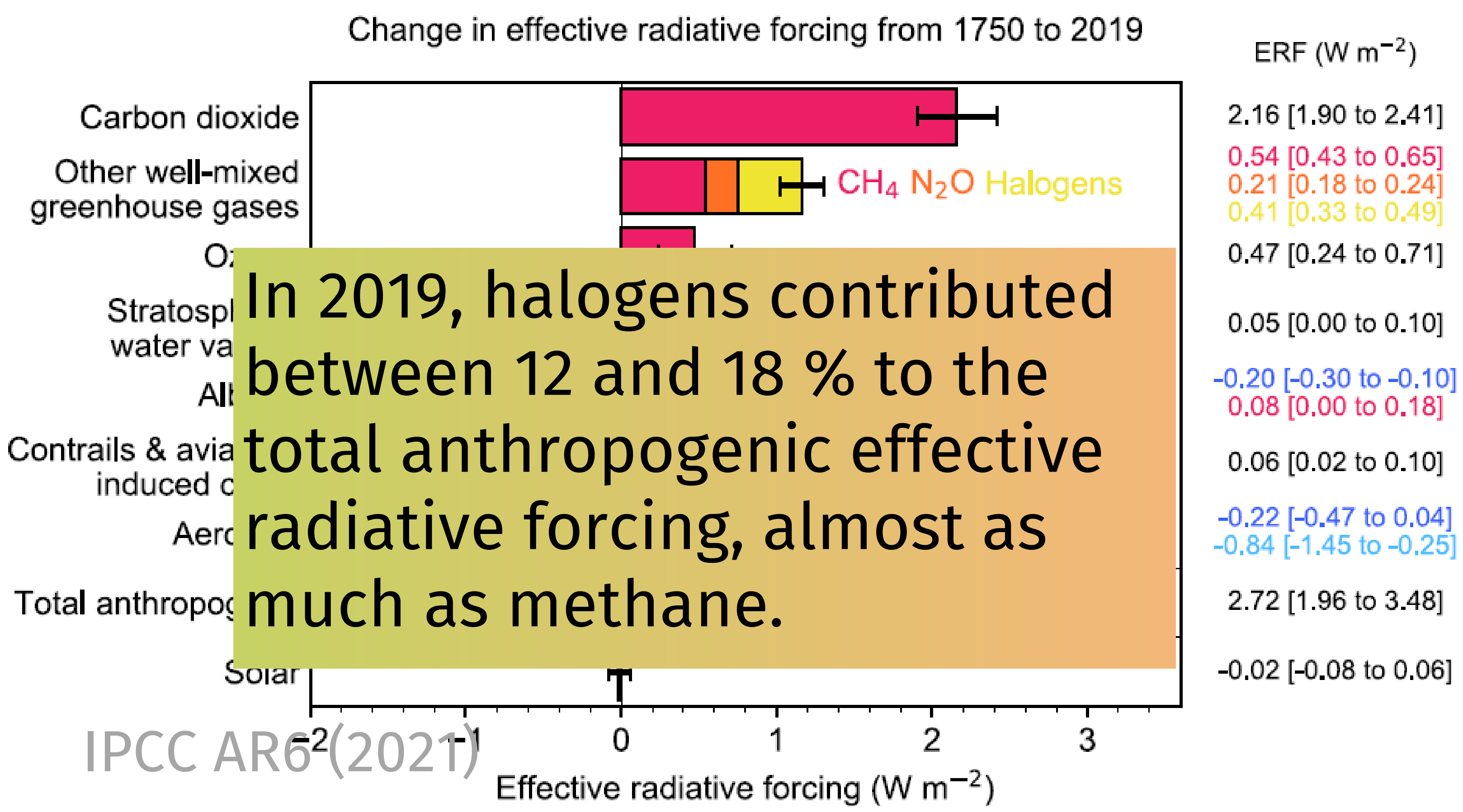
Being Parties to the Vienna Convention for the Protection of the Ozone Layer,[2]

Mindful of their obligation under that Convention to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer,

Recognizing that world-wide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment,

Conscious of the potential climatic effects of emissions of these substances,

[1] Came into force on 1 January 1989, the date provided for by the Agreement, since by that date at least



In 2019, halogens contributed between 12 and 18 % to the total anthropogenic effective radiative forcing, almost as much as methane.

IPCC AR6 (2021)

What if there was no Montreal protocol?

Counterfactual or “world avoided” model simulations

E.g, Velders et al. (2007), Young et al. (2021)

Caveat: large uncertainties as these are hypothetical scenarios

2019 ERF due to halogens could be twice as high (assuming 2.8%/year increase of production from 1995-2019)

Additional global warming by 2100 could be **2.5 K**

1.7 K due to radiative forcing

0.8 K due to UV damage to plants

“By 2010 the phaseout of these climate-threatening gases avoided about 15 gigatonnes (Gt) of equivalent CO_2 emission per year, much more than the 2 Gt per year that were targeted by the Kyoto Protocol."

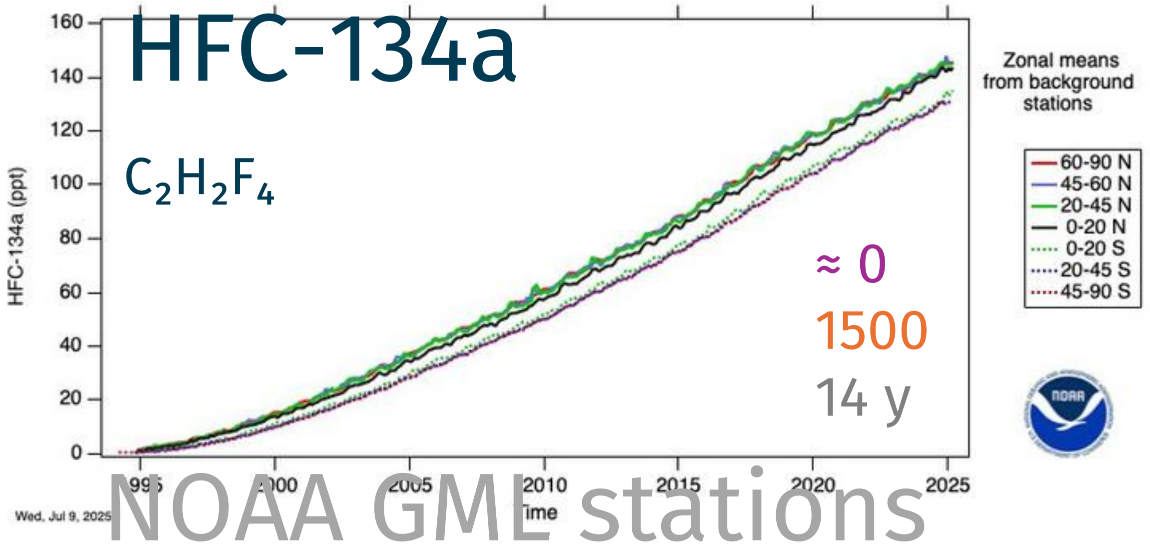
Solomon et al. (2020)

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

esa

SUSTAINABLE
COOLING FORUM

The Kigali amendment and HFCs: the role of space-based measurements



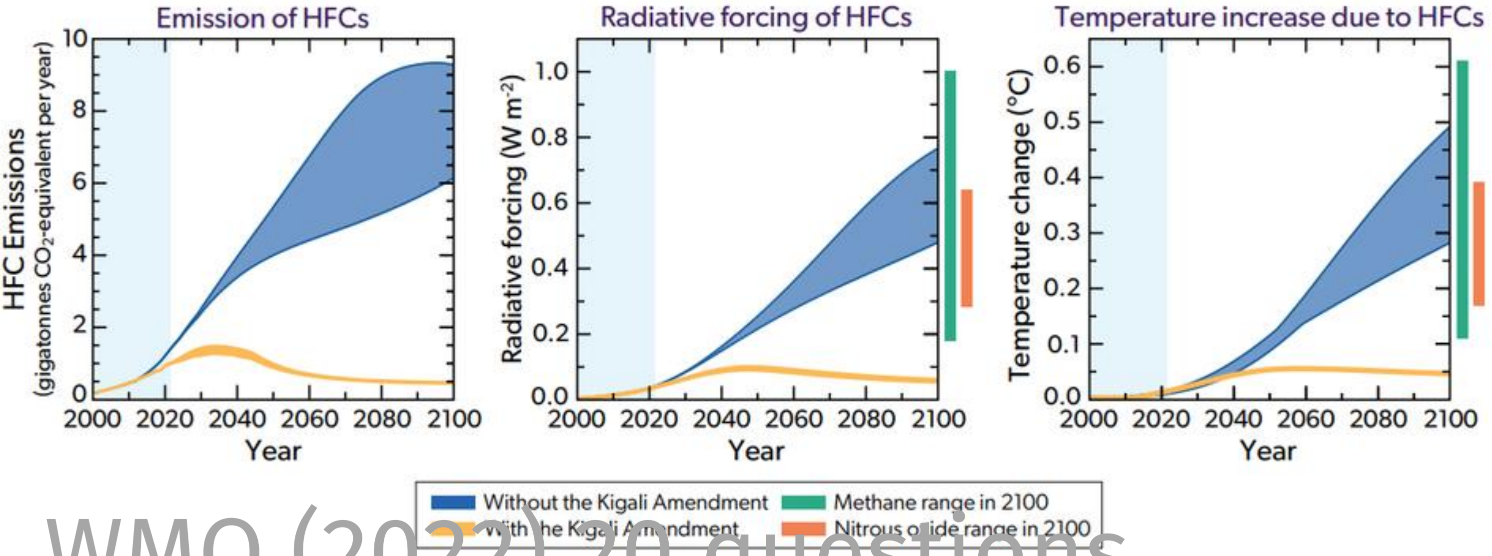
HFC-134a

$C_2H_2F_4$

≈ 0
1500
14 y

NOAA GML stations

Groundbased in-situ measurements:
Very precise but sparse



WMO (2022) 20 questions

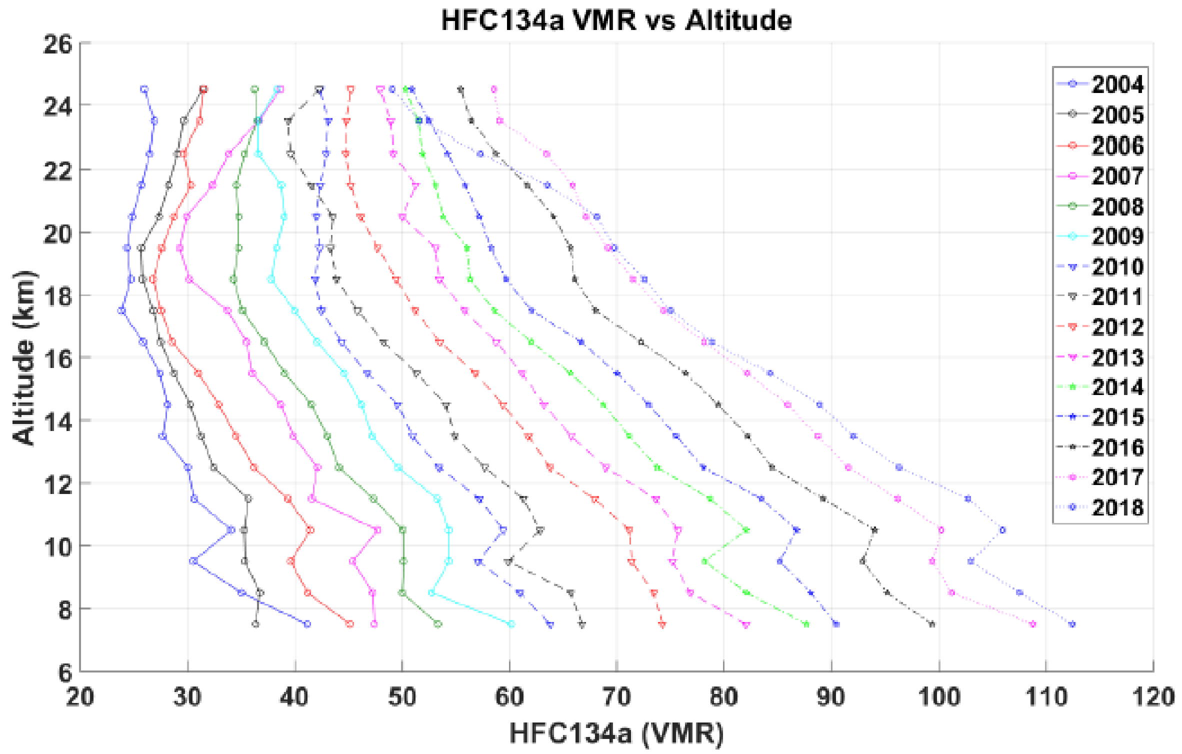
Satellite measurements:
Higher uncertainties, but global coverage and vertical profiles
(Also: backup system)

Currently only one sensor:
Canadian ACE-FTS
(IR solar occultation)
Operating since 2003!

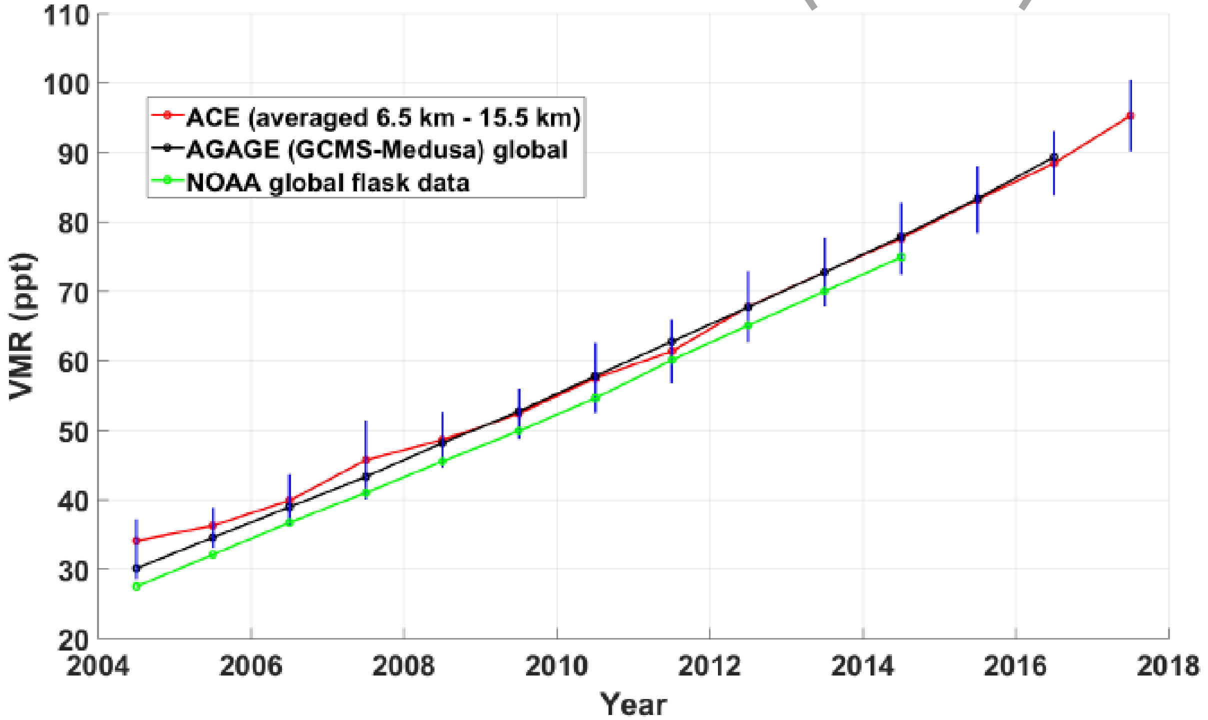
NASA STRIVE mission planned for 2030, but: shorter wavelength range, and HFCs are not in the list of target gases (CFC-11 and CFC-12 are)

ESA currently has no plans for an HFC-capable mission

Potential observation gap



Fernando et al. (2019)



The Montreal protocol – a double (and remarkable) success story

1. The halt of negative ozone trends and beginning of ozone recovery due to the decline in ODS levels since the mid-1990s is evident from global observations. Return to 1980 ozone levels is expected to occur by the middle of this century, and about one to two decades later above Antarctica.

2. A significant additional contribution to global warming has been avoided by the phase-out of ODS so far. This needs to be continued and monitored for any climate-relevant replacement substances such as HFCs.

The role of space-based monitoring for international agreements

Space-based monitoring is not only a scientific tool but a transparency and accountability mechanism for the international community.
This is reflected in ESA's Earth Observation Science Strategy (2024).

"STRATEGIC OBJECTIVE 3
To develop scientific knowledge and capacity to deliver high-quality validated, trusted, actionable information products relevant to national, international and global policy frameworks.

EO [Earth Observation] science provides the basis for the future definition and enforcement of policy outcomes and legislation. Examples of this benefit include Measurement, Reporting and Verification systems used for carbon accounting, Montreal Treaty support, and policing marine protected areas."

SUSTAINABLE COOLING FORUM

Thank you

Michael Eisinger
Climate Applications Scientist
ESA Climate Team
European Space Agency
Harwell, United Kingdom
Michael.Eisinger@esa.int

esa
→ THE EUROPEAN SPACE AGENCY

esa

Recorded presentation

Ms. Radhika Khosla, University of Oxford

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

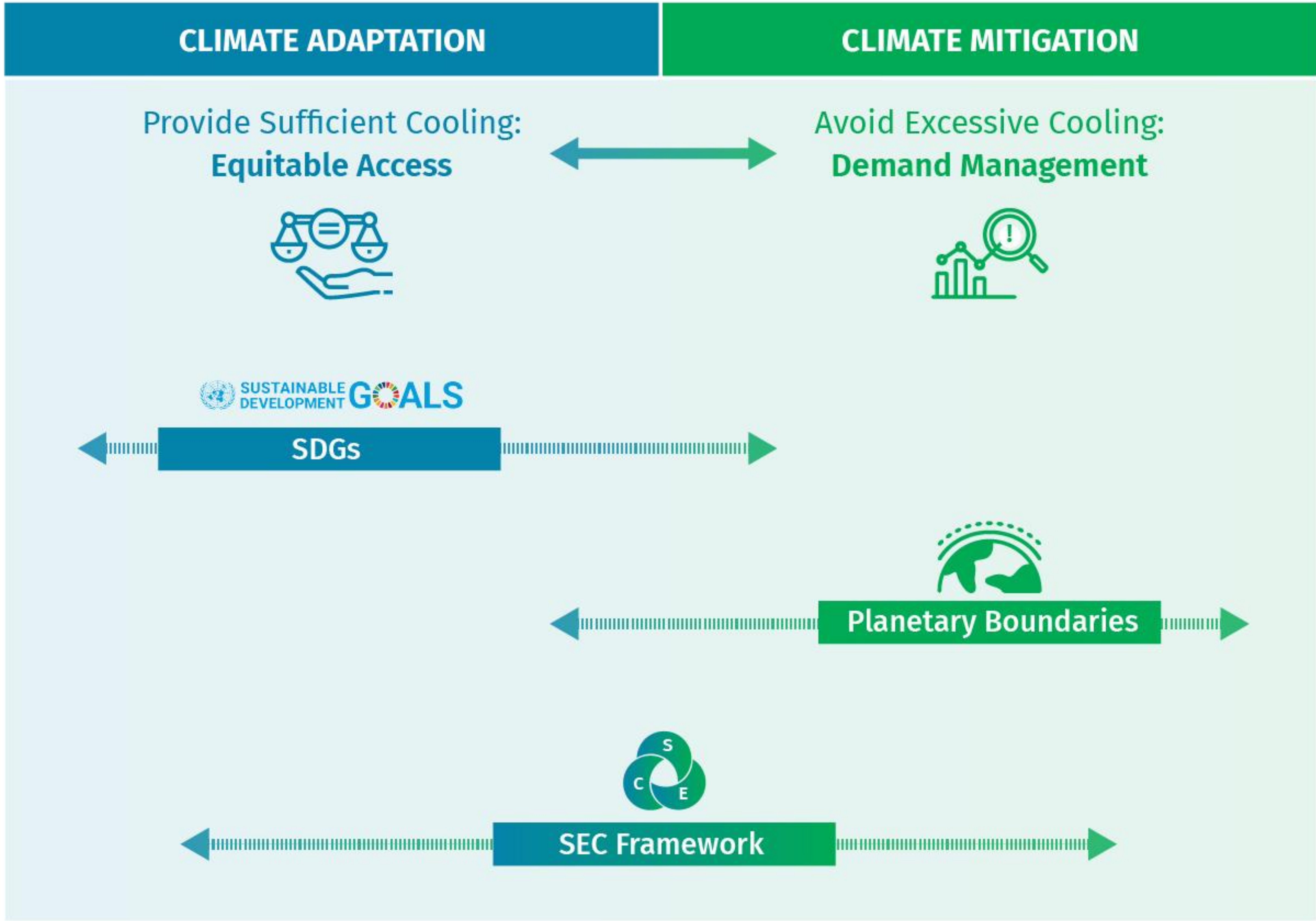
Systems thinking approach to cooling

International Institute for
Applied Systems Analysis
IIASA

Keynote: Systems thinking approach to cooling

Cooling:

A Double Bind?



Systems thinking approach to cooling

„A system is more than the sum of its parts"

Donella Meadows

Boundaries

Connections

Delays and Timings

Feedback

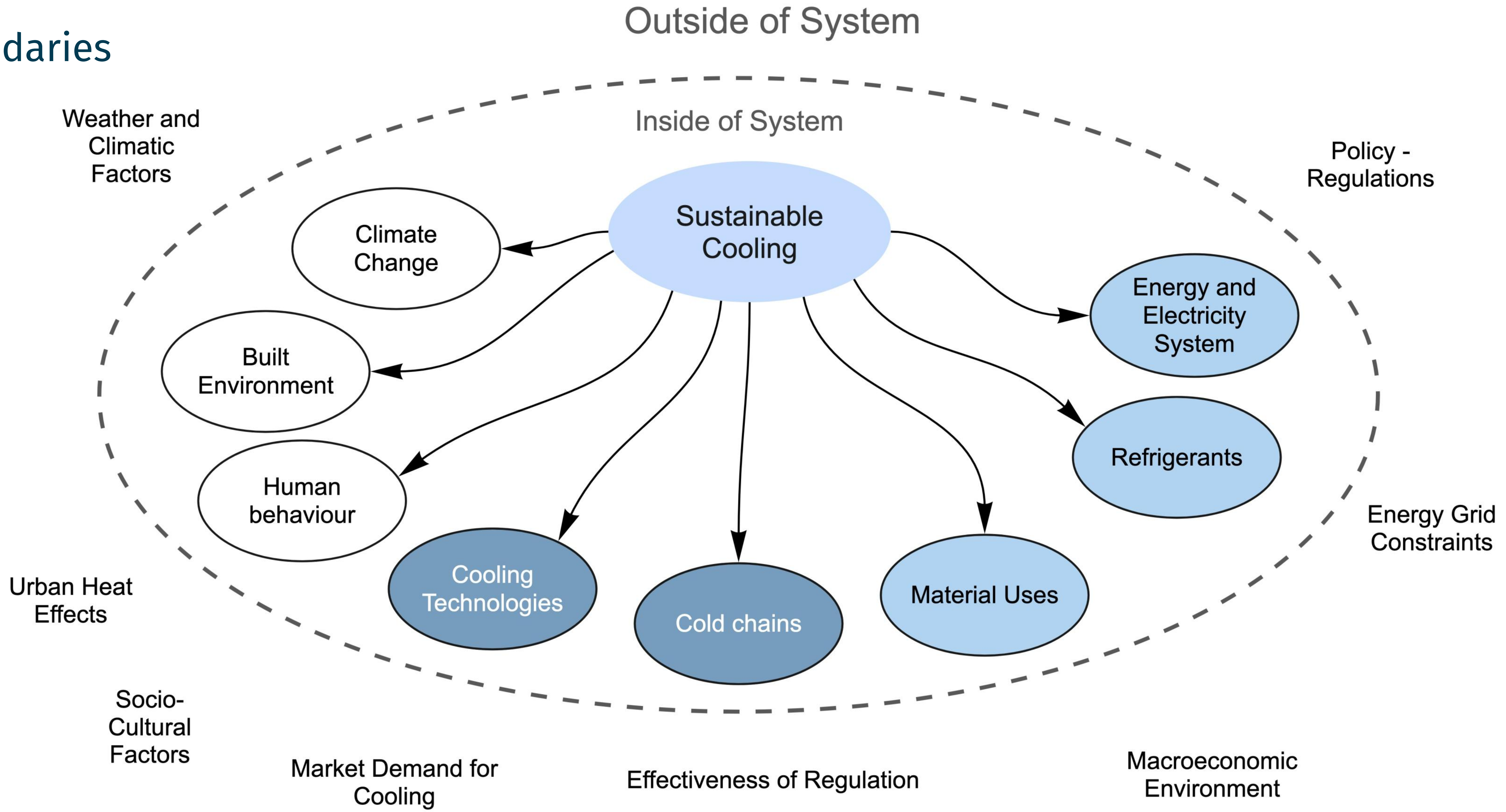
Emergence

Bounded Rationality

In cooling: Focus on interconnections, not just components

Systems thinking approach to cooling

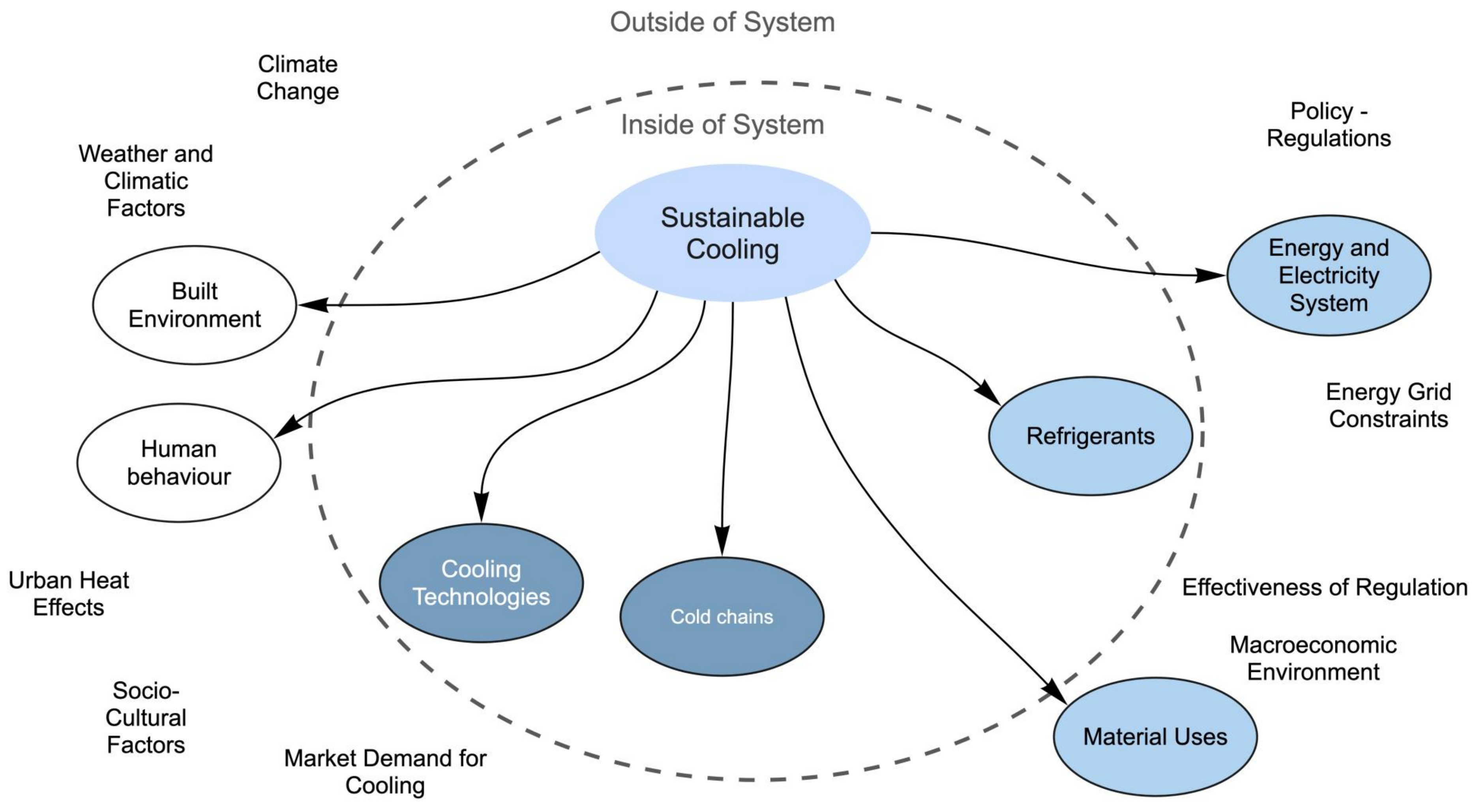
Boundaries

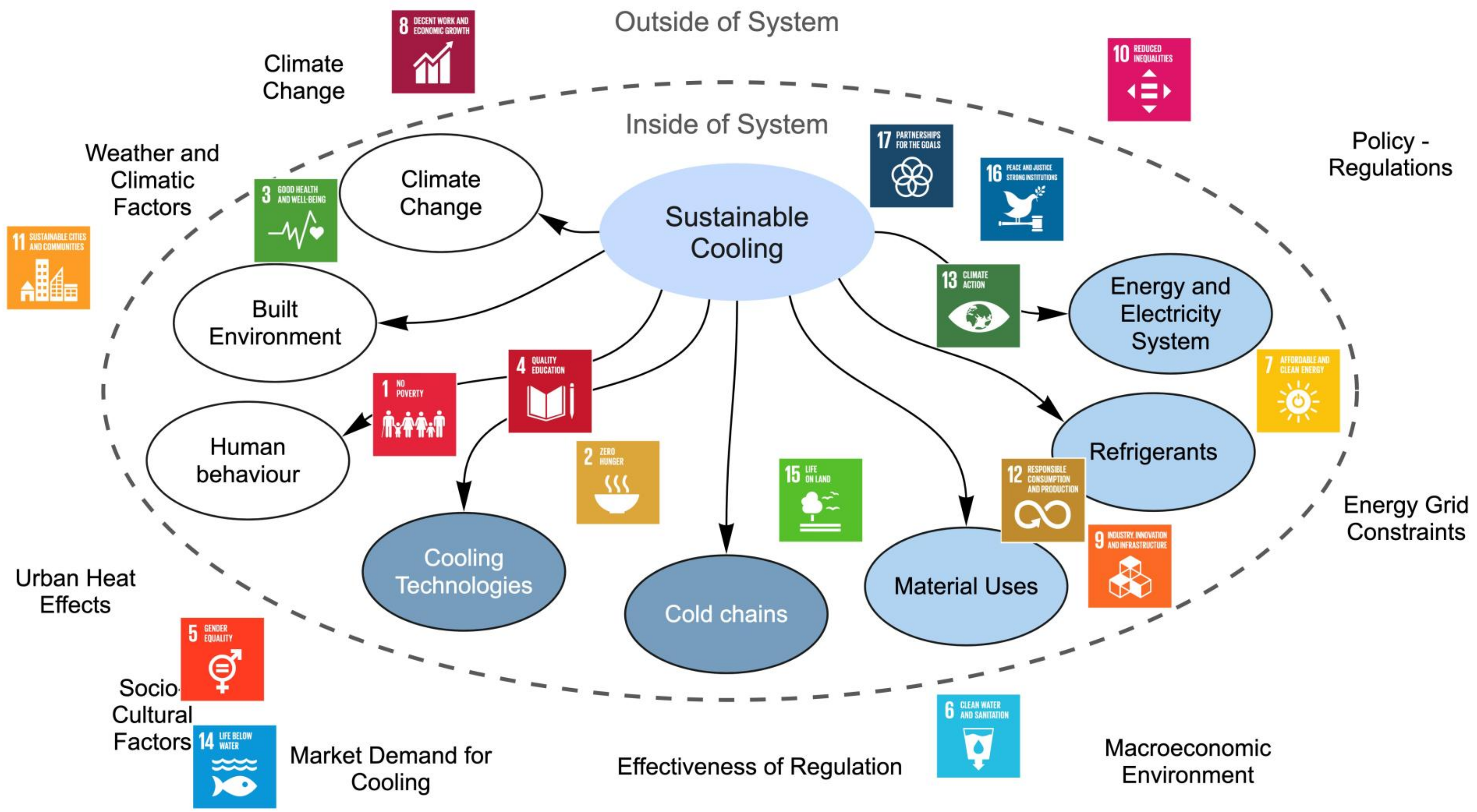


UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING FORUM

Narrower and Wider Boundaries



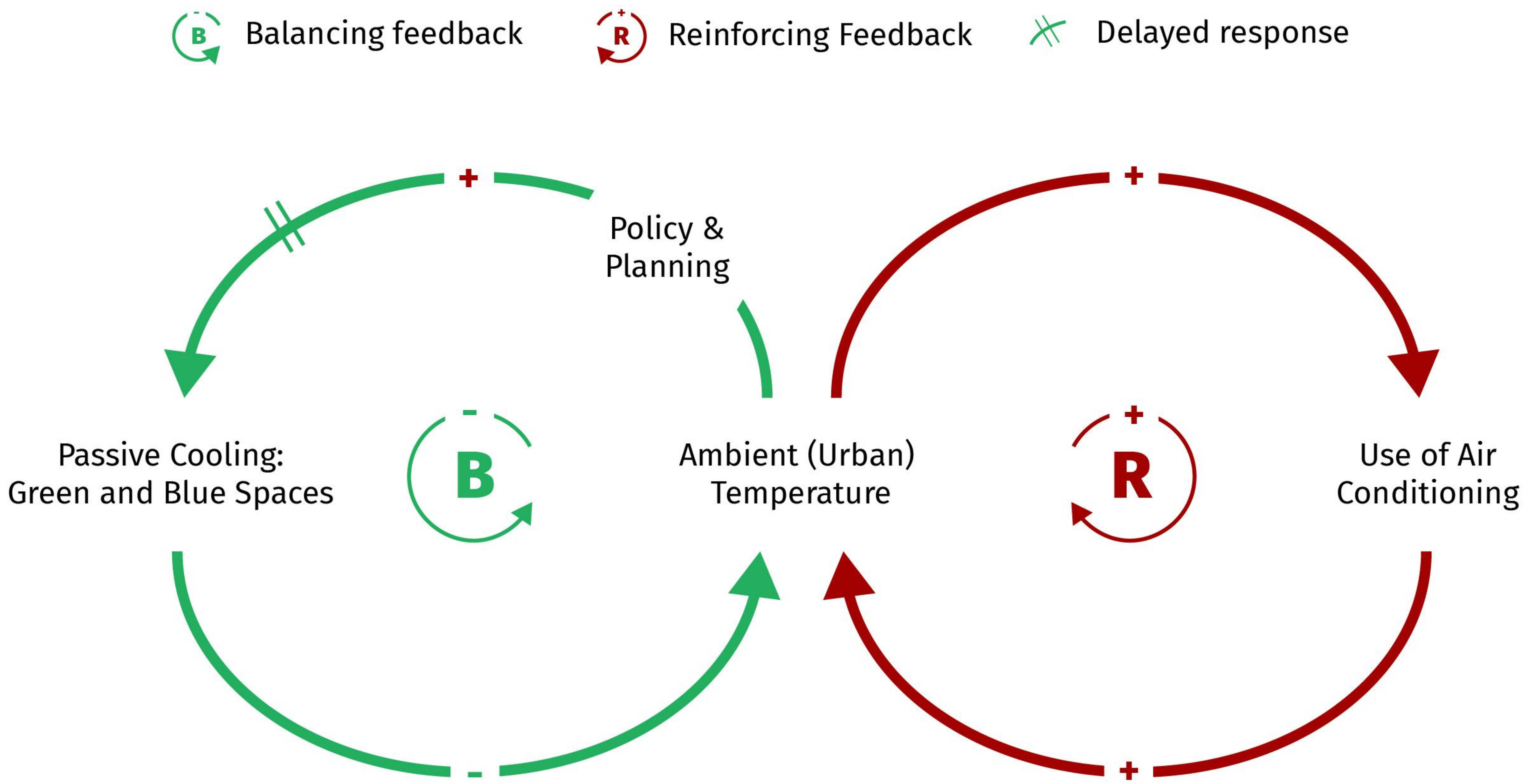


Systems thinking approach to cooling

Feedback and Interactions:

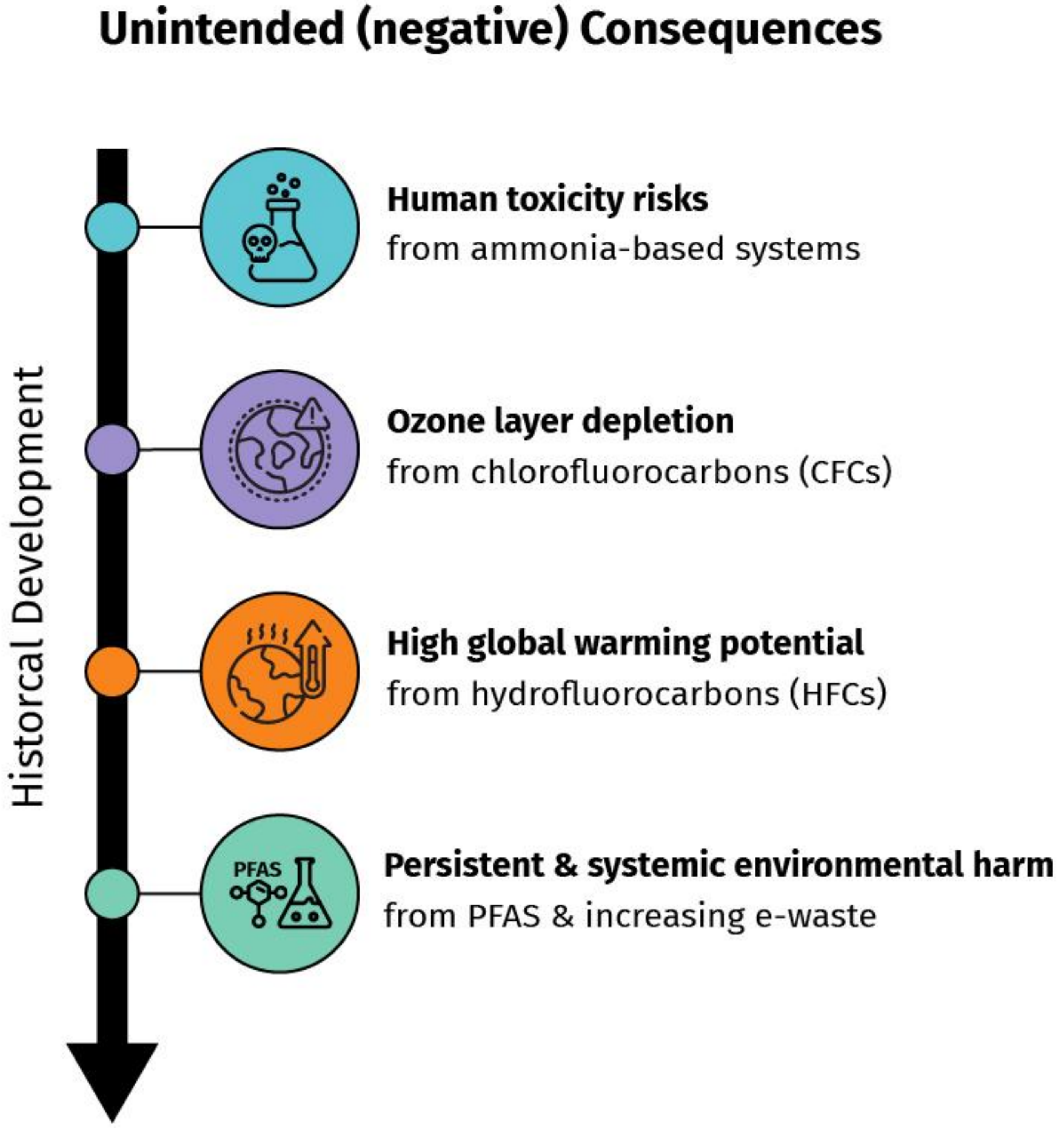
Causal Loop Diagrams

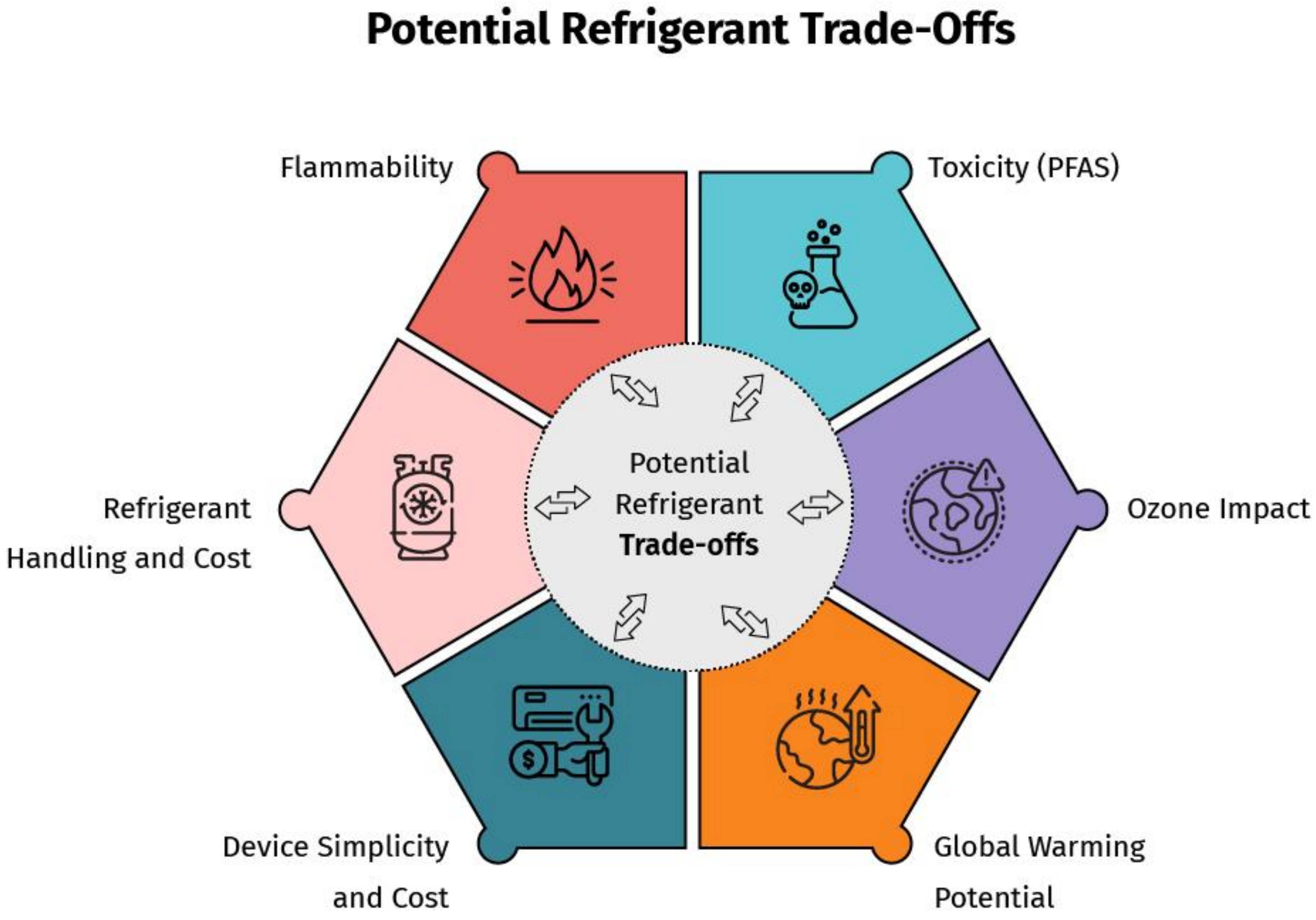
- Here: Urban Heat and Cooling
  - Individual cooling not always best answer
  - Policy governs balancing measures



Systems thinking approach to cooling

Emergence and Unintended Consequences



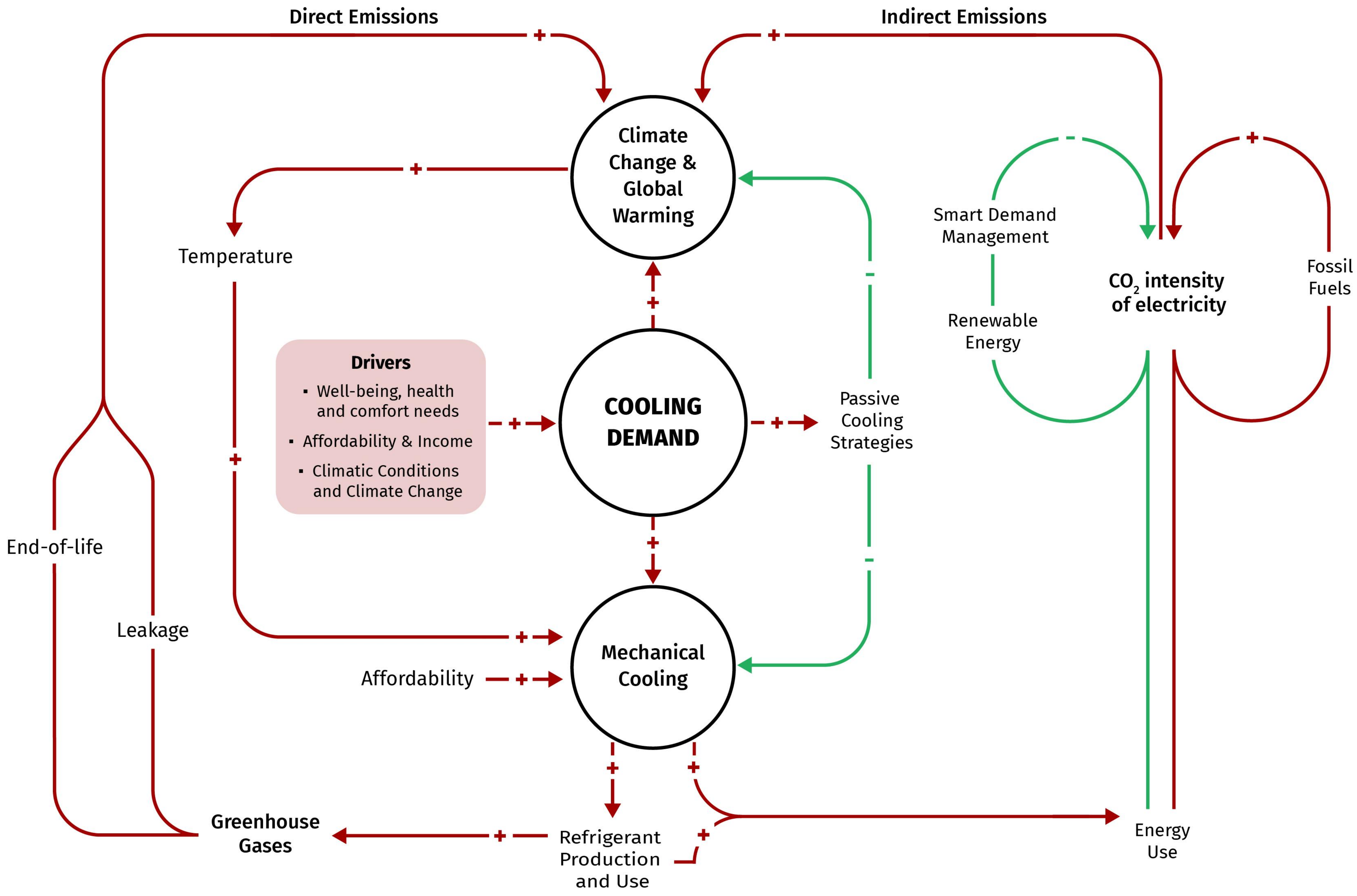


Systems thinking approach to cooling

Feedback and Interactions:

Causal Loop Diagrams

- Towards a full-systems perspective
- Omission is on purpose



Systems thinking approach to cooling

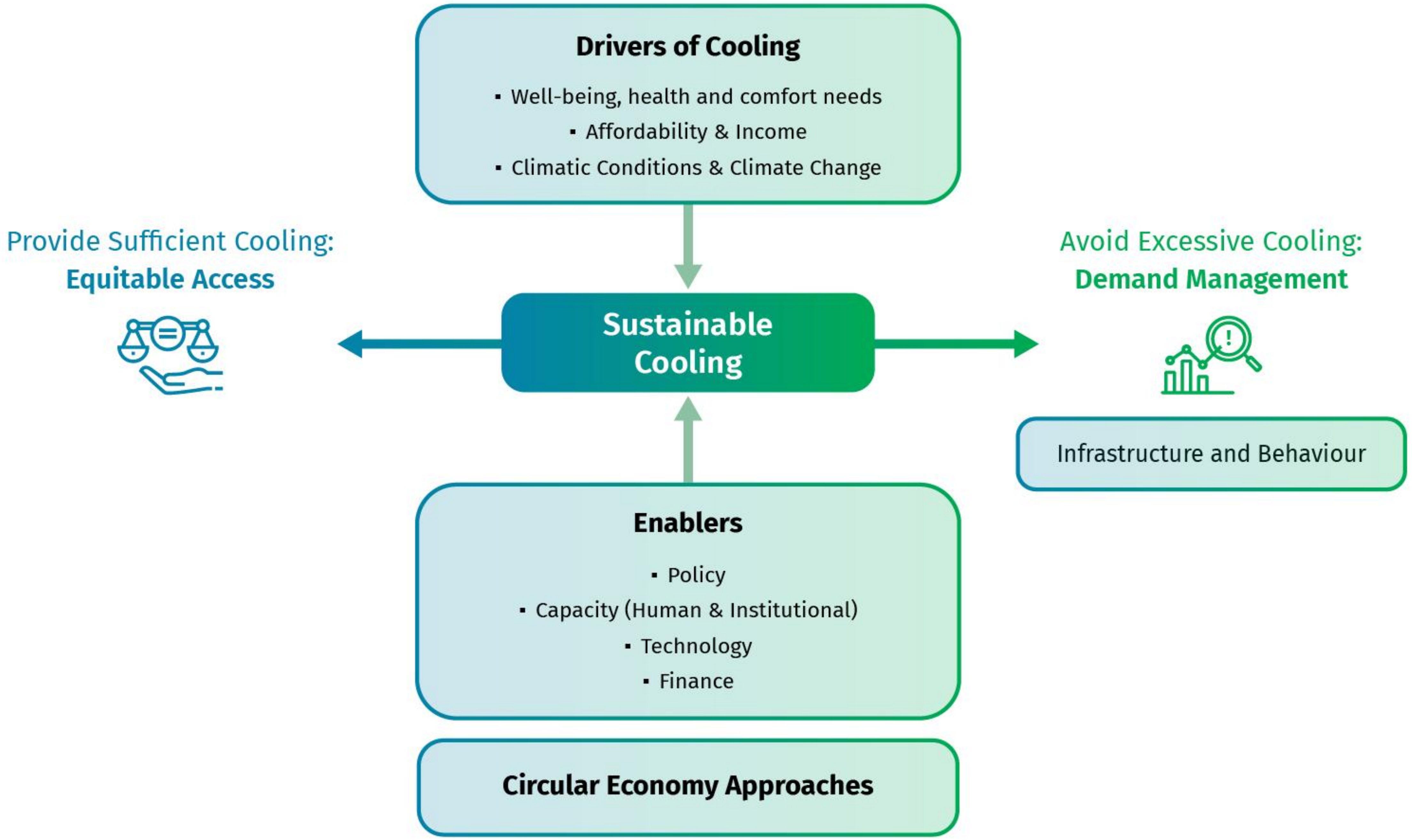
Governing a System:
The Case of Sustainable Cooling

Drivers: Driving Sustainable Cooling:

- Well-being
- Affordability
- Climate

Enablers: To govern Sustainable Cooling:

- Policy
- Capacity
- Technology
- Financing



SUSTAINABLE COOLING FORUM

Thank you

Steffen Lohrey, Edward Byers, Alessio Mastrucci, Pallav Purohit, Bas van Ruijven
IIASA
lohrey@iiasa.ac.at

Introduction to the Sustainable Cooling Forum

Mr. Alois Mhlanga
Climate Innovation and Montreal Protocol Division
UNIDO

Mr. Michael Eisinger
Climate Team
European Space Agency

Ms. Radhika Khosla
Associate Professor
Oxford University

Mr. Steffen Lohrey
Researcher
International Institute for Applied Systems Analysis

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Session 1

Enabling policy and regulatory frameworks for sustainable cooling

SESSION 1: Enabling policy and regulatory frameworks for sustainable cooling

Ms. Elena Miceva
Montreal Protocol Unit
UNIDO

Mr. Mehrali Ecer
Directorate of Climate Change
Türkiye

Ms. Sergio Merino
National Ozone Unit
Mexico

Mr. Fernando Santiago
Division Industrial Policy Advice and Capacity Development
UNIDO

Ms. Agnieszka Truszczynsk
Directorate-General for Climate Action
European Commission

Speakers' biographies

Agenda

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

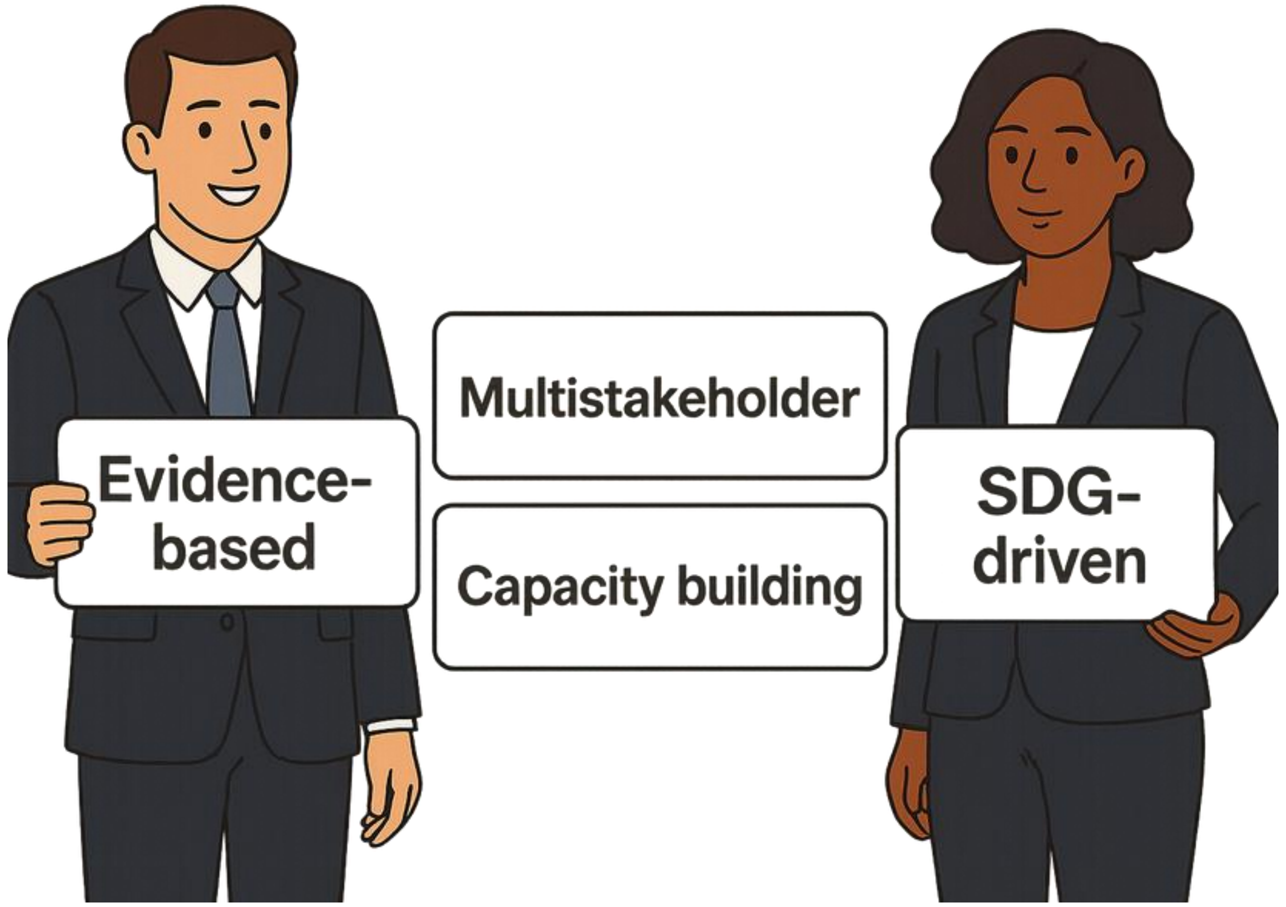
UNIDO's approach to Industrial Policy Advice

Shaping markets through policies

SESSION 1: UNIDO's approach to industrial policy advisory services.

- Industrial policy is back!
- Governments in developing countries lack capacities to tackle rapid changes and global transformations:
  - Missing awareness of the role of evidence in decision-making
  - Outsourcing (sub-optimal) policy capacities
  - Difficulties to create platform and partnerships on strategic choice
  - Missing culture of monitoring and evaluation

Our operating principles:



Prof. Jeffrey Sachs: "**UNIDO is vital for helping those 150-160 countries that cannot manage to decarbonize on their own. UNIDO** has a unique role and the potential of high-level partnerships with other multilateral institutions."

Keynote address
UNIDO Multilateral Industrial Policy Forum 2023

SESSION 1: Shaping markets through policy, a focus on demand

- Some basic economic principles:
  - Supply + Demand and their interactions in the market
- R&D&innovation (variety creation) ⟷ competition (selection mechanism)
- Shaping domestic demand drives industrial leadership, trade competitiveness and employment creation:
  - Consumers (private demand) as change agents
- Industrial and innovation policy converge to provide policy space
  - But… capabilities matter

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

SESSION 1: Governments shape markets in multiple forms: a policy-mix approach.

Role of government

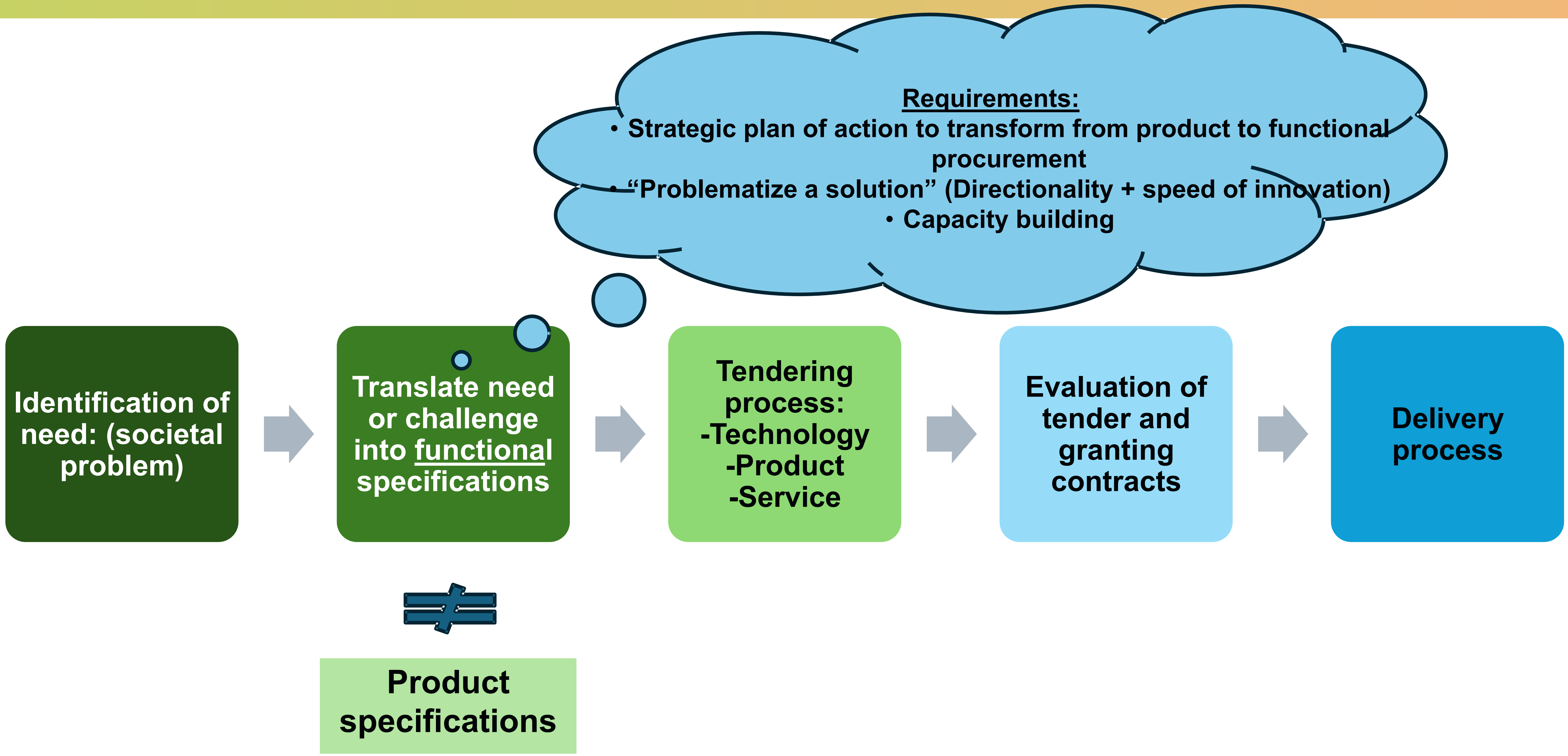
Targets framework conditions

- Facilitating industrial upgrading
- Technological capability building partner
- Market antenna

Steering the ecoomy in concrete **directions**

- Consumer
- Regulator
- Information provider/ awareness raiser
- Facilitator/ co-generator of innovation
- Price-based mechanisms
- Non-financial mechanisms

SESSION 1: Shaping markets through strategic public procurement



SESSION 1: Key messages

- International context is more open to pursue industrial policy to achieve national interests… but not every country in the world plays in the same league.
- With the right policy-mix, developing countries can tap into opportunities and tools available to foster industrialization.
- Governments can play many different roles and pursue several policy outcomes through supply- and demand-oriented policies as two complementary dimensions.
  - This is consistent with SDG-oriented industrial and innovation policies.
- The choice of industrial policy instruments depends on desired development outcomes, differences in market structures and consumers' behaviors.
  - Timing and duration of interventions and the speed of adjustment in consumer behaviors matter.
- Public procurement, as a demand-driven innovation policy instrument, is seldom used to foster equitable and sustainable development in developing countries.

SUSTAINABLE COOLING FORUM

Thank you

Fernando Santiago
Industrial Policy Officer
IPC/TCS/UNIDO
f.santiago@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Accelerated phase out and an integrated planning of MLF projects

Türkiye case study

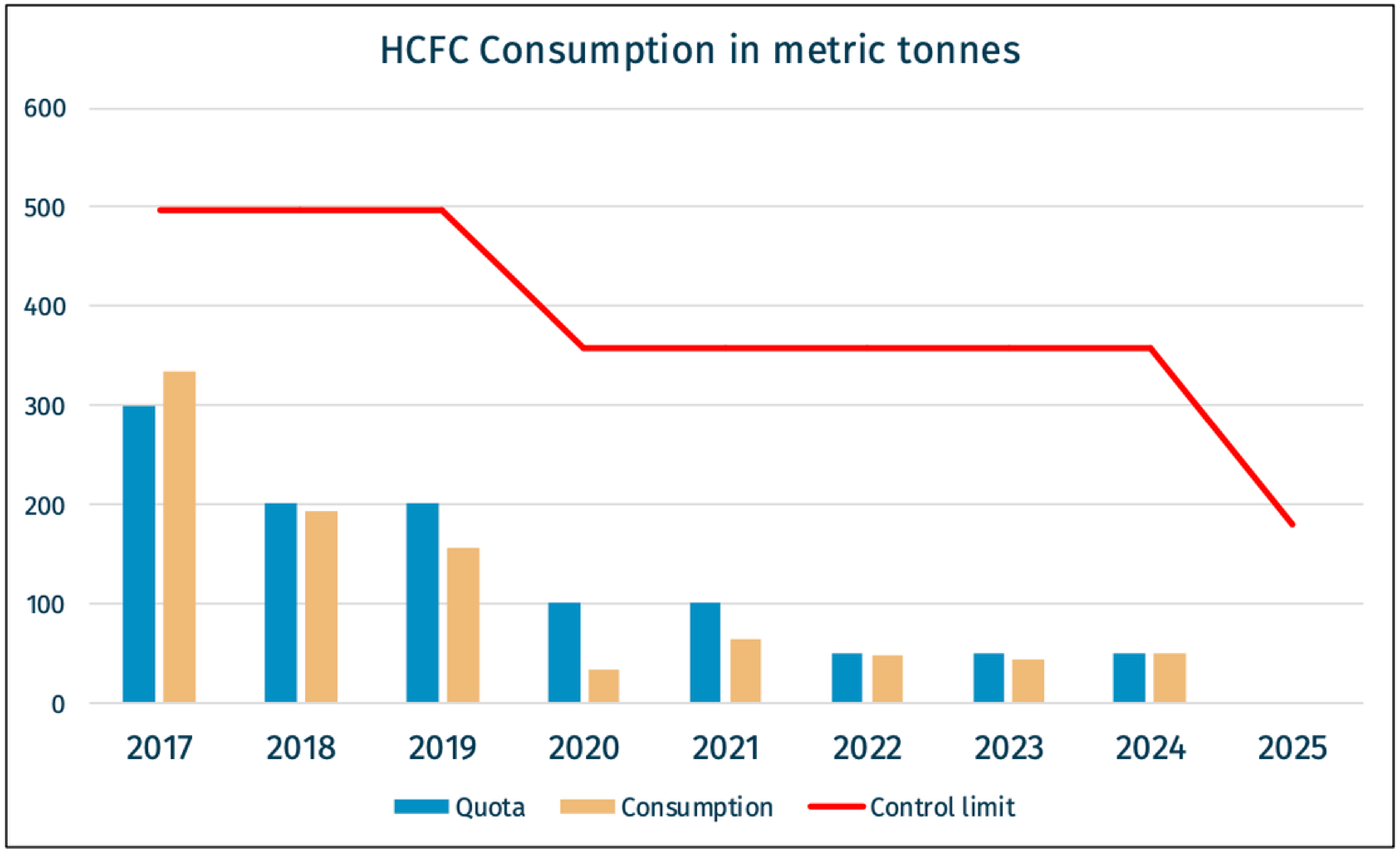
REPUBLIC OF TÜRKİYE
MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE

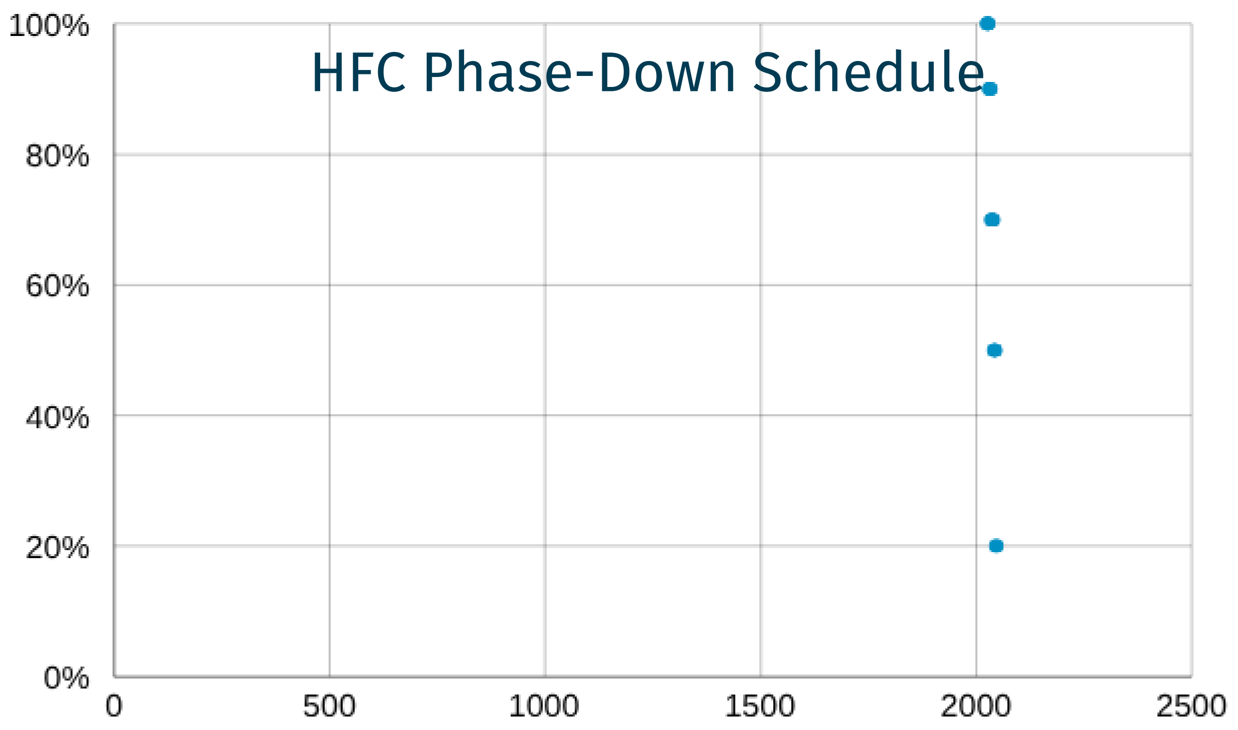
REPUBLIC OF TÜRKİYE MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE
DIRECTORATE of CLIMATE CHANGE

SESSION 1: Türkiye's Journey Through the HCFC Phase-Out

- 1991 – Becoming a party to Vienna Convention and Montreal Protocol
- 2007 – Publishing ODS Regulation
- 2010 – Ban on HCFC-containing equipment imports
- 2013 – Ban on HCFC-141b imports
- 2015 – Ban on HCFC-22 in RAC equipment production
- 2017 – Publishing New ODS Regulation
- 2018 – Publishing F-gas Regulation
- 2021 – Ratification of Kigali Amendment
- 2022 – Publishing **new** F-gas Regulation
- 2023 – Annual F-gas Reporting Import/Export Licensing
- 2024 – Freeze Year HFC Quota Allocation
- 2024 – Publishing Climate Law
- 2025 – Ban on ODS in servicing sector

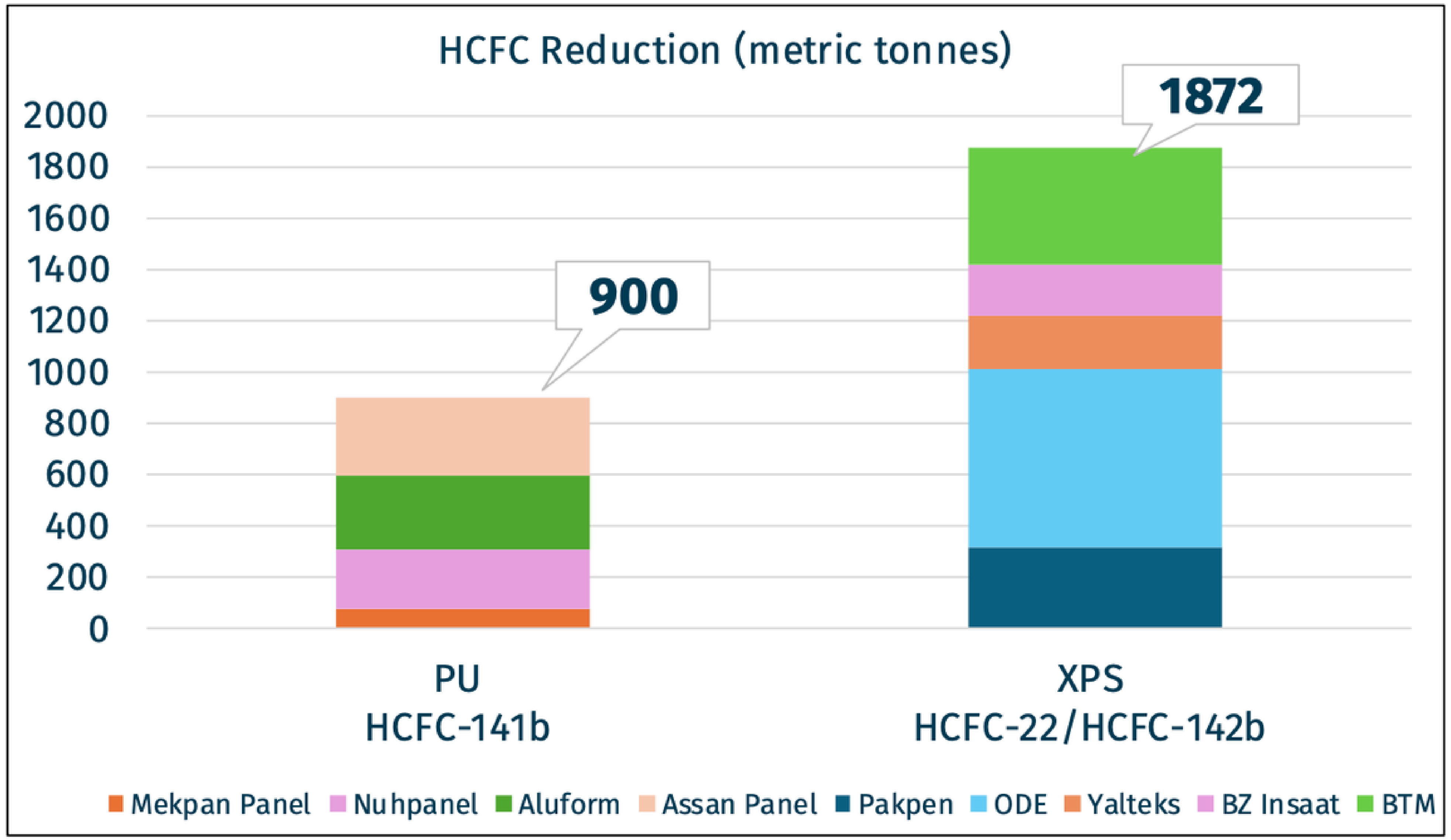
Latest Progress in Türkiye





- HCFC phase-out completed as of 2025.
- Transition to alternative refrigerants
- Strong support to industry

Technical assistance for SMEs in the foam sector



- HPMP umbrella project for SMEs
- 9 companies supported in foam sector
- Significant HCFC reduction achieved

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

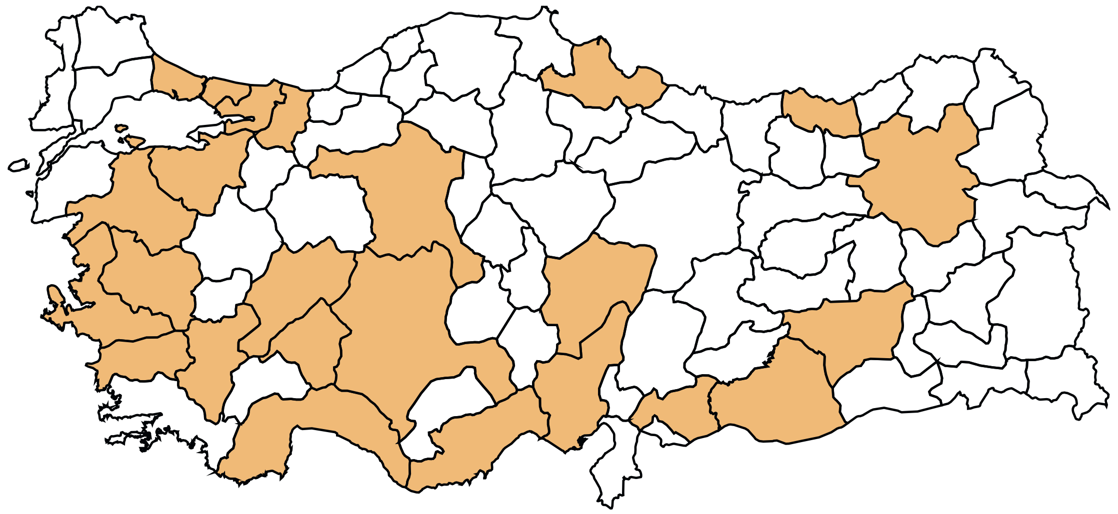
SUSTAINABLE COOLING FORUM

Emissions reduction / good practice programme

- Equipment provision to 25 vocational high schools





- Training for 2700 technicians

Demonstration and pilots for encouraging low GWP refrigerants

İZMİR – UNILEVER ALGIDA

2019

NH3 and glycol were replaced with NH3&CO2

İSTANBUL

2019

- **SARIYER MARKET FERAHEVLER**
- **SARIYER MARKET ETİLER**
- **ÇAĞRI MARKET**

In five facilities, R-22 & R404 were replaced with R448A & R452A

ANKARA - ETİ SODA
2019

In chiller application, R134A was replaced with R1233zd

Custom Training and Capacity Building

- Awareness Training on Illegal Refrigerant Trade for Customs
- Procurement of Identifiers for Customs

SUSTAINABLE COOLING FORUM

Thank you

Mehrali ECER
Deputy Director
Directorate of Climate Change, Türkiye
mehrali.ecer@iklim.gov.tr

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

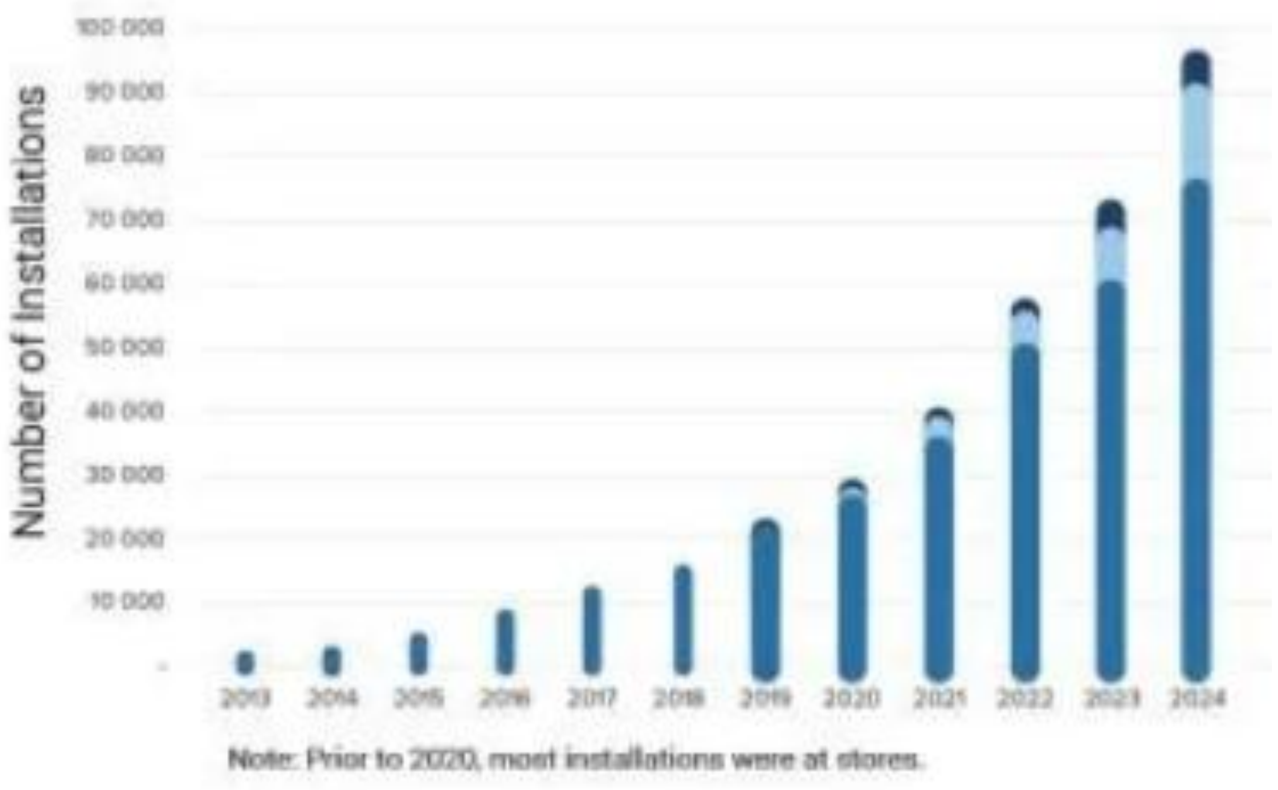
European Union policies on cooling

Shaping markets through policies

European Commission

Progress, in particular in refrigeration

- Today over **95,000** CO_2 transcritical systems installed in Europe of which over 75,000 are centralised systems;
- **market penetration in European stores has reached 30%.**
- **17 million** self-contained hydrocarbon-based cabinets
- 3,600 low charge ammonia systems and 3650 hydrocarbon-based chillers (industrial sites).

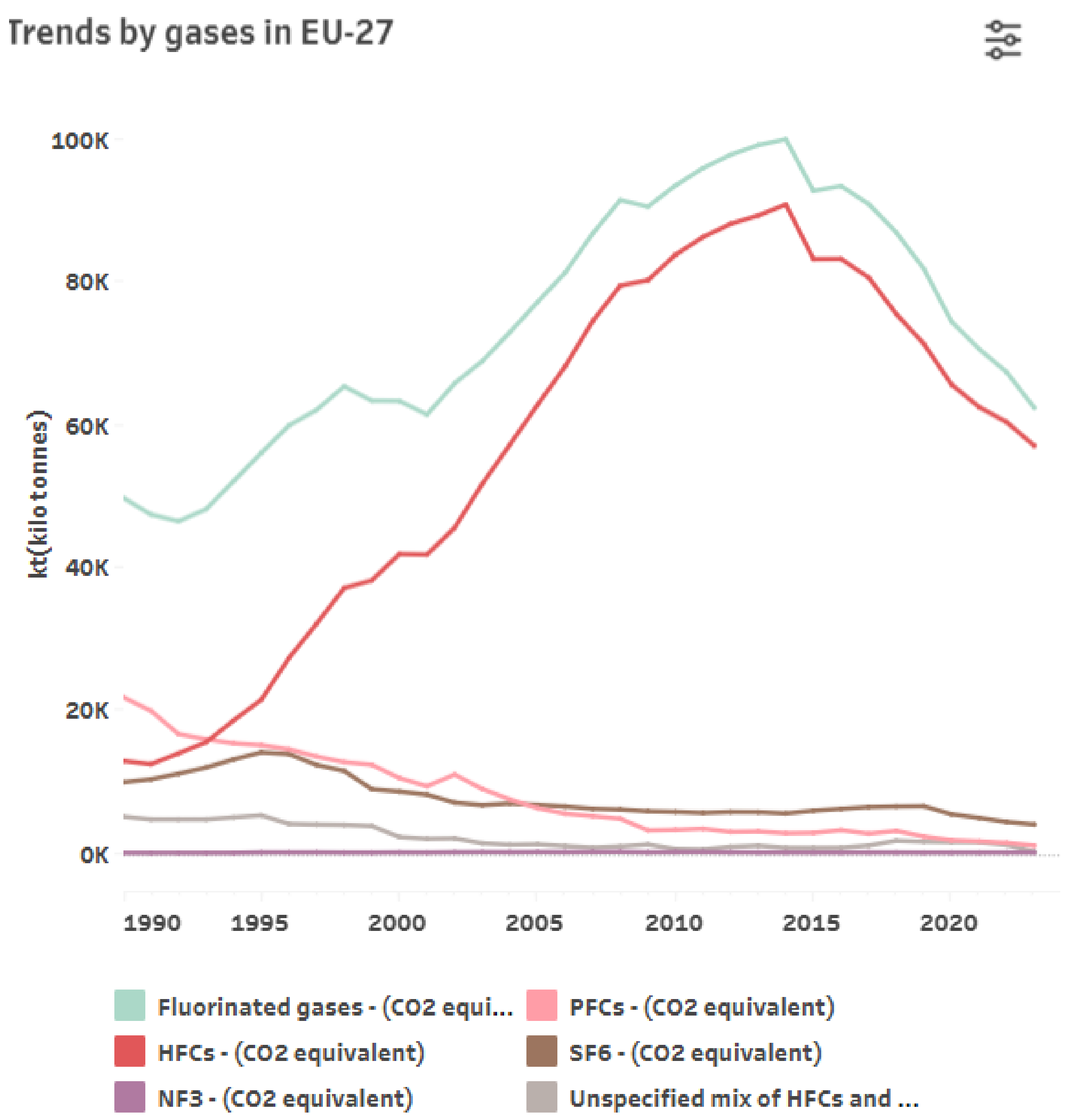


Source: All data from ATMO market report 2024

- **Technology adjustment costs only €6/tCO_2eq (2015-19)**

lower than estimated beforehand (€17/tCO_2eq)

Enabling policies and regulatory frameworks for sustainable cooling
European Union policies on cooling



During the period 2015-2023, total F-gas emissions fell by 32.8% and HFCs by 31.4%

Total F-gas emissions in 2023 fell by 7.4% compared to 2022 (HFCs by 5.5%)

Source: ***EEA greenhouse gas data viewer*** *based on data reported by EU Member States under the EU 'Governance Regulation'*

Enabling policies and regulatory frameworks for sustainable cooling
European Union policies on cooling

Restrictions in new refrigeration equipment			
	Existing	**Near term**	**Medium term (2030+)**
Domestic	**<GWP150** (2015)	**No F-gases (2026)**	
Commercial Fridges/Freezers	**<GWP150** (2022)		
Other self-contained	**<GWP150** (2025)		
Multi-pack supermarket systems	**<GWP150** (2022)		
Small chillers <=12kW	<GWP2500 (2020) Except for T<-50 C	**<GWP150** (2027)	**No F-gases (2032)**
Large chillers >12kW		<GWP750 (2027)	
All other refrigeration	<GWP2500 (2020) Except for T<-50 C		**<GWP150** (2030)

Source: Annex IV to the F-gas Regulation (Regulation (EU) 2024/573)

Enabling policies and regulatory frameworks for sustainable cooling
European Union policies on cooling

Restrictions in new AC equipment

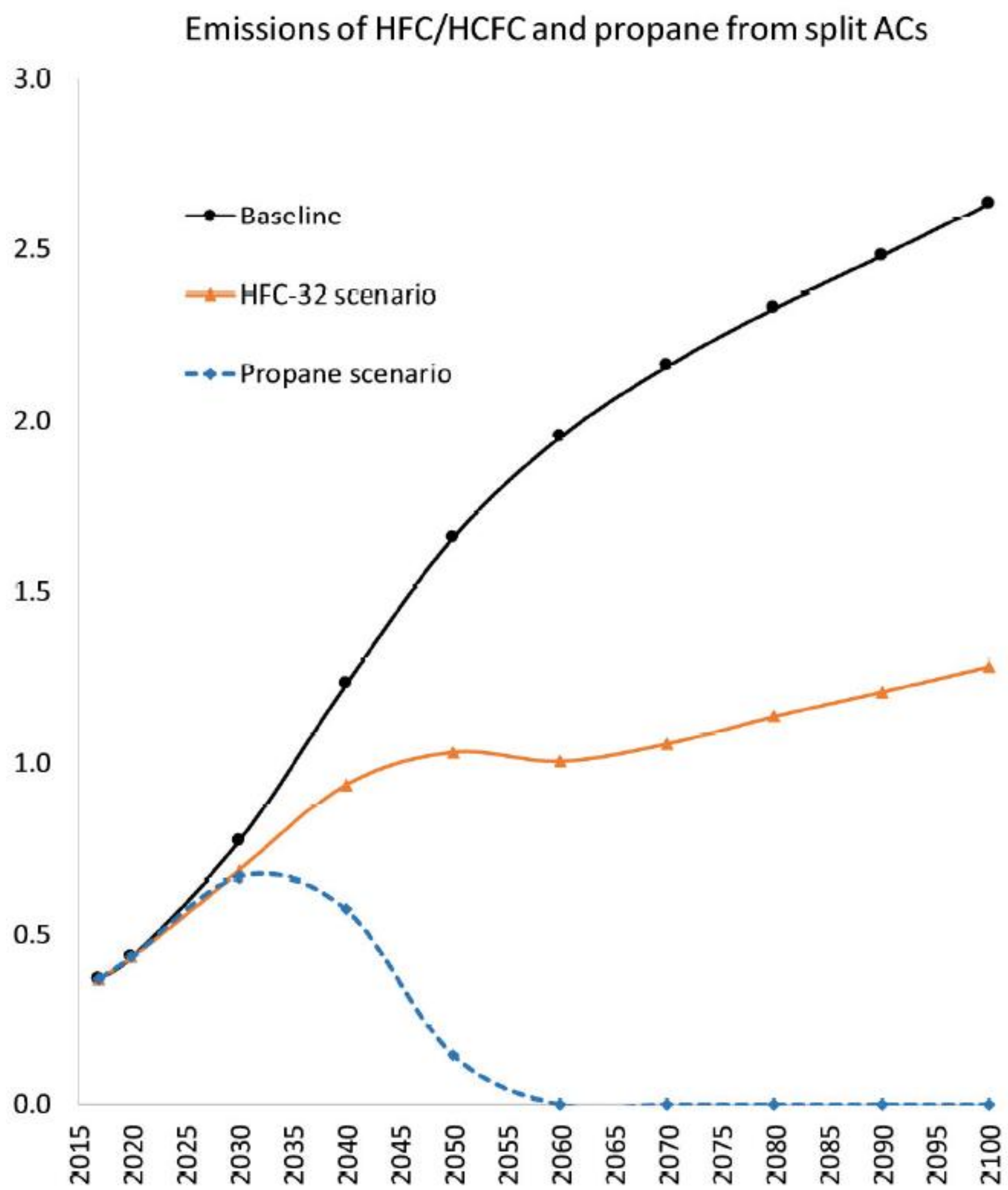
	Existing	Near term	Medium term (2030+)
Small self-contained AC/Heat Pumps <=12kW	**<GWP150** (2020) Movable plug-ins only	**<GWP150** (2027)	**No F-gases** (2032)
Large self-contained AC/Heat Pumps >12kW		**<GWP150** (2027) <=50kW	**<GWP150** (2030) >50kW
Small split AC/Heat Pumps <=12kW	<GWP750 (2025) Single splits with max 3kg charge only	**<GWP150** (2027) A/W	**No F-gases** (2035)
		<GWP150 (2029) A/A	
Large split AC/Heat Pumps >12kW		<GWP750 (2029)	**<GWP150** (2033)

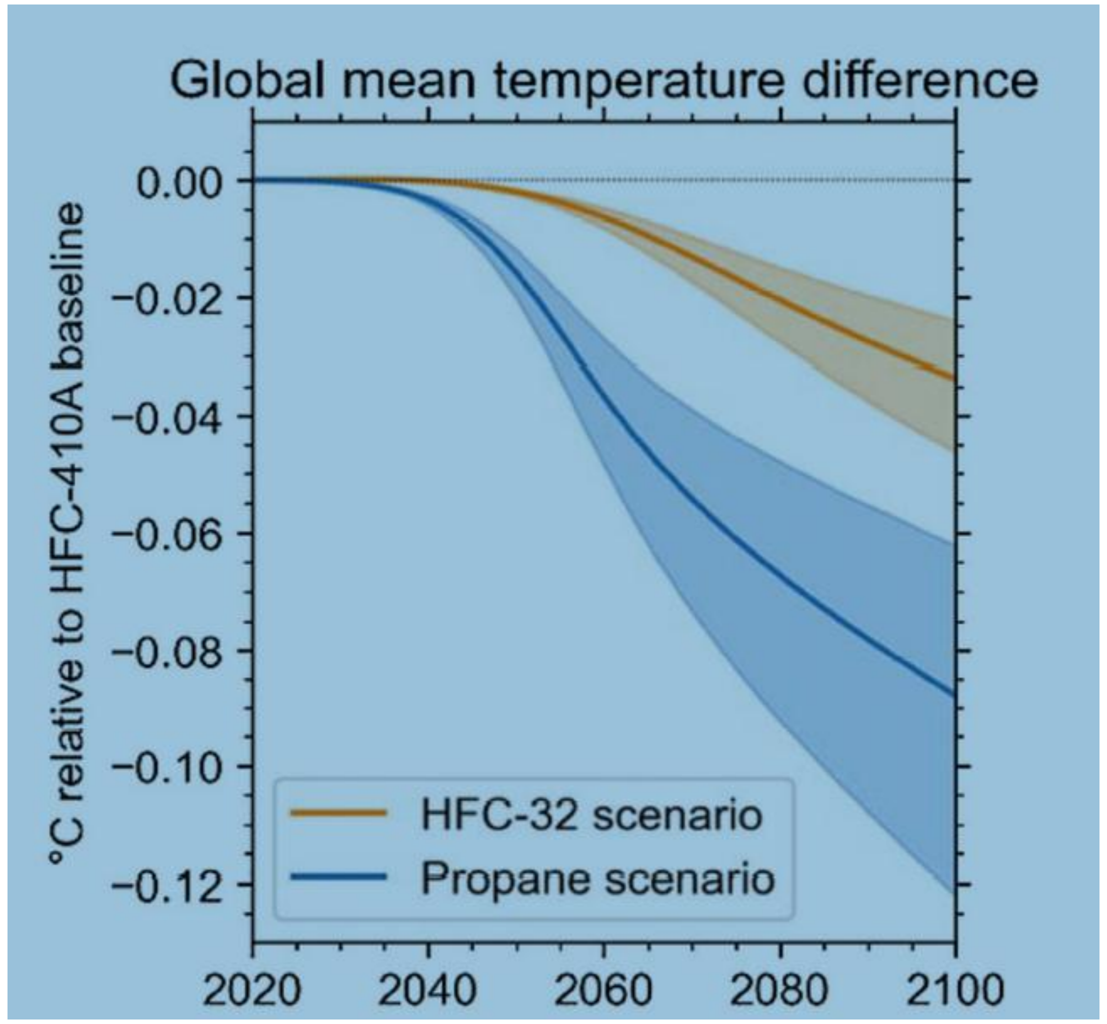
Source: Annex IV to the F-gas Regulation (Regulation (EU) 2024/573)

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Enabling policies and regulatory frameworks for sustainable cooling
European Union policies on cooling





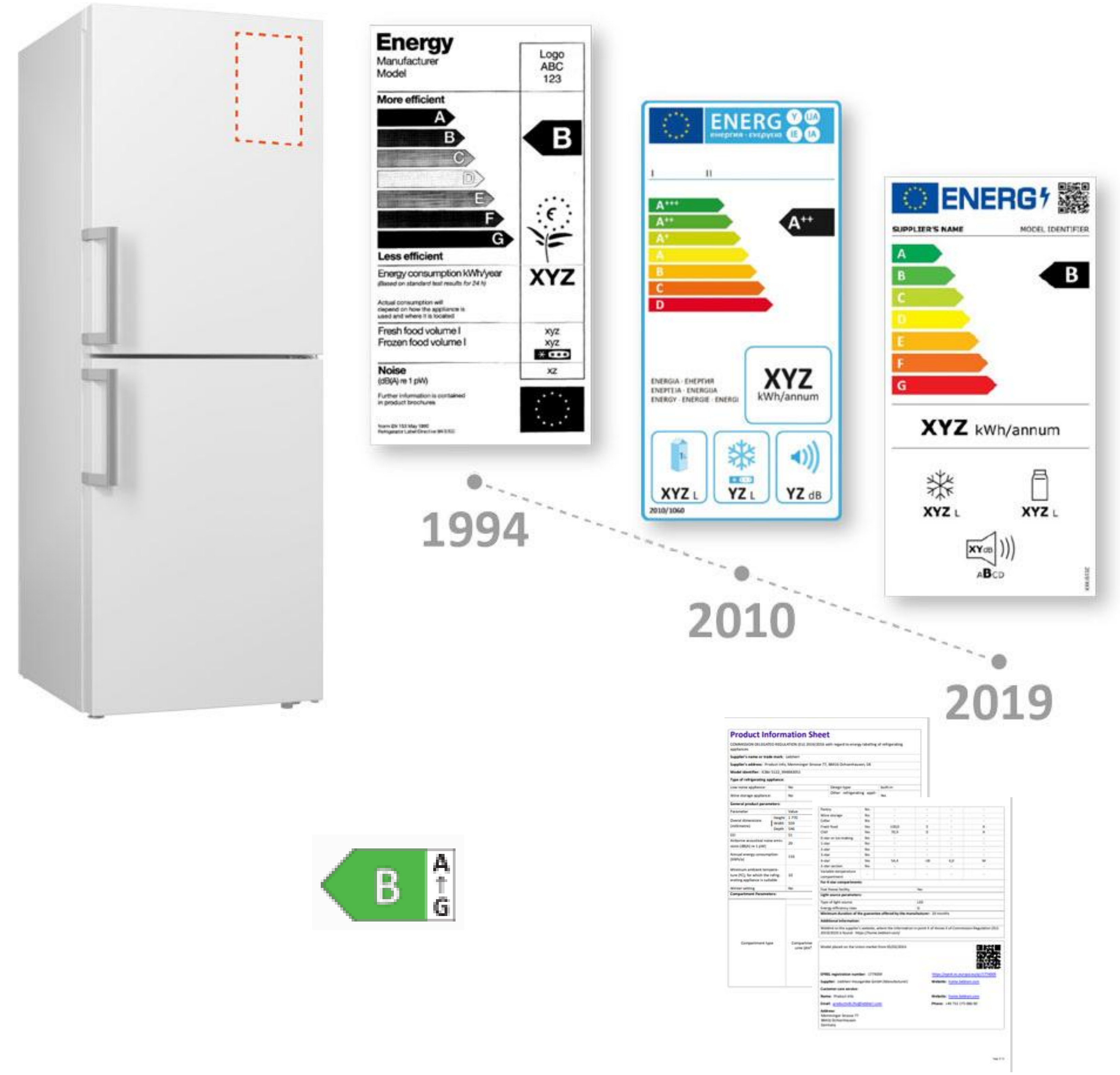
gress of warming only from th is sector!

Source: Purohit et al. (2022). PNAS.

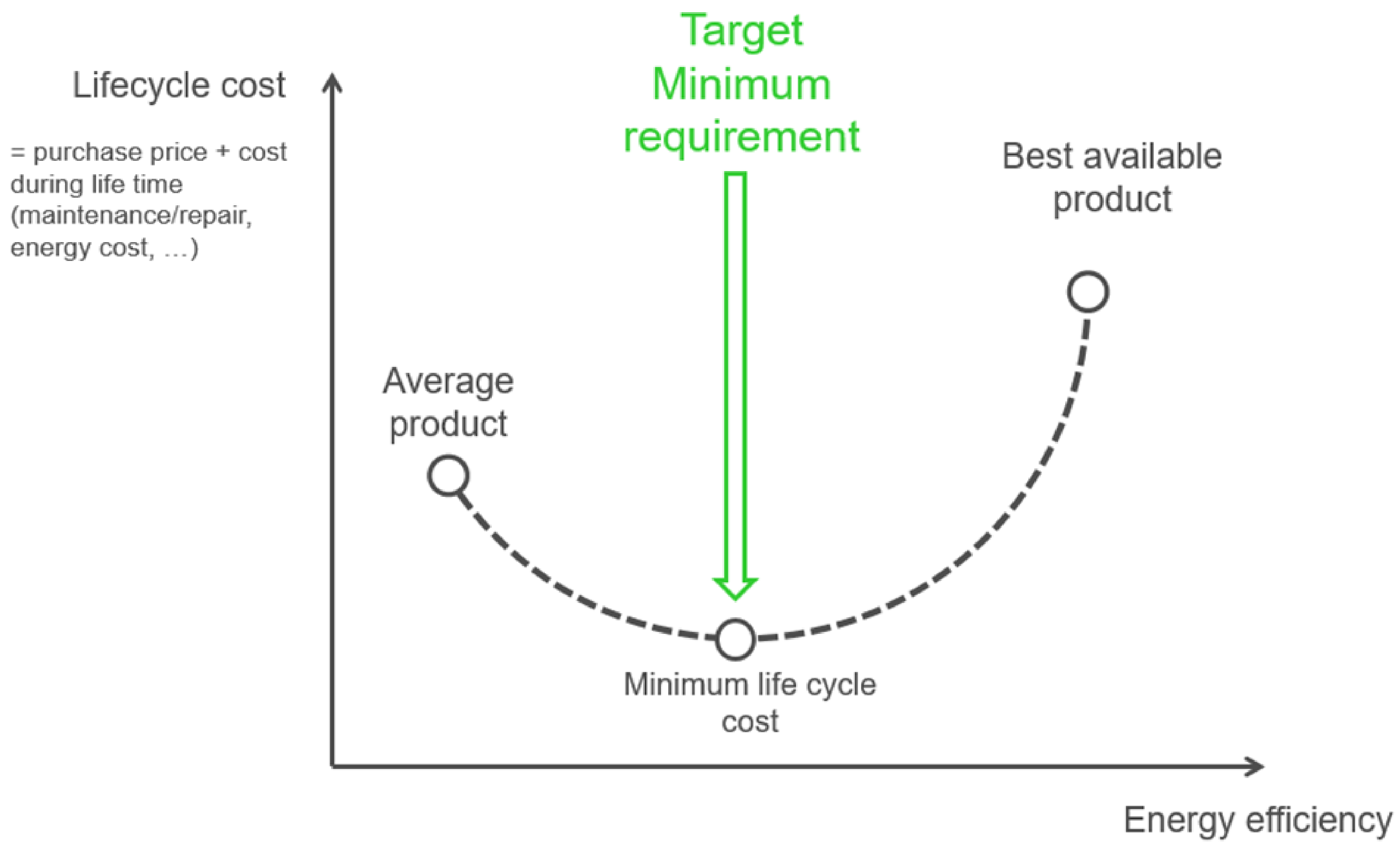
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Enabling policies and regulatory frameworks for sustainable cooling
European Union policies on cooling



Minimum efficiency requirements set based on minimum life-cycle costs for consumers



Plus, where relevant, other requirements e.g.:

- Air pollutant limit values
- Performance requirements
- Information requirements
- Spare part availability

Synergies with Eco-design - two distinct policy areas, but developed in coordination:

- F-gas Regulation design phase: only technologies with equal or better energy efficiency are considered.
- Exemptions can be granted if it is found that they have lower life-cycle emissions due to energy efficiency.
- Ecodesign: It is possible to include GWP criteria.
- Ecolabelling: Informed consumer choice, which can include refrigerant criteria (e.g., natural refrigerants) to support gradual reduction

Thank you

Agnieszka Truszczynska
Policy Officer
European Commission, DG Climate Action
agnieszka.truszczynska@ec.europa.eu

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

National Cooling Action Plan

Case study: Mexico

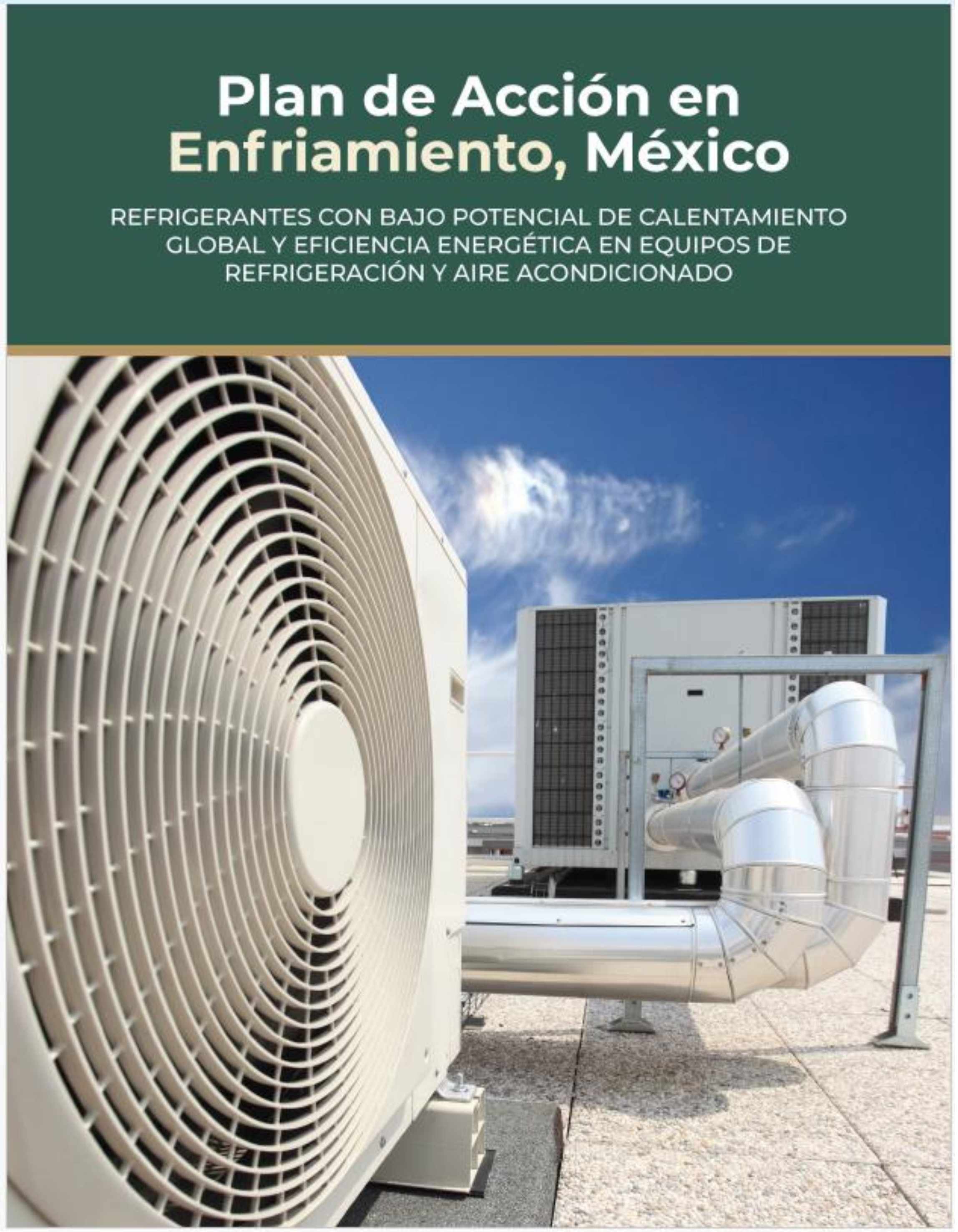
Gobierno de México | Medio Ambiente
Secretaría de Medio Ambiente y Recursos Naturales
25 ANIVERSARIO

Enabling Policies and Regulatory Frameworks for Sustainable Cooling

- Collaborative planning sets solid grounds for policies and regulation
  - Mexico's Cooling Action Plan (completed in 2022) resulted from the participation of different agencies related to environment, energy, trade and other stakeholders:

Directorates of: Climate change; Industry, Clean Energies and Air Quality Management

  - The proposed lines of action are of an indicative nature; even though not mandatory, they provide the basis for the alignment of the regulatory framework, as well as public policy strategies and programs.



Collaboration between environmental and energy efficiency authorities is key

NOM-011-ENER-2025
Central AC units, package or split

NOM-012-ENER-2019
Condensing and evaporating refrigeration units

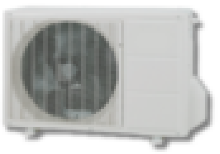
NOM-015-ENER-2018
Domestic refrigeratos and freezers

NOM-021-ENER/SCFI-2017
Room air conditioners

NOM-022-ENER/SCFI-2014
Self-contained commercial refrigeration

NOM-023-ENER-2018
Split air conditioners, without air ducts

NOM-026-ENER-2015
Split air conditioners (Inverter)



- Partnership with EE authority (CONUEE)
  - KIP-related EE strategy involves the support to CONUEE in the updating of seven existing standards (NOMs).
  - KIP-related activities have also contributed to the updating of EE-label, with better information about the refrigerant used in RAC devices.

https://www.gob.mx/cms/uploads/attachment/file/1009373/Estudio_etiqueta_amarilla_NOM_Eficiencia_Energetica_Refigeracion.pdf

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

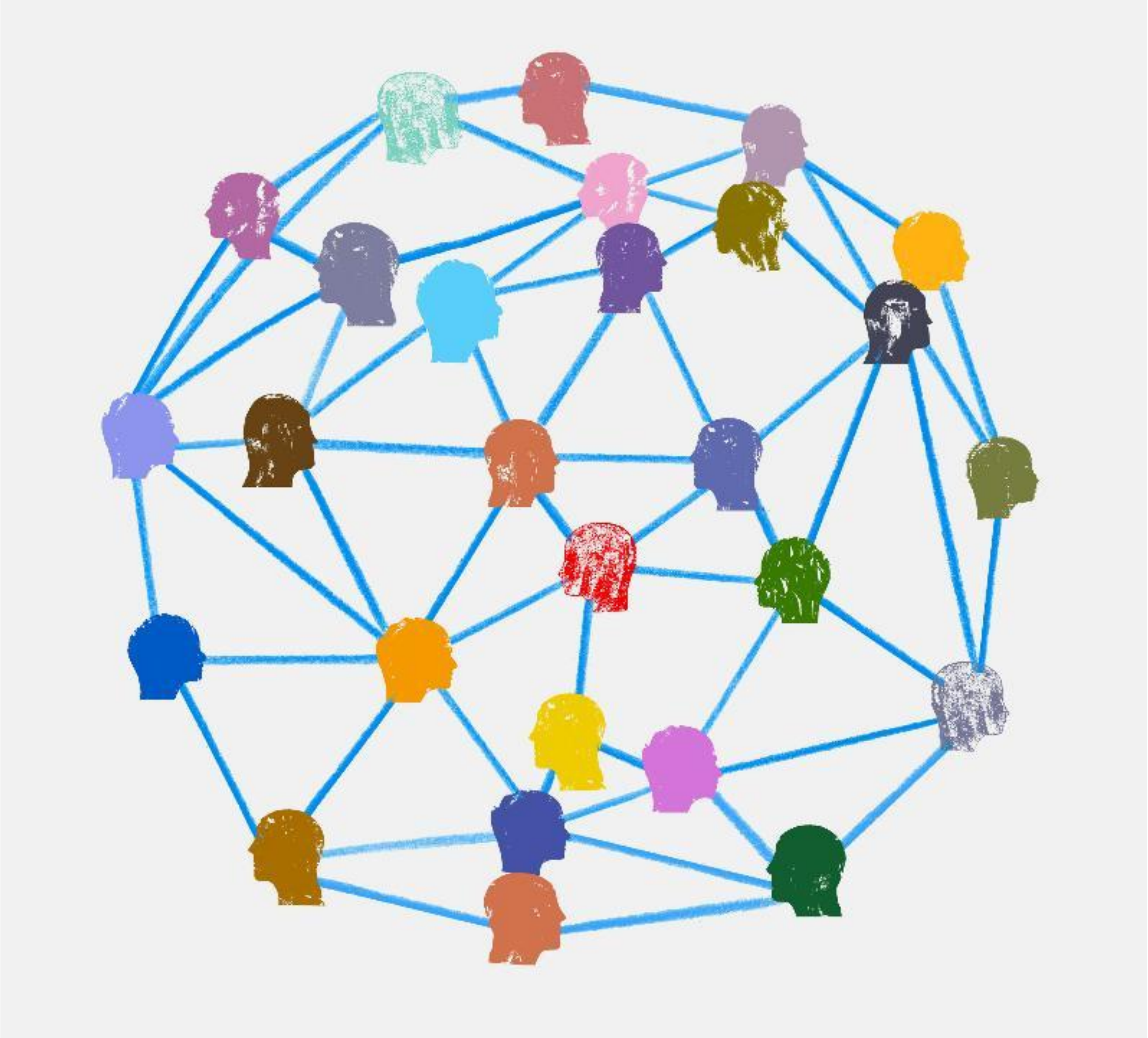
A solid conformity assessment system is essential for MEPS to actually deliver results

- EE standards (NOMs) rely on solid Conformity Assessment Procedures
  - First EE standards were published in 1994 (refrigerators and window AC units)
  - In collaboration with manufacturers and importers.
  - Conformity assessment infrastructure started to be developed in 1995 (testing laboratories and product certification bodies), followed by a verification and third-party bodies in 1999.
  - By 2022, the conformity assessment system for EE in products included:
    - 90 testing laboratories
    - 21 certification bodies
    - 215 inspection units
  - Some of them are able to provide services to third-country customers

https://www.gob.mx/conuee/acciones-y-programas/organismos-de-certificacion-de-producto-y-laboratorios-de-prueba-en-la-nom-022-ener-scfi-2014

What´s next? Sustainable cooling requires continuous collaborative efforts

- Regulatory alignment
  - Participation of NOUs in updating of laws and other regulatory instruments to ensure HPMP/KIP commitments are supported (Example: strengthening venting prohibitions).
- Policy coordination
  - Reinforce dialogue with other policy-making agents (for example, urban planning agencies, to explore the viability of district cooling projects).



Keeping an eye on opportunities arising from a broader industrial strategy

SUSTAINABLE COOLING FORUM

Thank you

Sergio Merino
National Ozone Officer
Secretaría de Medio Ambiente y Recursos Naturales de México
coordinacion.upm@semarnat.gob.mx

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Questions and Answers

SESSION 1: Enabling policy and regulatory frameworks for sustainable cooling

Ms. Elena Miceva
Montreal Protocol Unit
UNIDO

Mr. Mehrali Ecer
Directorate of Climate Change
Türkiye

Ms. Sergio Merino
National Ozone Unit
Mexico

Mr. Fernando Santiago
Division Industrial Policy Advice and Capacity Development
UNIDO

Ms. Agnieszka Truszczynsk
Directorate-General for Climate Action
European Commission

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING FORUM

Lunch

12:30 – 14:00

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Session 2

Technology innovation, development and deployment

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

SESSION 2: Technology innovation, development and deployment

Mr. Yunrui Zhou
Montreal Protocol Unit
UNIDO

Ms. Xiaoyan Li
Ministry of Ecology and Environment
China

Mr. Carloandrea Malvicino
Stellantis
Italy

Mr. Samuel Jacobs
Energy Partners
South Africa

Mr. David Marcucci
Country Office for Brazil
UNIDO

Speakers' biographies

Agenda

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Advancing Sustainable Cooling: China's Progress in Air Conditioning Technologies

Policy, Innovation and Market Transformation

Foreign Environmental Cooperation Center, Ministry of Ecology and Environment, China

Background and Context

- Rapid growth in global cooling demand
- China: world largest RAC producer and market
- HFC use concentrated in AC, refrigeration, refrigeration servicing (~81%)
- Challenge: balance demand with climate goals

Policy & Regulatory Actions

- 2021-Import/export license system HFCs included
- 2021/2024-Restrictions on new HFCs production capacity
- 2021-Mandatory destruction of by-product HFC-23
- 2023-Updated *Regulation on ODS management*, HFCs were included in the controlled substance list
- 2024-HCF production Quota system was initiated

April 2025-National Implementation Program for the Montreal Protocol on Substances that Deplete the Ozone Layer (2025–2030)

1 MAC — 1 July 2029, Declared M1 vehicles GWP<150

2 Residential AC — 1 January 2029, RAC for China Market GWP<750

3 Domestic Refrigeration — 1 January 2026, HFCs are prohibited

4 Unitary and Duct AC — 1 January 2029, GWP<750

5 Other Refrigeration Systems — New construction or expansion, GWP<2500

Transition Strategy in RAC Sector-R290 Technology Development

01
02
03

Identification-R290 as Future Refrigerant for RAC

R290 (propane) was identified as a next-generation refrigerant based on its advantages in environmental impact, energy efficiency, safety, and cost

Validation-Research and Pilot Installation

Support extensive research, safety assessments, key components adaptation, prototype testing, pilot installation and establishment of standard systems

Commercialization

Production line conversions, policy support, market promotion, and capacity building

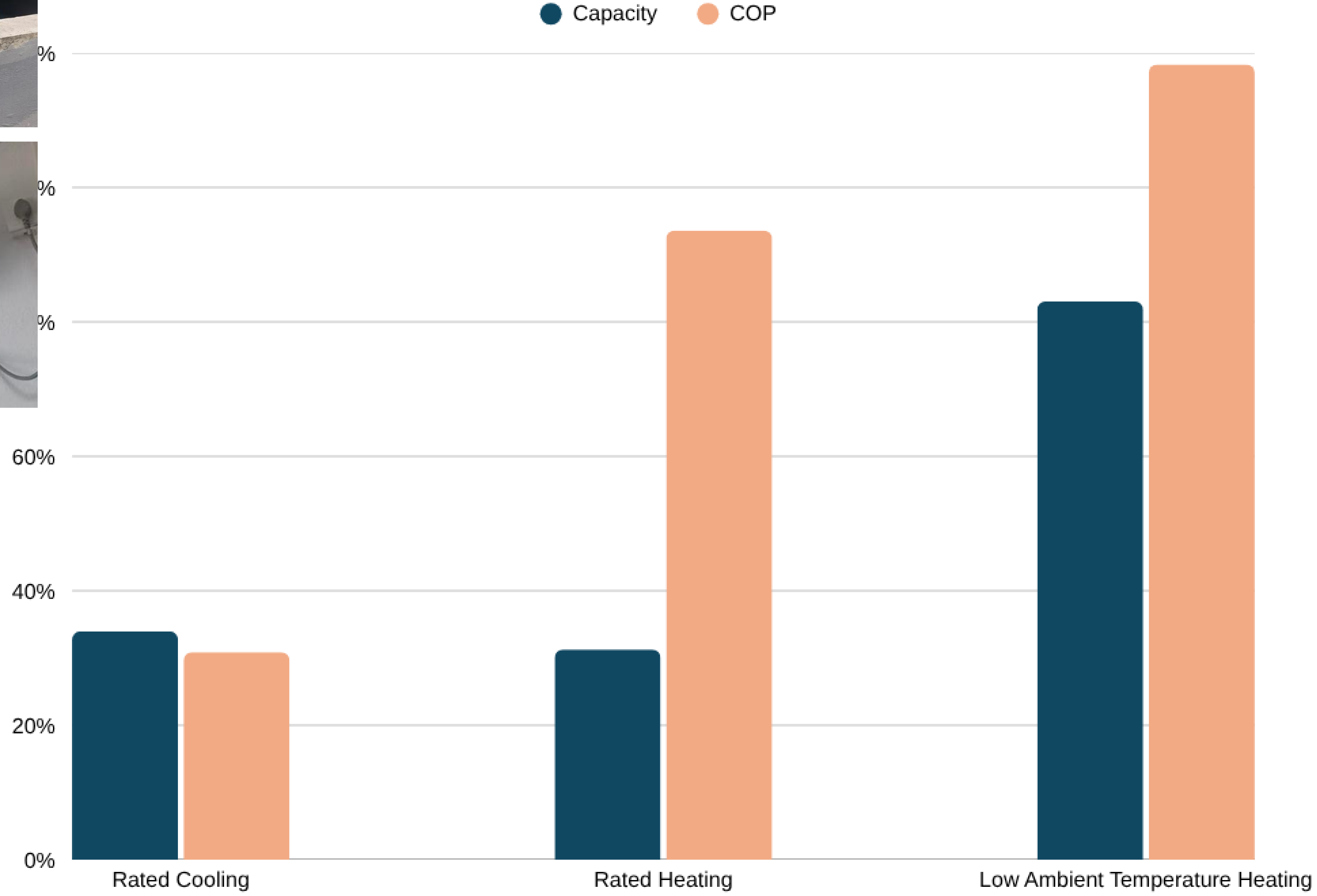
Transition Strategy in RAC Sector-R290 Technology Development

Is R290 AC safe and Energy-Efficient?

Transition Strategy in RAC Sector-R290 Technology Development

1,062 R290 Room Air conditioners
10 Years Operation
0 Accident

R290 RAC's Performance Degradation After 10 years Operation (Compared to R22 RAC)



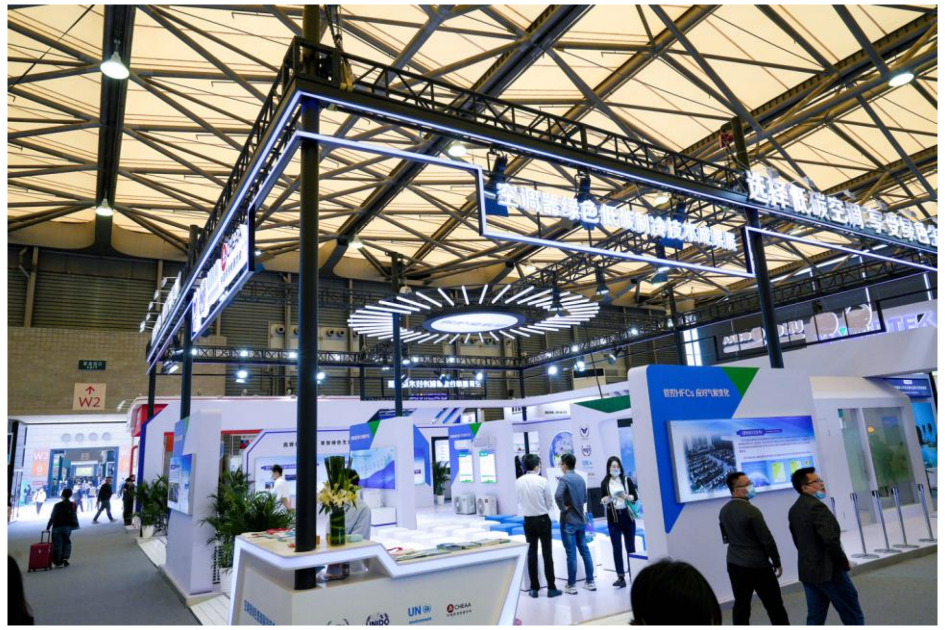
UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Transition Strategy in RAC Sector-Market and Ecosystem Development

Government encourages green consumption-fluorine free Refrigerators and ACs
JD.com-Launched **Fluorine-Free AC Zone**

Update National energy standard for RAC
Dynamic APF+ carbon footprint



Use the IOC subsidy flexibly, **only supporting the highest energy efficiency R290 models**

Organize training for **other A5 countries on R290**
Supported by the Government of Italy

Way Forward and International Cooperation

R290 is the smart, proven choice for cost-effective, compliant, and sustainable cooling

01 China is on track to install over 2 million units in 2026, creating massive economies of scale

02 Global adoption will further close the price gap, making R290 even more competitive

03 Kigali Compliance made easy: Ultra-low GWP (≈3) supports strong cooling demand growth without HFC quota restrictions

04 Significant Carbon Reduction: Superior energy efficiency + near 0 direct emissions + smart energy management technology deliver real climate impact

China's R290 progress has been strongly supported by the MLF and international partners. We are ready to strength cooperation with other countries and partners to accelerate R290 adoption and achieve shared sustainability goals

SUSTAINABLE COOLING FORUM

Thank you

Li Xiaoyan
Senior Program Manager
FECO/MEE China
li.xiaoyan@fecomee.org.cn

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

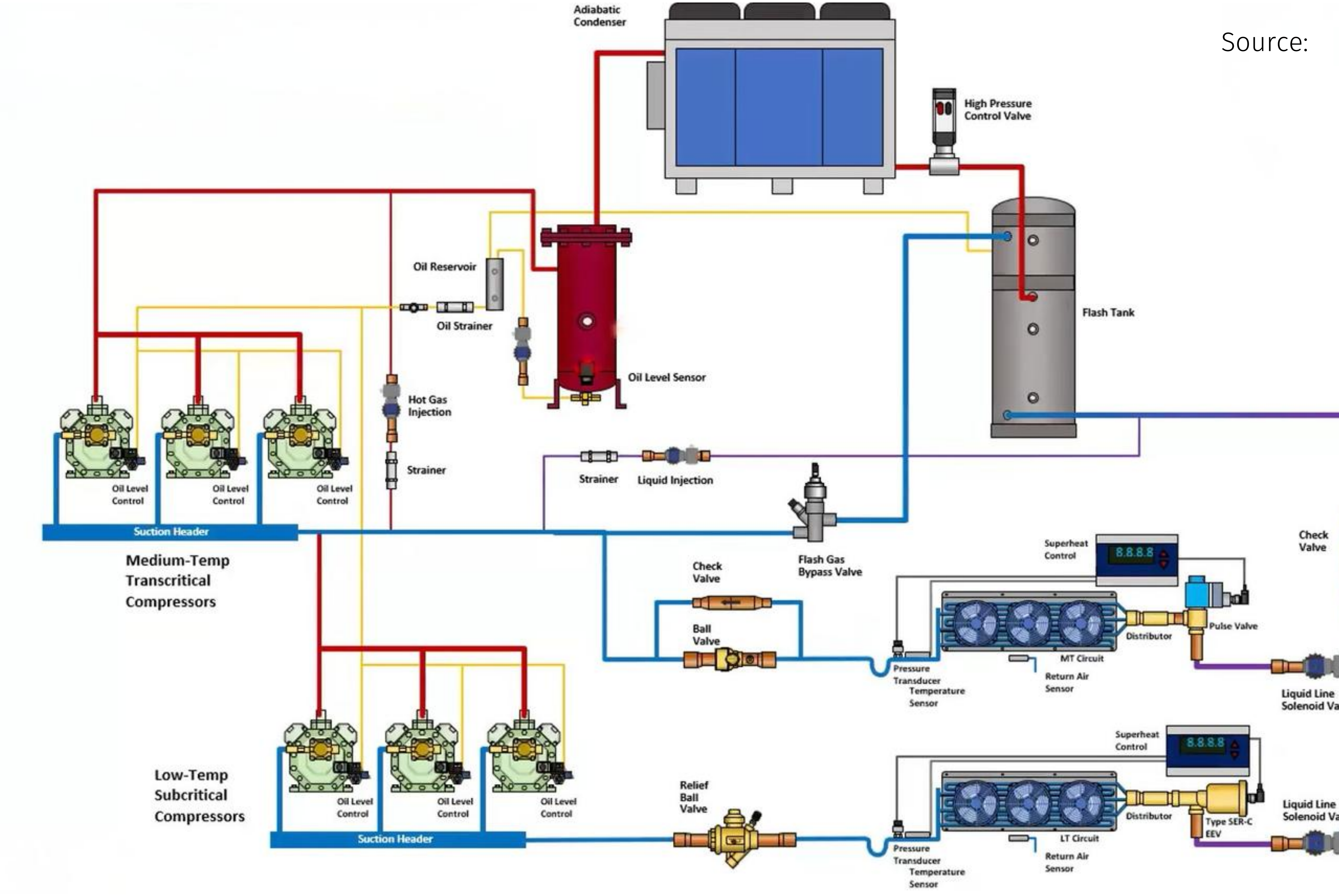
SUSTAINABLE
COOLING
FORUM

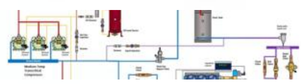
CO2 technology in commercial systems

ENERGY
PARTNERS
REFRIGERATION

SESSION 3: CO2 technology in commercial systems – Safety considerations

- Design considerations
  - UPS (HPV & FGV operation)
  - Pressure rated components
  - Hydrostatic pressure
  - Aux cooling
- Operating considerations
  - Gas bottle handling & storage (900PSI)
  - Dry ice formation (liquid drier core replacement)
  - Suitable service tools (gauges & hoses)
  - Asphyxiation (displaces oxygen in confined spaces)



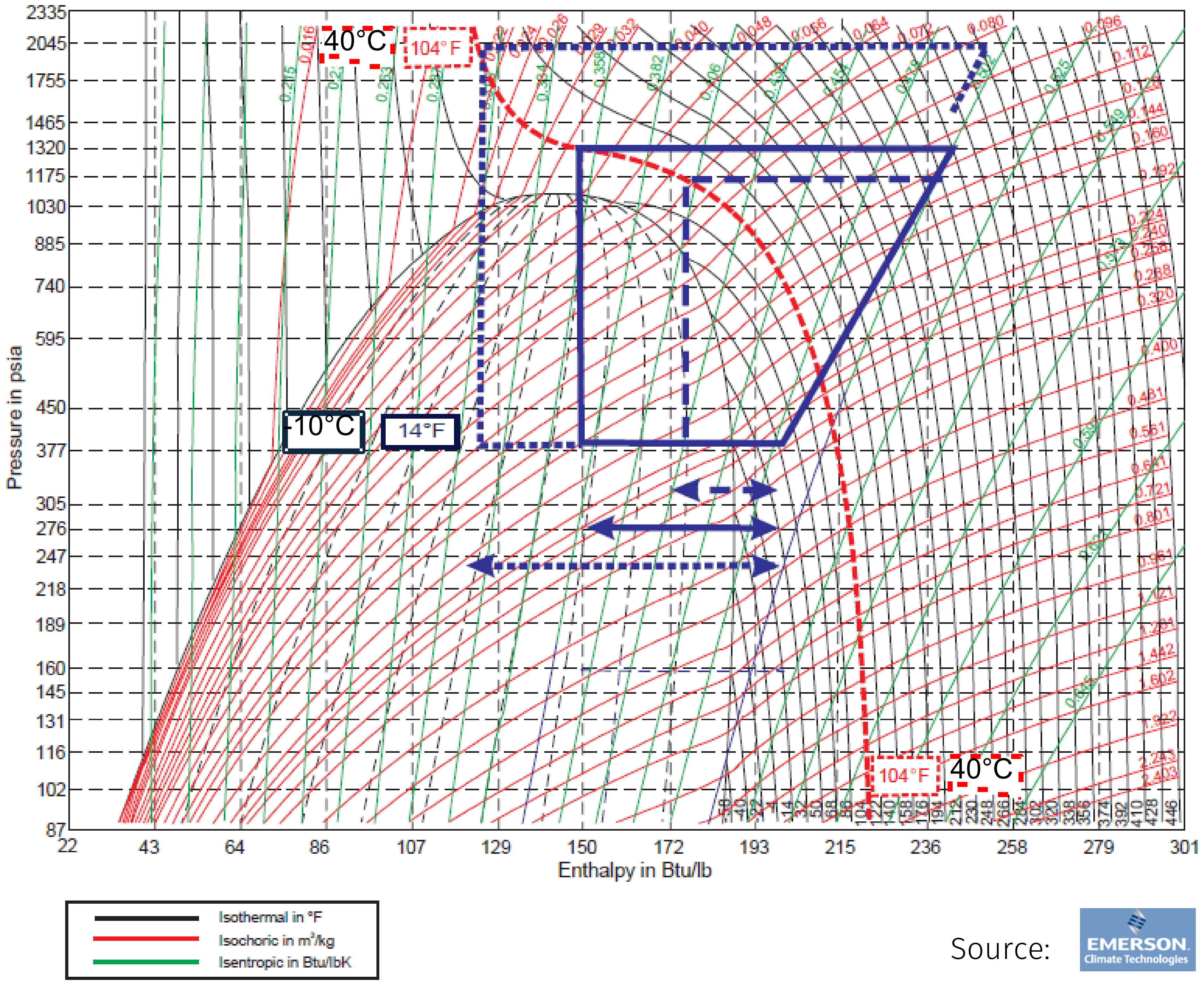
Source: 

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

SESSION 3: CO2 technology in commercial systems – Ambient conditions

- Europe/parts of USA cooler ambient - Subcritical
  - Operation below critical point (31°C)
  - Lower compression ratio
  - Phase change with condensing
  - Lower condensing pressure improves CoP
- Africa/ close to equator warmer ambient - Transcritical
  - Operation above critical point (31°C)
  - Higher compression ratio
  - Higher discharge (smaller delta T)
  - Larger heat rejection with only sensible heat.
  - Lower gas cooler pressure does not necessarily improve CoP (must optimize pressure for tension CoP v capacity)

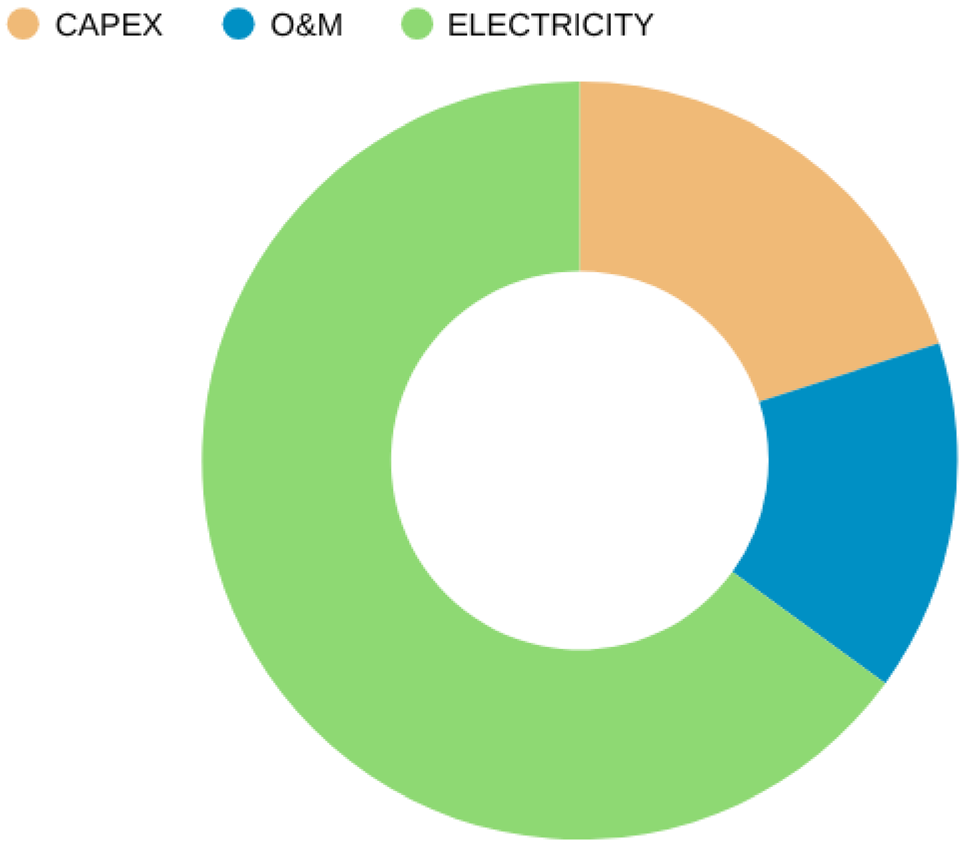


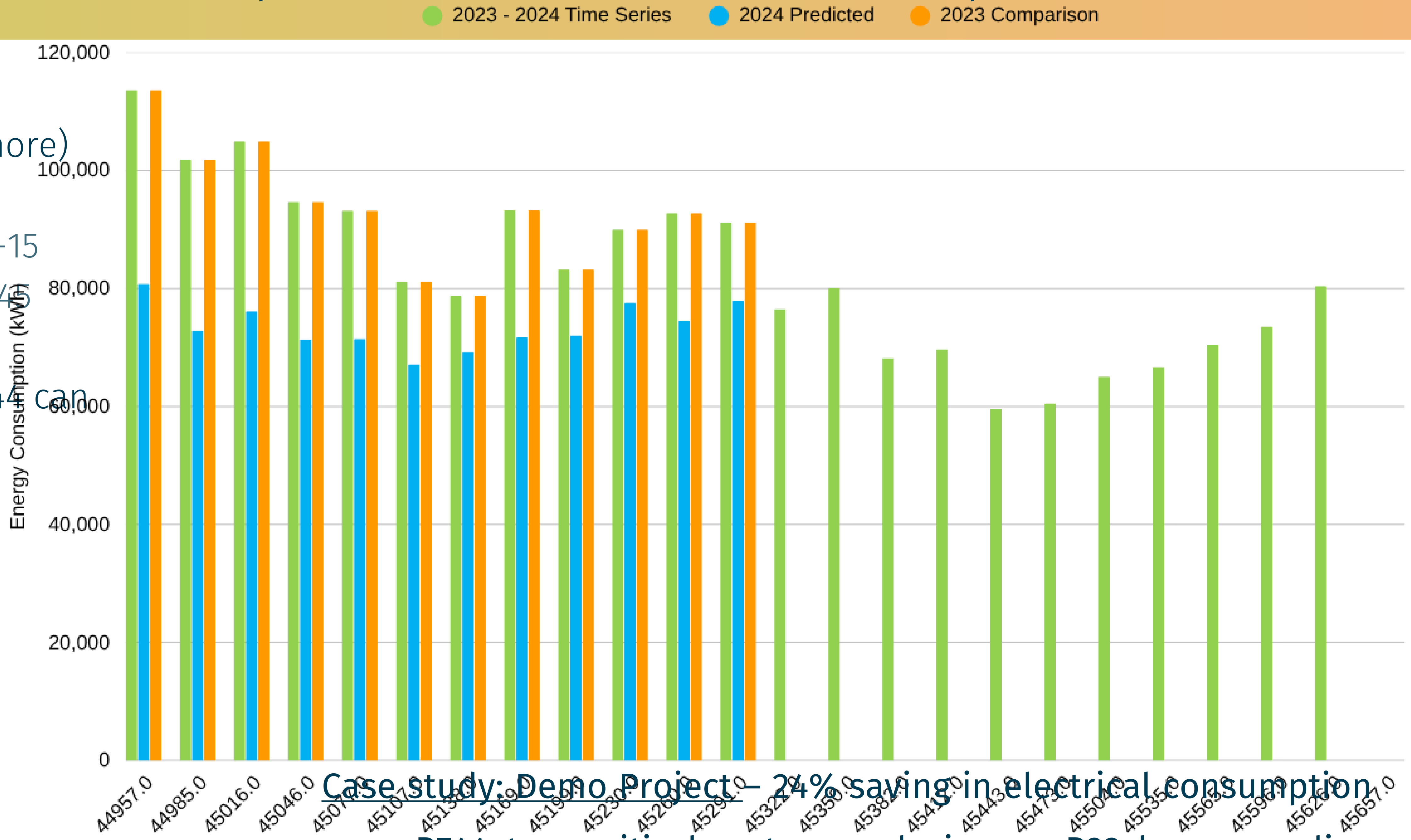
Source: EMERSON Climate Technologies

SESSION 3: CO2 technology in commercial systems – Total cost of ownership

Life cycle cost approach

- Capex on system (enhancements generally 30% more) due to transcritical operation.
- O&M – R744 prices has been stable and lower (~5-15 EUR/kg) compared to high GWP refrigerants (~30-45 EUR/kg) and sharply rising [1].
- Consumption – Depending on the application, R744 can achieve up to 20-25% better consumption.





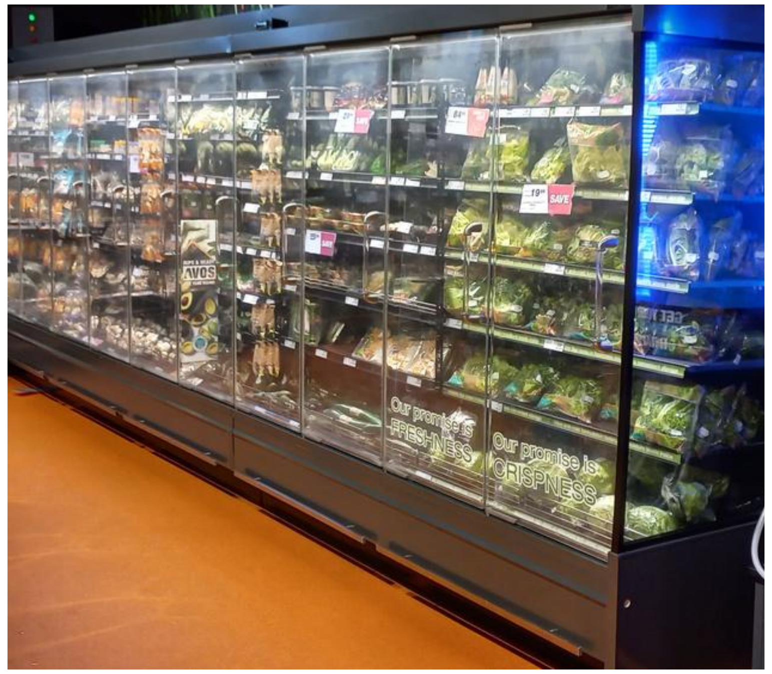
Case study: Demo Project – 24% saving in electrical consumption on a R744 transcritical system replacing an R22 legacy cooling system. Snapshot of Yr 23/24 with prediction vs actual based vs legacy with CoP optimization.

[1] High GWP Refrigerants Face Soaring Prices as Natural Alternatives Offer Stability - GIZ Proklima

SESSION 3: CO2 technology in commercial systems - Applications

- R744 single and booster systems
  - Large store application for MT and LT applications
- R744 water loop
  - Smaller store application for MT and LT applications
- R744 cascade & hybrid cascade
  - Light /heavy industrial applications

Typical booster system



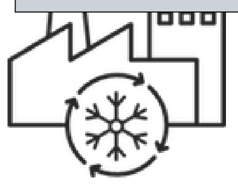
Typical water loop system

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

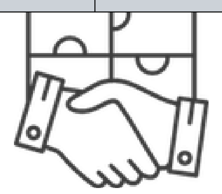
SUSTAINABLE COOLING FORUM

SESSION 3: How do we scale? Long term multiple utilization & building value chains (Tier 2 markets) will result in exponential utilization.

Intervention	Sust. Impact on capital		Sust. Impact on O&M		Sust. Impact on energy consumption		Value chains	Scaling
	Short – Medium	Long term	Short - Medium	Long term	Short – Medium	Long term		
DFI/blended capital/concessions								
Cost of efficient technology								
Regulations								
Stakeholders upstream & downstream of EVP								
Servitization								
		Multiple Utilization		Multiple Utilization		Multiple Utilization	Building value chains	**Exponential Utilization**



Owning the system



Using the system

Fee Structure

Servitization

- Shifts capital & technology to service partner.
- Embeds efficiency with long term "on the ground" focus.

Markets

- Tier 1 – consolidated value chains
- Tier 2 – fragmented value chains

SUSTAINABLE COOLING FORUM

Thank you

Samuel Jacobs
Executive Head: Business Development
Energy Partners
samuelj@energypartners.co.za

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Mobile Air Conditioning

Hydrocarbon Option

STELLANTIS

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

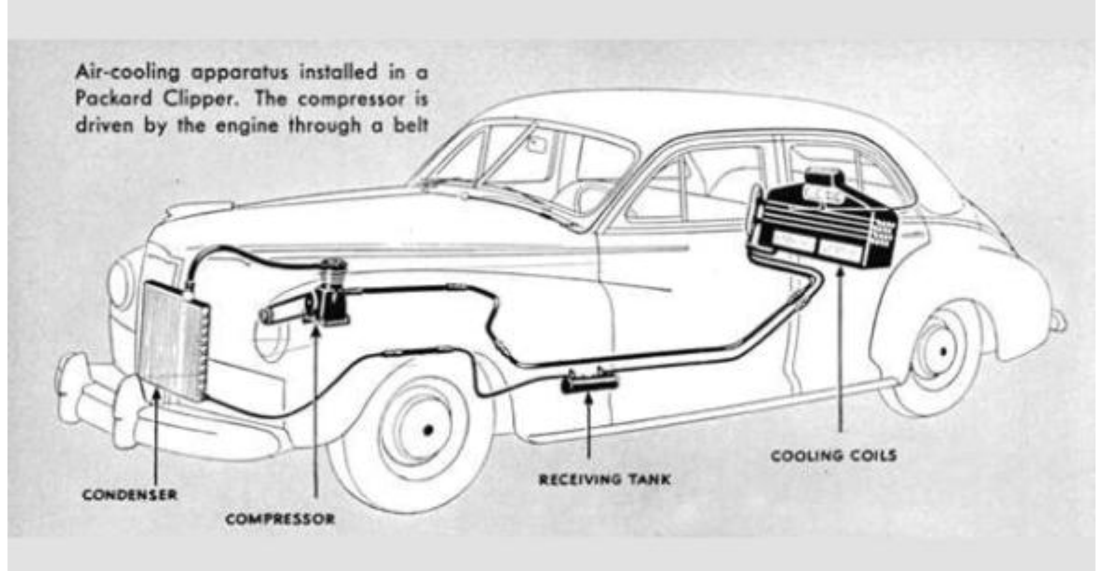
Mobile Air Conditioning Global Scenario

In 2040 there will be up to 2 billion of circulating vehicles (1.2B in 2022, 1.6B in 2025): >**1.5 Mton of refrigerant (50%** new cars **50%** for recharge/leakage)*

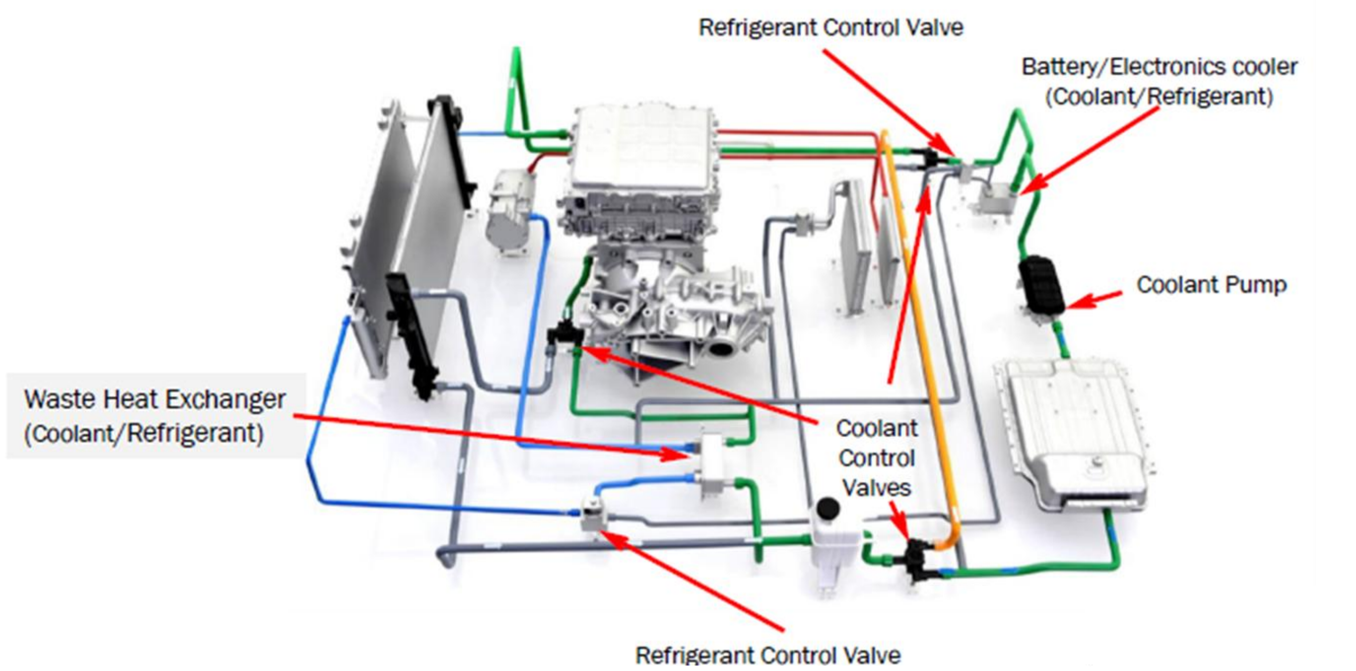
The MAC are responsible of **> 1% of GHG global** emission**

Now HFC-134a and **HFO-1234yf** are the mostly and commonly worldwide used refrigerants

Due to **HFC-134a high GWP** (Global Warming Potential) European Union as other Countries/regions set measures/provisions to **phasing out** refrigerant (e.g., ban out in EU from 2011 on Passenger cars EU (2006/70/156)



1940 Packard, Air Conditioning Pioneer



Current example of Air Conditioning/Thermal system

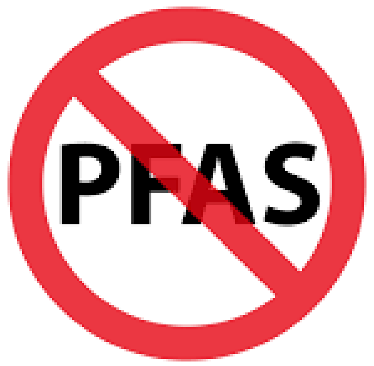
*Light and heavy-duty vehicles for 0.3 kg to 1.4 kg refrigerant, buses up to 16 kg; Lifespan 20 Year; 5% leak/recharge

** WW GHG emission: Transport 22.9% 70% of which due to Road transport; MAC generate > 6% of road vehicle GHG emissions

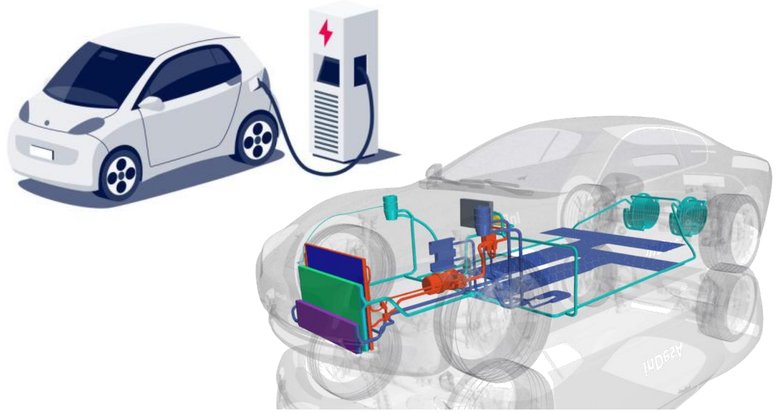
Van der Hernst, Nissens Future Vehicle Thermal Management Systems *Discussion of system designs, components and refrigerants* May 27, 2025 – XXI EU conf RAC Milan

The Mobile Air Conditioning Challenges

Challenge 1: HFO-1234yf, HF-134a generate **PFAS** (per and polyfluoroalkyl substances) as decomposition product and dangerous for most of living beings. **EU and US have initiatives to limit/ban the PFAS substances**



Challenge 2: The Mobile Air Conditioning is becoming a **complete thermal** system to answer the road **transport electrification needs** (thermal comfort battery and power electronics thermal management).



Challenge 3: MAC **generates <1% of global GHG emissions**, without any improvement this will increase de to road transport electrification. **The MAC efficiency improvement is a crucial,** especially for electric/electrified vehicles.

The Mobile Air Conditioning is part of automotive Platforms, that usually ask for > 5 year for being developed and remain in the market > 10 years

PFAS timeline and impact on Mobile Air Conditioning

- **The U.S. federal PFAS framework is evolving but remaining fragmented.** EPA activity includes drinking water restrictions, TRI additions, and expanded TSCA scrutiny
- **No universal PFAS ban exists at the federal level.**
- **The transition away from PFAS-containing refrigerants is indirect**, driven by climate policy (GWP limits) rather than PFAS toxicity or persistence concerns

- **EU is planning a PFAS Ban Under REACH (March 2026 started the consultation)**
- The EU has advanced a PFAS proposal covering >10,000 PFAS substances.
- **Fluorinated gases (HFCs + HFOs) represent 63% of total PFAS** emissions in the EU, largely through direct leaks, and breakdown into TFA (a PFAS)
- **PFAS-based refrigerants** risk to be "no longer viable" long-term, they are **considered “lowest hanging fruit” for PFAS reduction**

Electrification and Thermal System evolution

Internal Combustion Engine (ICE)

Hybrid Electric Vehicle (HEV)

Plug-in Hybrid Electric vehicle (PHEV)

Range Extender Electric vehicle (REEV)

Battery Electric Vehicle (BEV)

ELECTRIFICATION

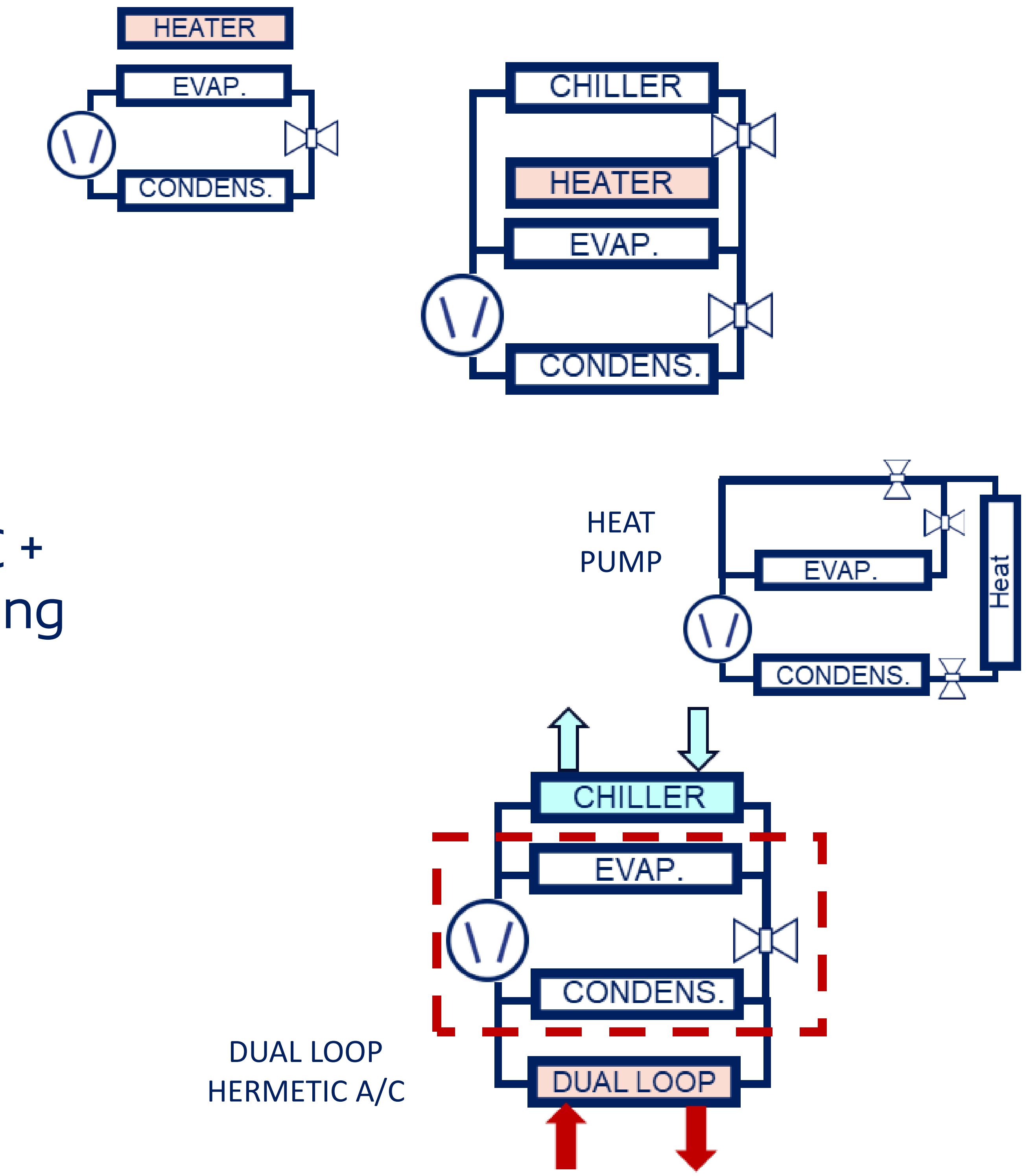
Heating +A/C

Heating +A/C + passive battery cooling

Heating (elec.)+A/C + active battery cooling

Simple heat pump +battery cooling

Full thermal management



Synthetic vs Natural Refrigerants

The development and deployment of a new generation of MAC system **requires at least 10 years** considering the component development and the industrialization of the automotive platforms

Synthetic Refrigerants

PROs
- Already in use
- Performance can be designed
- Several PFAS-free blends are under study (selective leak/glide… effect to be addressed)
- Compatible with current systems/component

CONs
- Expensive
- Risk of monopoly/patents
- The long-term effect on environment are difficult to predict and assess (see HFO-1234yf)

Natural Refrigerants (R-290, R-744)

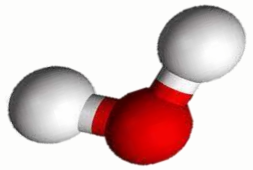
PROs
- Less expensive
- no patents
- The effect on the environment are very well known and very low or none
- Widely used in stationary refrigeration

CONs
- They requires new components or specific system design
- The performance can not be tuned/designed
- Not widely used for vehicle applications

Natural Refrigerants

The development and deployment of a new generation of MAC system **requires at least 10 years** considering the component development and the industrialization of the automotive platforms

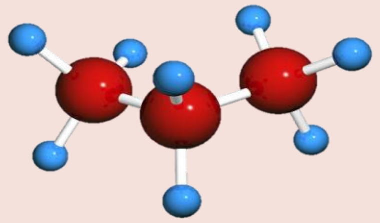
R-744 (CO_2)



PROs
- Natural (no patent)
- Efficient in low/mild climate and severe winter conditions
- Direct and Indirect expansion
- Already in use

CONs
- System cost (more expensive)
- Requires a new generation of components
- Not efficient in severe summer conditions

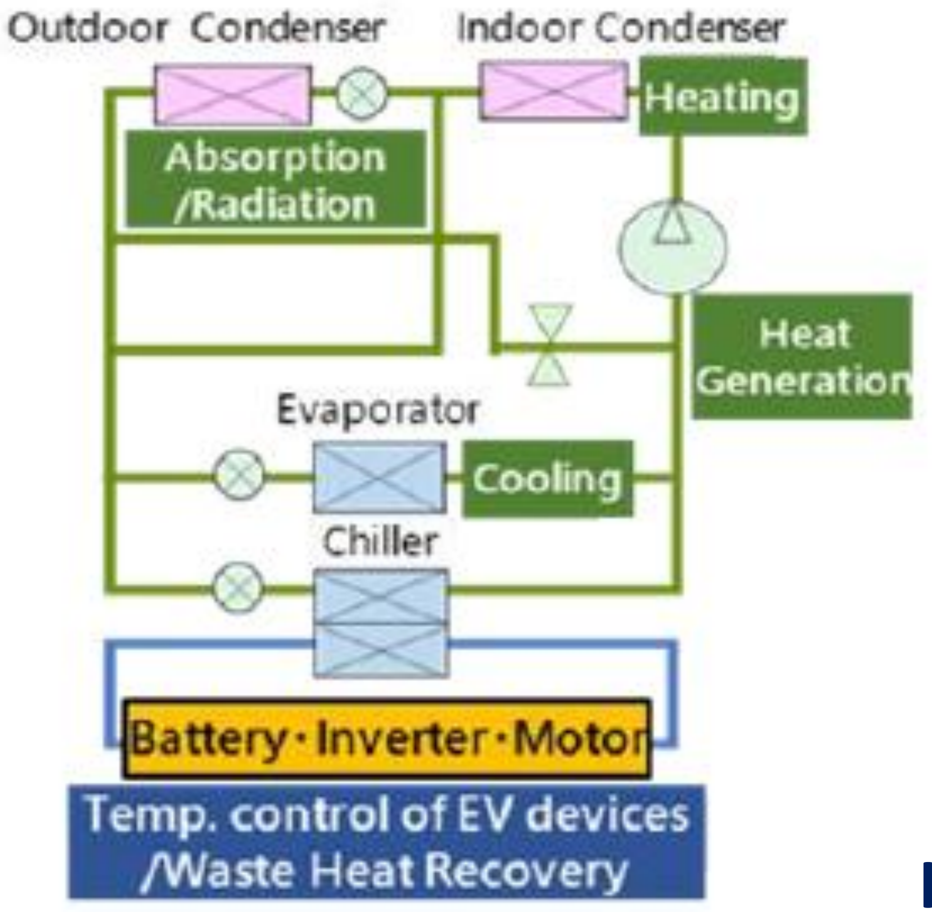
HC-290 (Propane)



PROs
- Natural (no patent)
- Compatible with current technology (low cost)
- Efficient in also in very hot conditions

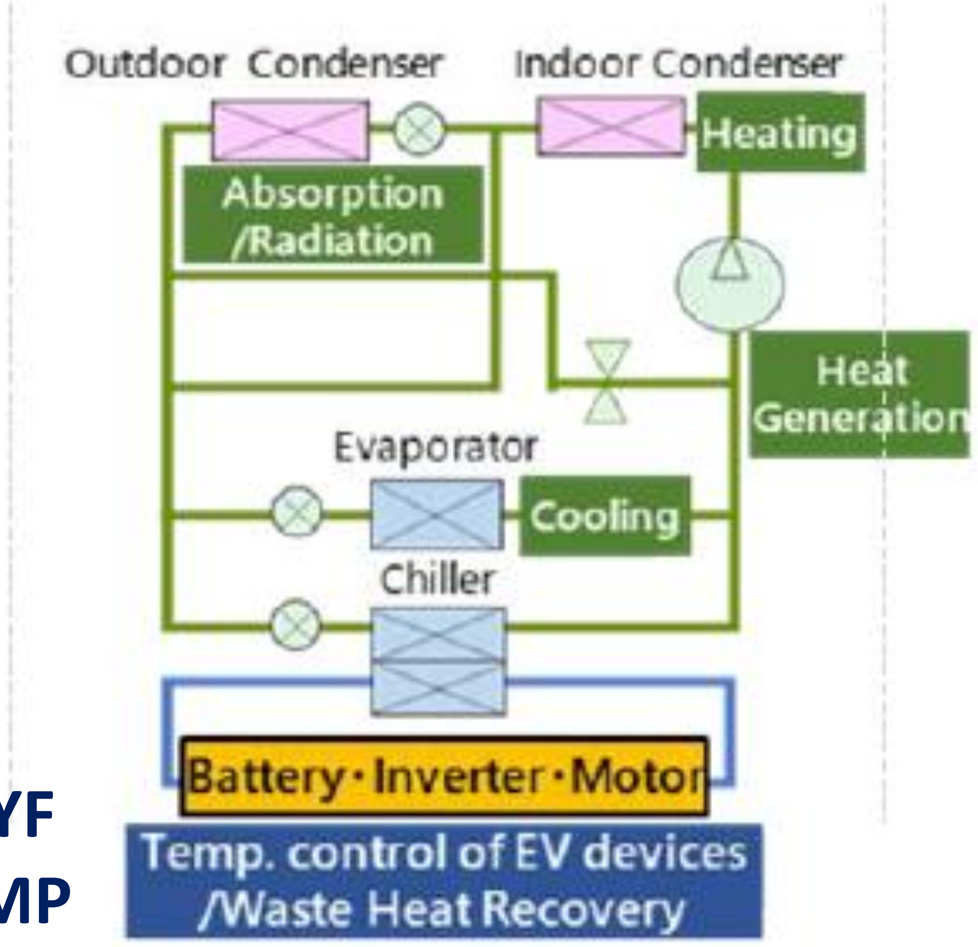
CONs
- Flammable (it requires dual loop)
- Not efficient as Heat Pump in very cold weather
- In US need EPA approval: on going for BEV, to be asked for all other energies (3 year delay)
- Not in use

Electrification and Thermal System evolution

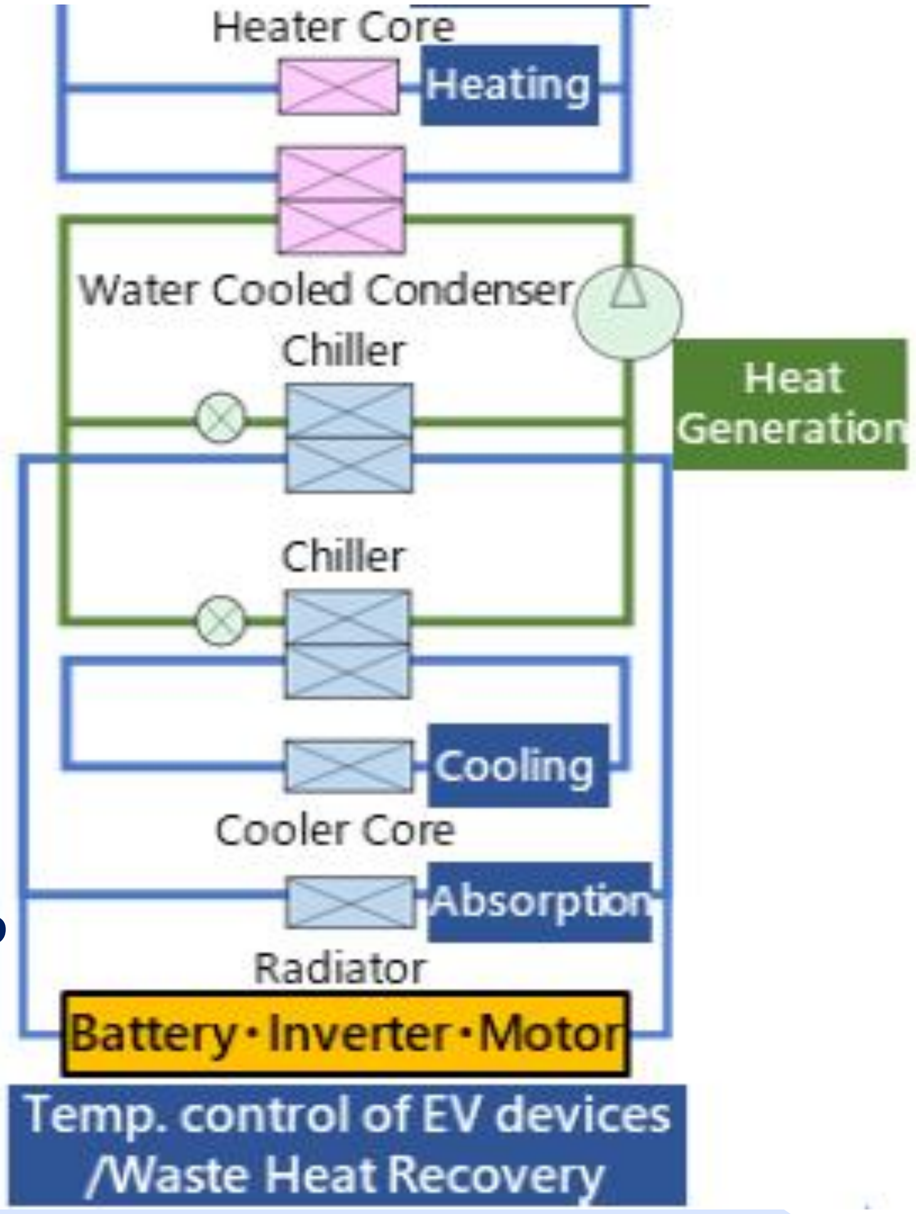


R-744
HEAT-PUMP

HFO-1234YF
HEATT-PUMP



R-290
HEAT-PUMP
DUAL LOOP



SYSTEM COMPLEXITY

REFRIGERANT COMPLEXITY

PFAS FREE THERMAL MANAGEMENT SYSTEM WITH R290
Massano C., Sorrentino L., Vitali D., Denso Thermal Systems S.p.A
SAE – CO2 reduction for Transportation System Conference, Turin 2024

Conclusions

1. **The widely used refrigerants HFO-1234yf and R-134a are at risk** of being restricted or banned as PFAS related substance:

   - The **automotive industry** is reacting re-assessing **natural** substances such as **R-744 and HC-290 or** developing **new blends (e.g., R-494B, R-4101A) made of PFAS-free syntehic** fluids

   - The process/methods/regulation to promote the replacement of a refrigerant have been already applied successfully at least once in the past (HCFC)

2. The Road Transport **electrification** asks the **MAC** to become a complete **Thermal System** requiring highly energy-efficient solutions to **not offset the electrification environmental benefits**

Industry, public authorities and NGOs must answer with solution that must be **environmentally, socially and economically sustainable on a global scale**

SUSTAINABLE COOLING FORUM

Thank you

Carloandrea Malvicino
Stellantis – Enlarged Europe
CO_2 Emission Reduction Strategies

carloandrea.malvicino@stellantis.com

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Progress by innovation

SUSTAINABLE
COOLING
FORUM

UNIDO’s approach

Technology Innovation, Development and Deployment

Modular chiller HC and water/glycol R-744 condensed centralized refrigeration system for HCFC-22 replacement

UNIDO implemented project under Brazil's HPMP – Stage II, from 2018 to 2020.

Project supported conversion to non-HCFC solution in two relevant national (A-5) refrigeration systems manufacturing companies from the supermarket sector.

Each company earned a set of safety measures for flammable refrigerant handling (included, exhaust system, leak monitoring, charging station, leak detector etc.), technical assistance for product development.

Each company developed their own solution medium-temperature indirect system based of R-290 and subcritical R-744 for low-temperature applications.

1. Water-cooled solution to be installed inside a machine room – more expensive;
2. Air cooled solutions to be installed outdoors;

Technology development and timeline

UNIDO's technical assistance to the sector was essential to support the adoption of the technology and:

- Stakeholders and refrigeration components manufacturing engagement through workshops and technical bulletins.
- Technicians training centers created under HPMP Stage 2 (GIZ).

Low flammable refrigerant charge for a sector easier adoption, up to 1,2 kg for the Level I and no more than 3 kg (per circuit) for the Level III of the technology.

Concurrency between companies was an excellent motivator for engagement another manufacturing companies.

It is estimated that at least 3 more manufacturers has been proposed similar solutions.

Trust in the national technology too!

Level I

Water-cooled modular chiller (MT)

Parallel compression subcritical rack (LT)

Level II

Air-cooled modular chiller (MT)

Parallel compression subcritical rack (LT)

Level III

Water-cooled modular chiller (MT)

Air-cooled Direct module cascade R-290/R-744 (LT)

HPMP Project

2018 – nowadays

Refrigeration commercial sector technology deployment - Technical assistance continues ....

Demonstration projects for the supermarket sector under Brazil’s HPMP 3

- Eight (8) HCFC-22 centralized refrigeration system to be replaced and environmentally sound disposal and recovery.
- Systems performance parameter monitoring and data collection for technical materials preparation and awareness.
- Different regions of the country to be assessed, different ambient conditions evaluation!

The supermarket sector is gradually accepting the indirect system/R-744 subcritical layout!

It is expected that more than 50 projects using this layout has been installed!

Other factors has been engaged the transition:

- Low leakage probability (more safety and less maintenance).
- Low refrigerant charge: before the project more than 700 kg, after less than 40 kg.
- Modular capacity, robustness of the cooling solution.

Innovation continues:
Low-charge ammonia (NH_3) and low-GWP high temperature heat pump for IR sector

Now UNIDO is proposing a similar approach as for the supermarket sector but now focusing on the Industrial Refrigeration sector to HFC phase-down.

The proposal aimed to **support development of the technology in national (A-5)** industrial refrigeration systems manufacturing company. In this case the company will receive a set of safety measures for flammable and toxic refrigerant handling, technical assistance from UNIDO and support from a national/international consultancy for product development.

The main outcomes of the projects will be:

An indirect solution for industrial modular cooling applications:

- Air-cooled or water-to-water modular solution based on low-charge ammonia chillers (< 150 g per kW).

A high-temperature heat pump for waste heat recovery from industrial processes:

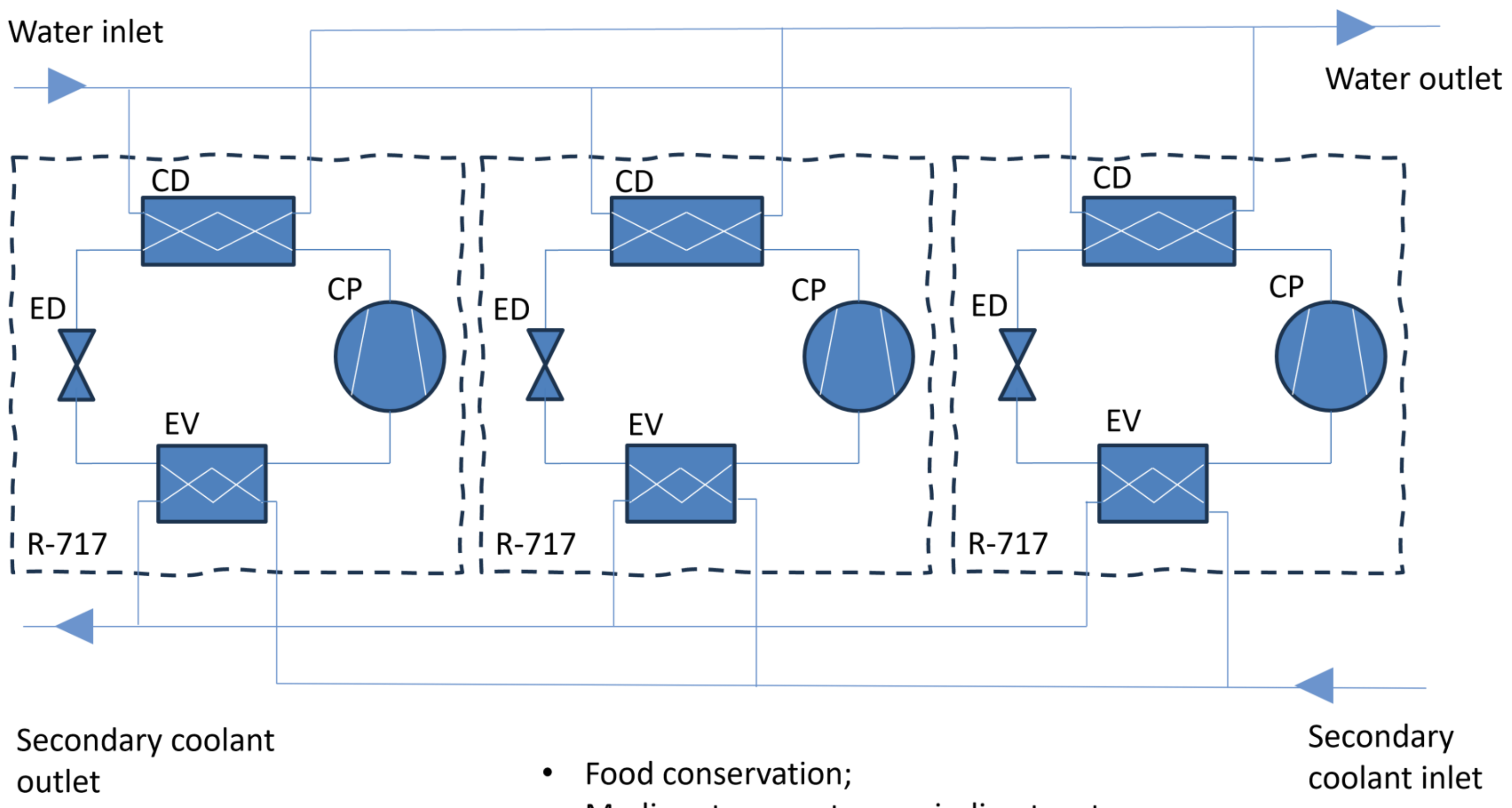
- Low-GWP water-to-water high-temperature heat pump for waste heat recovery (hot water generation).

The proposal includes technical assistance for the IR sector (workshops on low-charge ammonia and high-temperature heat pumps for waste heat recovery), feasibility studies, technical material for the proposed applications and two (2) end-user projects for technology demonstration.

Application example and conclusions

Application example

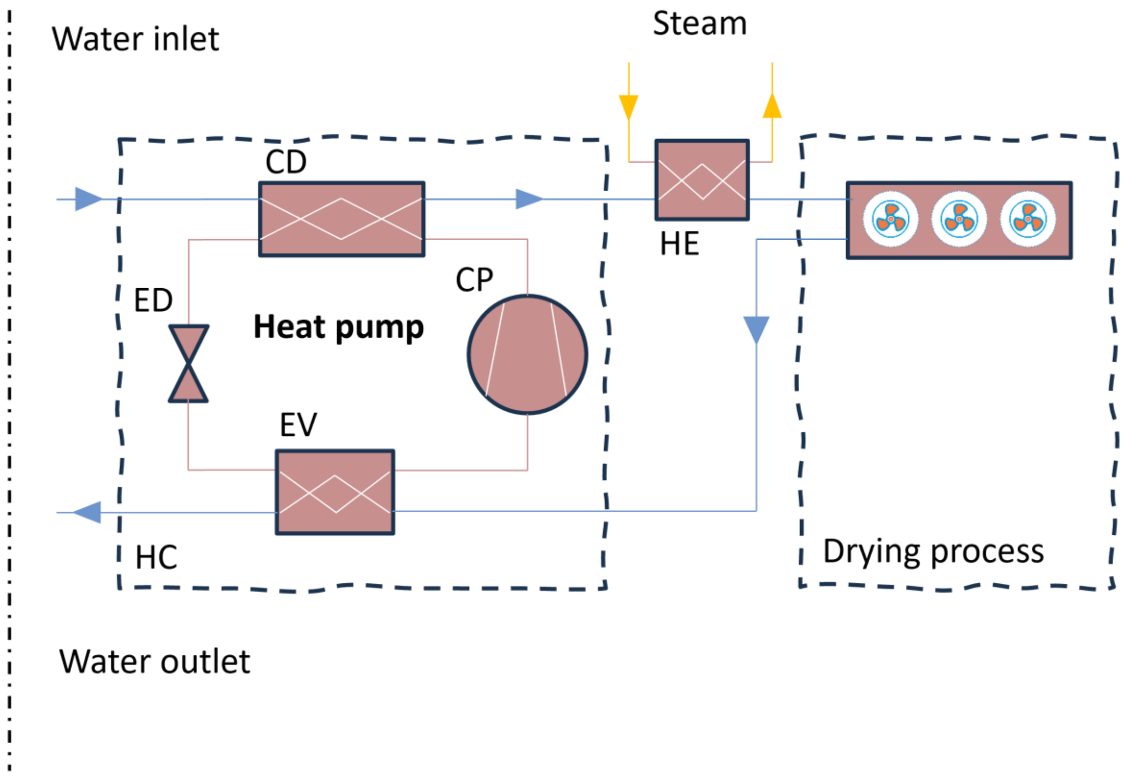
Modular NH_3 Industrial refrigeration system



Cooling demands

- Food conservation;
- Medium temperature as indirect system;
- High-tempearature cycle in cascade systems;
- Quick-freezing.
- Thermal control in industrial processes.

Waste heat recovery by using a high temperature heat pump



Independent heating demand

- Pasteurization;
- Distilation;
- Humidity control;
- Drying processes.
- Hot water production for CIP

- Safe transition for low-GWP refrigerants (focusing on ammonia, carbon dioxide and hydrocarbons), industrial system replacement, demonstration of the technology devolved by a national company.
- Energy consumption reduction, for cooling and heating applications, waste heat recovery from industrial processes concept introduction for decarbonization of the sector.

SUSTAINABLE
COOLING FORUM

Thank you

David Marcucci
National Specialist (ISA Consultant)
UNIDO Brazil
d.MARCUCCIPICO@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Questions and Answers

SESSION 2: Technology innovation, development and deployment

Mr. Yunrui Zhou
Montreal Protocol Unit
UNIDO

Ms. Xiaoyan Li
Ministry of Ecology and Environment
China

Mr. Carloandrea Malvicino
Stellantis
Italy

Mr. Samuel Jacobs
Energy Partners
South Africa

Mr. David Marcucci
Country Office for Brazil
UNIDO

Coffee break

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Session 3

Alternative cooling technologies

SESSION 3: Alternative cooling technologies

Ms. Liazzat Rabbiosi
Montreal Protocol Unit
UNIDO

Ms. Anna Pacak
International Institute of Refrigeration

Ms. Selin Gören
Carbon Containment Lab

Mr. Amir Nakhla
Country office for Egypt
UNIDO

Mr. Timur Sirman
Magnotherm

Mr. Ayman Eltalouny
Multilateral Fund

Mr. Peter Warren
A2D Facility
UNIDO

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING FORUM

Speakers' biographies

Agenda

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

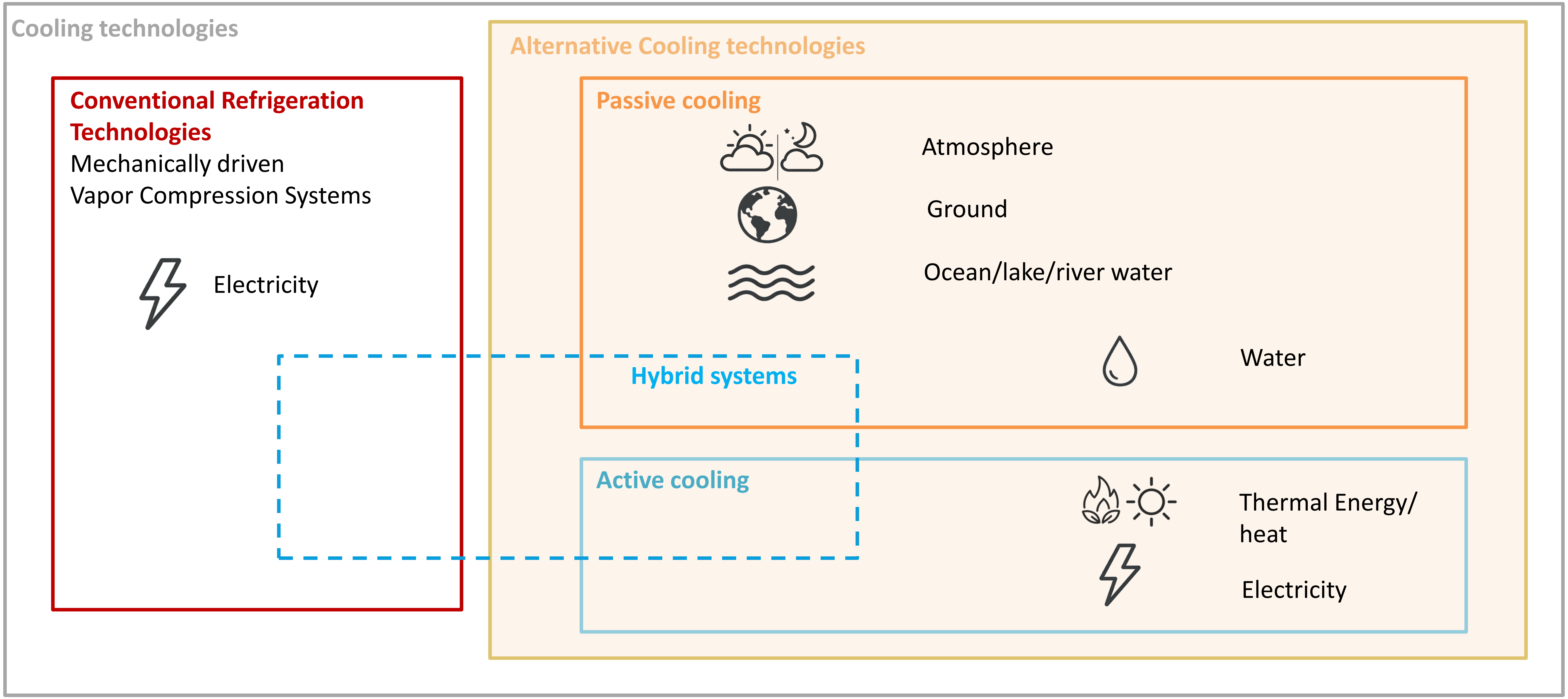
Alternative Cooling Technologies

Technology & Market Landscape

Carbon Containment Lab

IIF IIR
INSTITUT INTERNATIONAL DU FROID
INTERNATIONAL INSTITUTE OF REFRIGERATION

Alternative Cooling Technologies (ACTs) vs Conventional, sink and source of energy



ACTs Taxonomy

No performance control
Improving thermal comfort

AVOIDING COOLING
Shading
Good user habits
Insulation

PASSIVE COOLING
Natural ventilation (and night cooling)
Phase change materials (PCM)
Radiative cooling (RC)
…

PASSIVE COOLING
Ground
Water cooling
Evaporative cooling
…
auxiliary energy

+

Performance control

ACTIVE COOLING
Thermoacoustic systems
Absorption systems
Adsorption systems
…
HEAT SUPPLY

ACTIVE COOLING
Thermoelectric
Thermionic
Electrocaloric (EC)
Magnetocaloric (MC)
Barocaloric
Elastocaloric (eC)
ELECTRICITY SUPPLY

=

HYBRID COOLING
Solid desiccant systems
Liquid desiccant systems
Ground-coupled solid desiccant system
Evaporative liquid desiccant system
HEAT SUPPLY

HYBRID COOLING
plenty of configurations with passive cooling, heat pumps and conventional refrigeration technologies
…
ELECTRICITY SUPPLY

How to compare technologies – Performance indicators

No performance control
Only improving thermal comfort

AVOIDING COOLING

Energy savings

PASSIVE COOLING

Energy savings

PASSIVE COOLING

Energy savings*
*sometimes
COP, EER, SEER
(in literature)

auxiliary energy

Performance control

ACTIVE COOLING

Thermal COP

HEAT SUPPLY

ACTIVE COOLING

Electrical COP, EER, SEER

ELECTRICITY SUPPLY

HYBRID COOLING

Thermal COP

HEAT SUPPLY

HYBRID COOLING

Electrical COP, EER, SEER

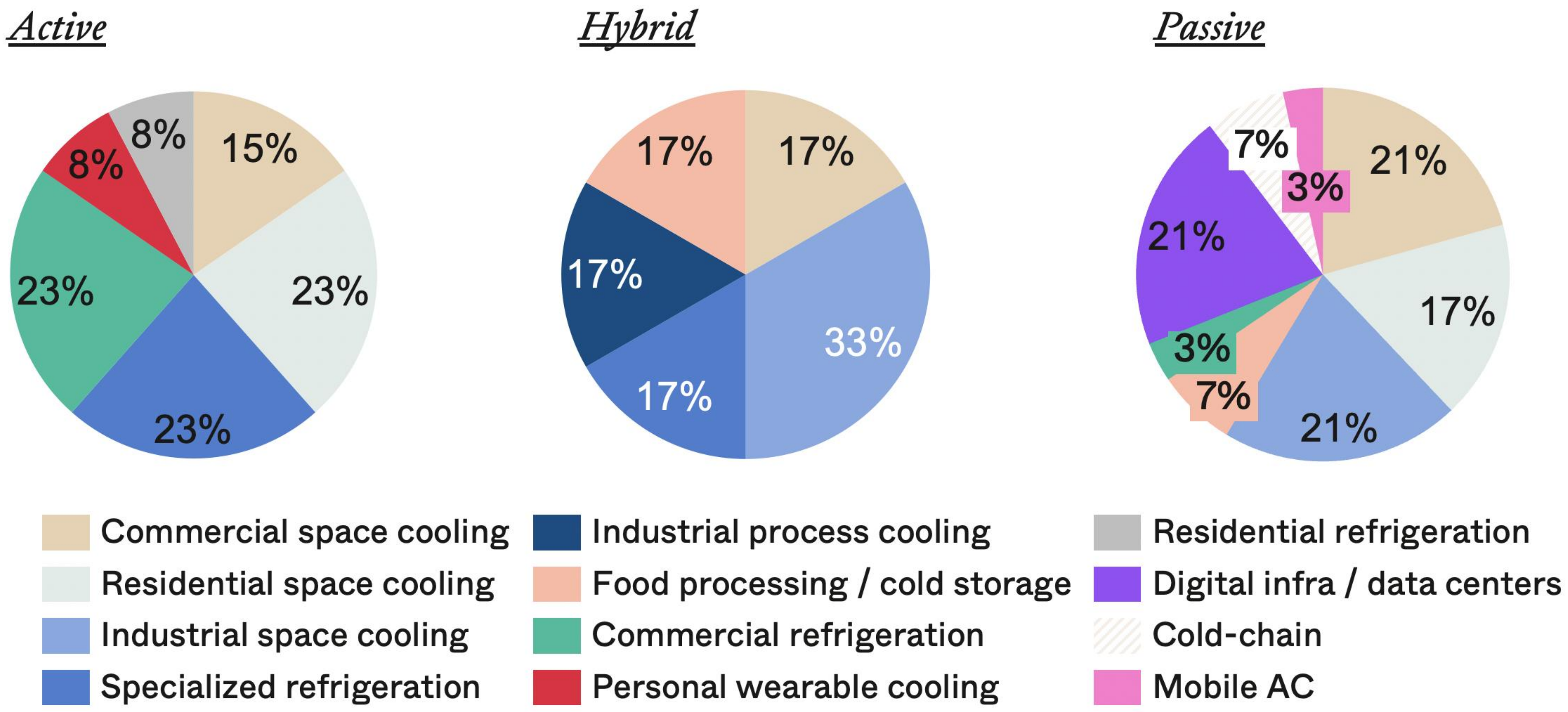
ELECTRICITY SUPPLY

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

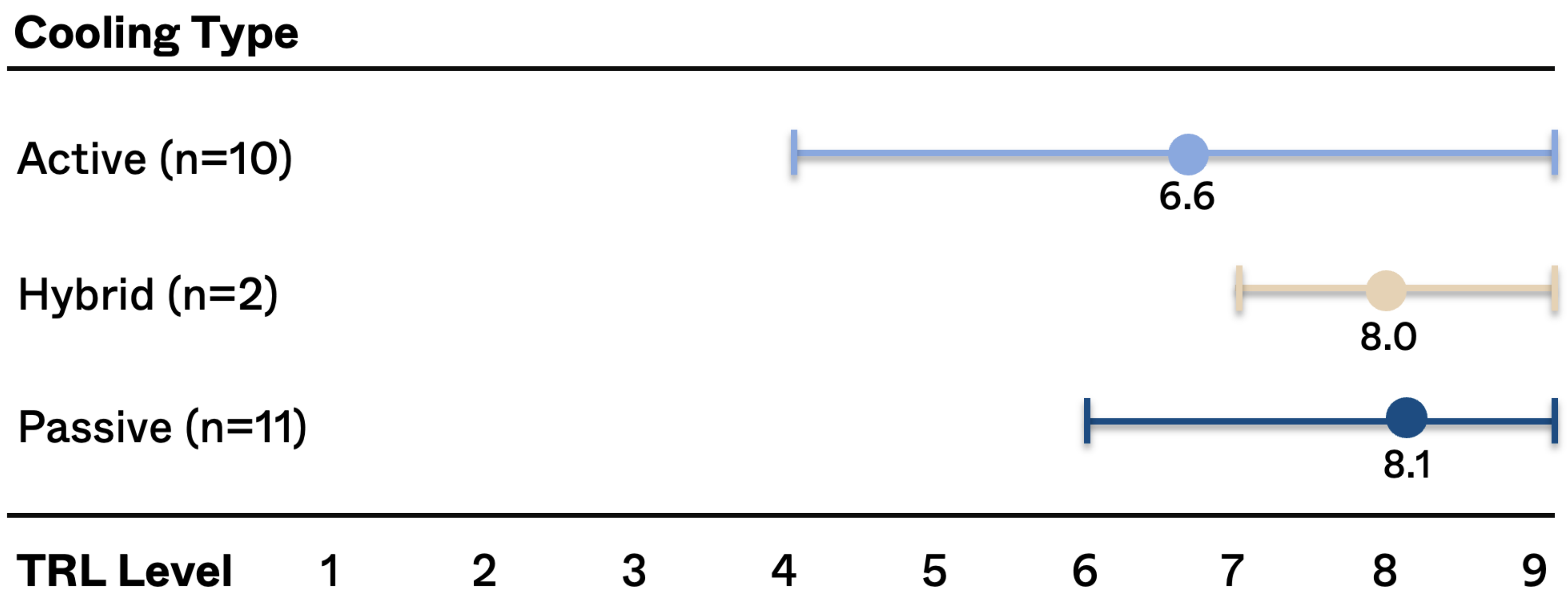
ACTs have diverse applications from residential to commercial to industrial.

Applications: Segmented by Active/Hybrid/Passive

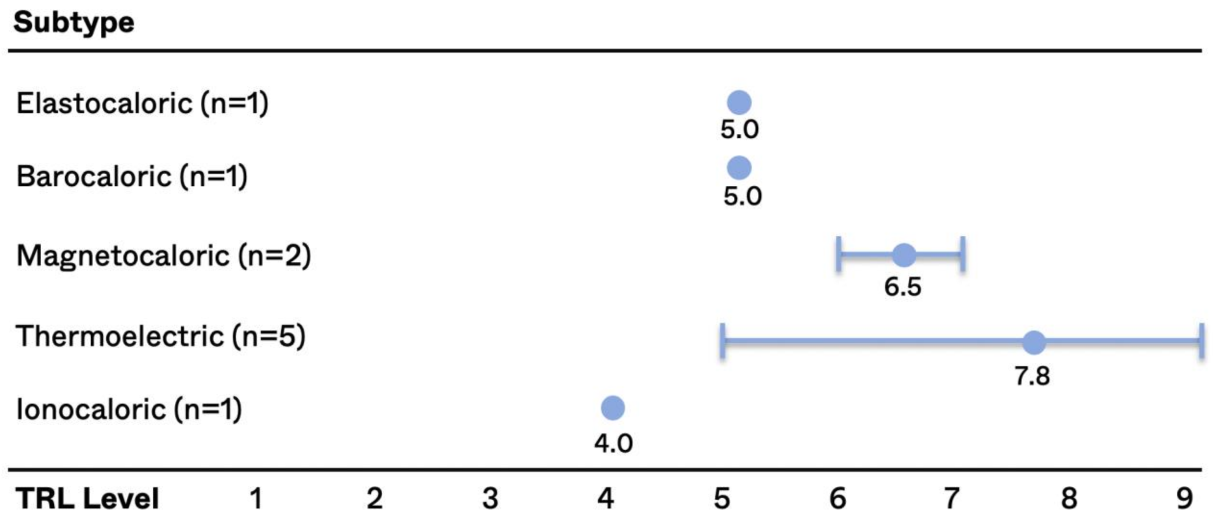


Passive leads on technology readiness | Active is most heterogeneous

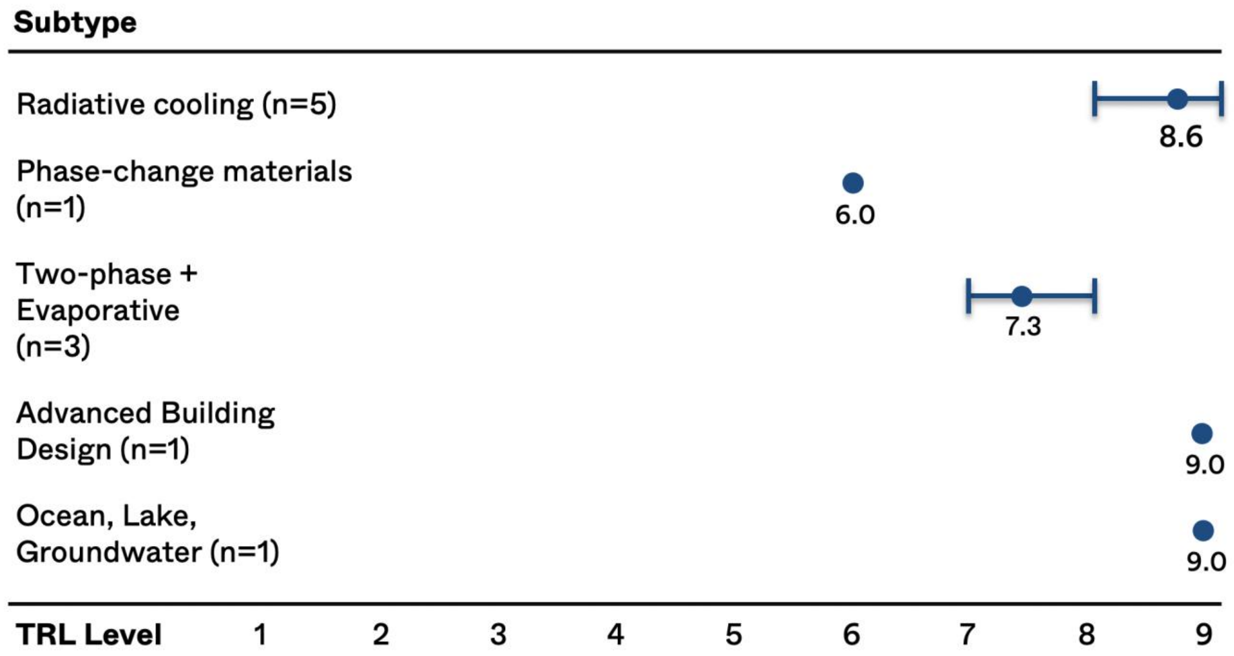
Technology Readiness Level (TRL): Overview by Active/Hybrid/Passive



TRL: Deep Dive into Active Cooling

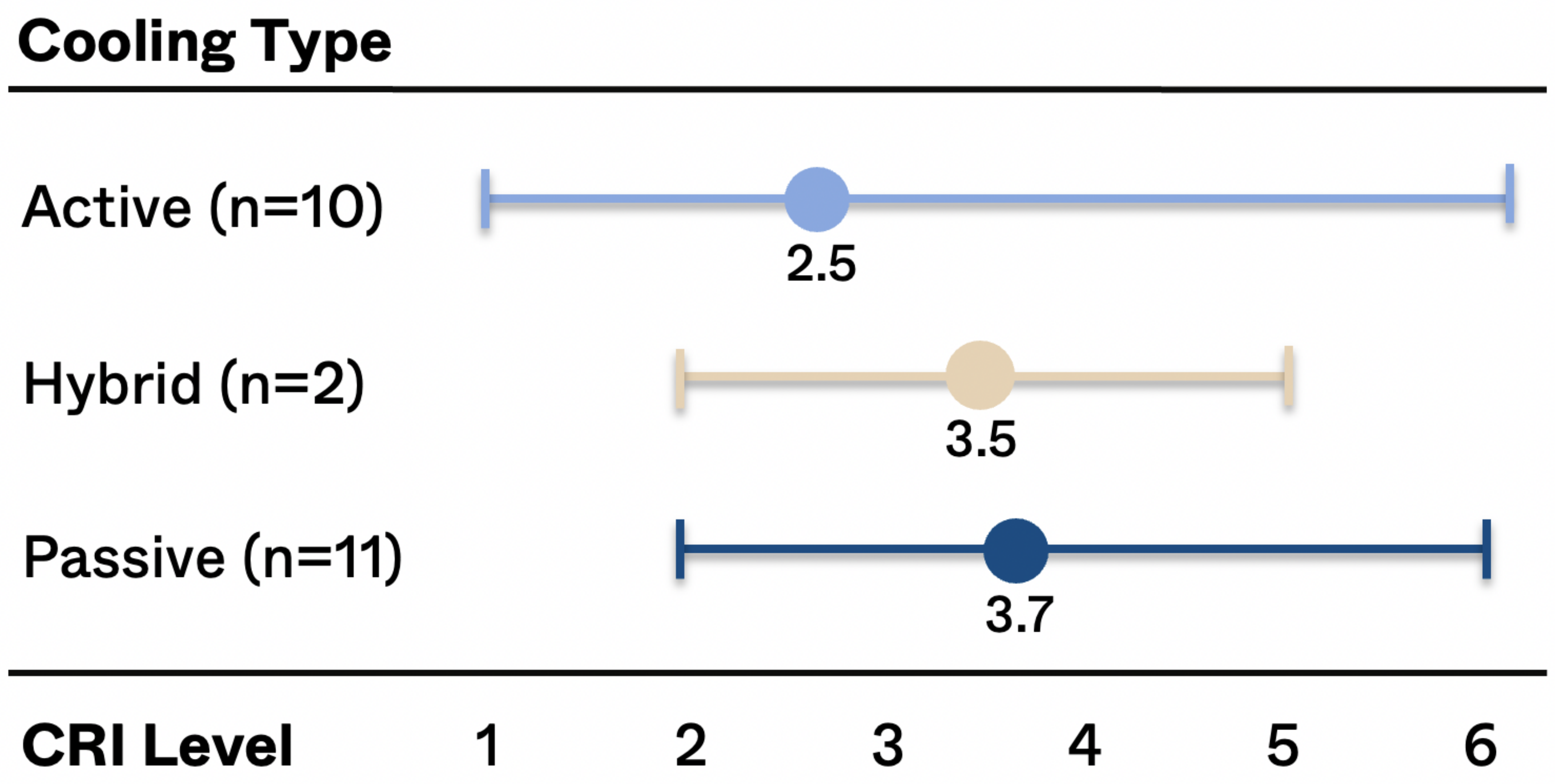


TRL: Deep Dive into Passive Cooling



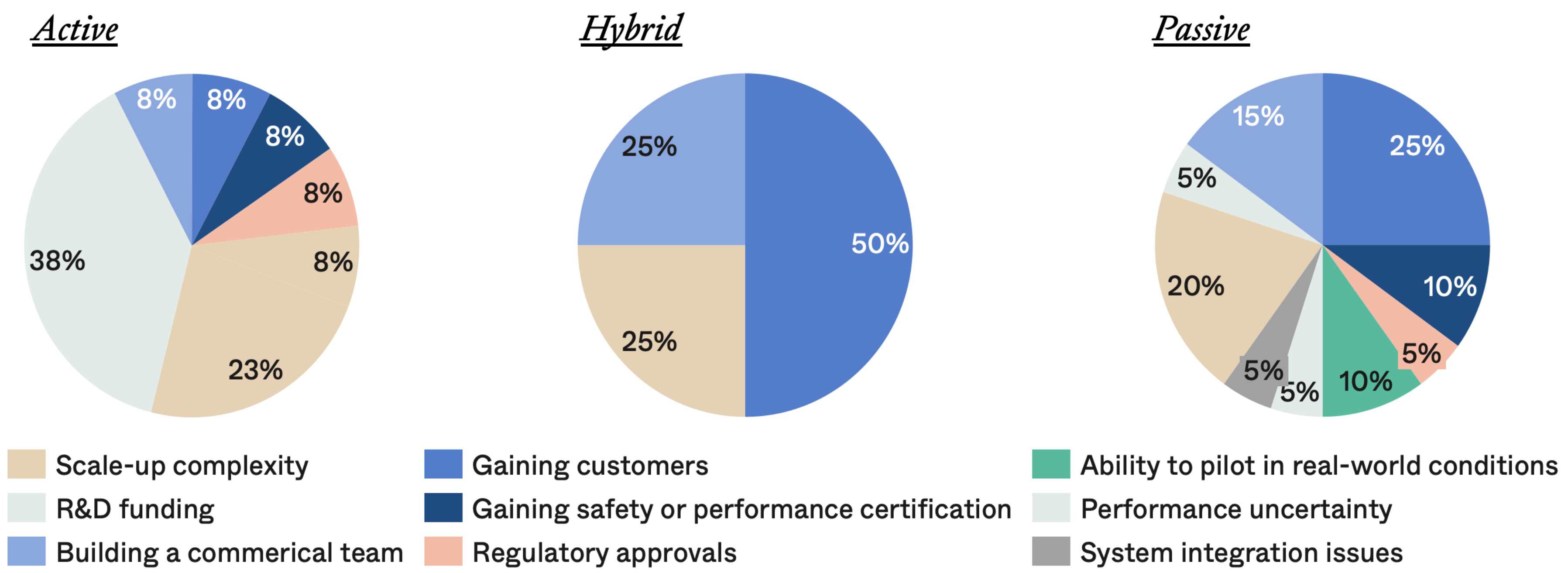
Many of the ACTs are technically mature but not yet bankable.

Commercial Readiness Index (CRI): Overview by Active/Hybrid/Passive

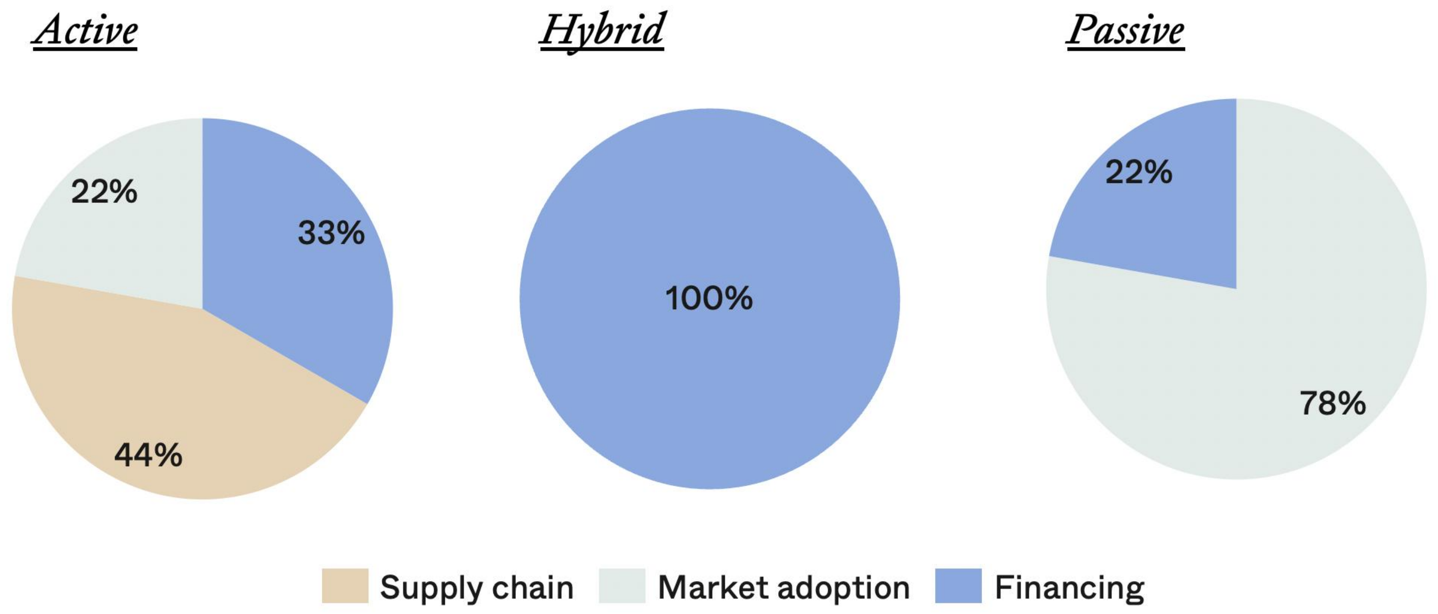


Scale-up, financing, and market adoption are slowing progress on ACTs.

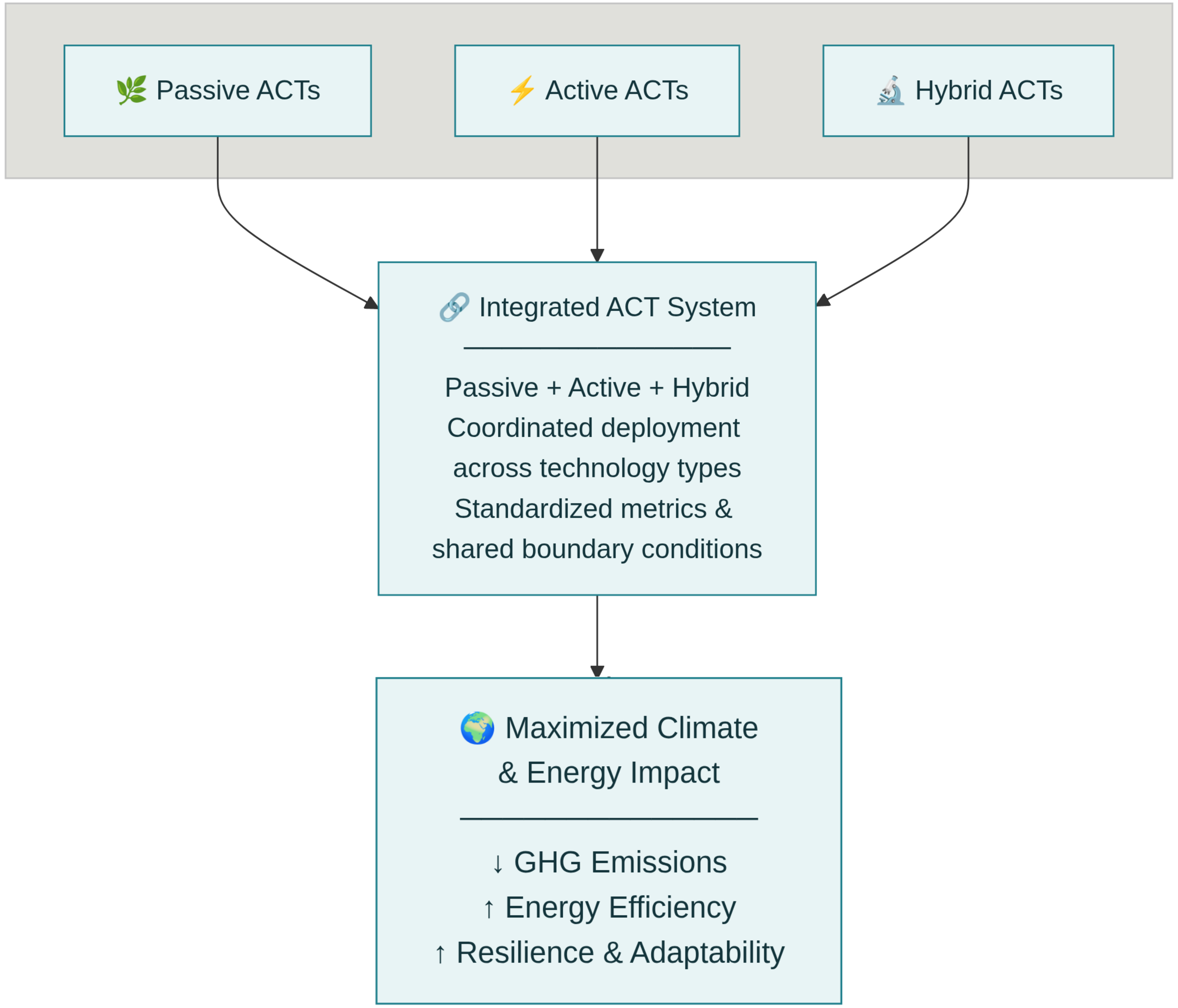
Barriers to next TRL: Segmented by Active/Hybrid/Passive



Barriers to next CRI: Segmented by Active/Hybrid/Passive



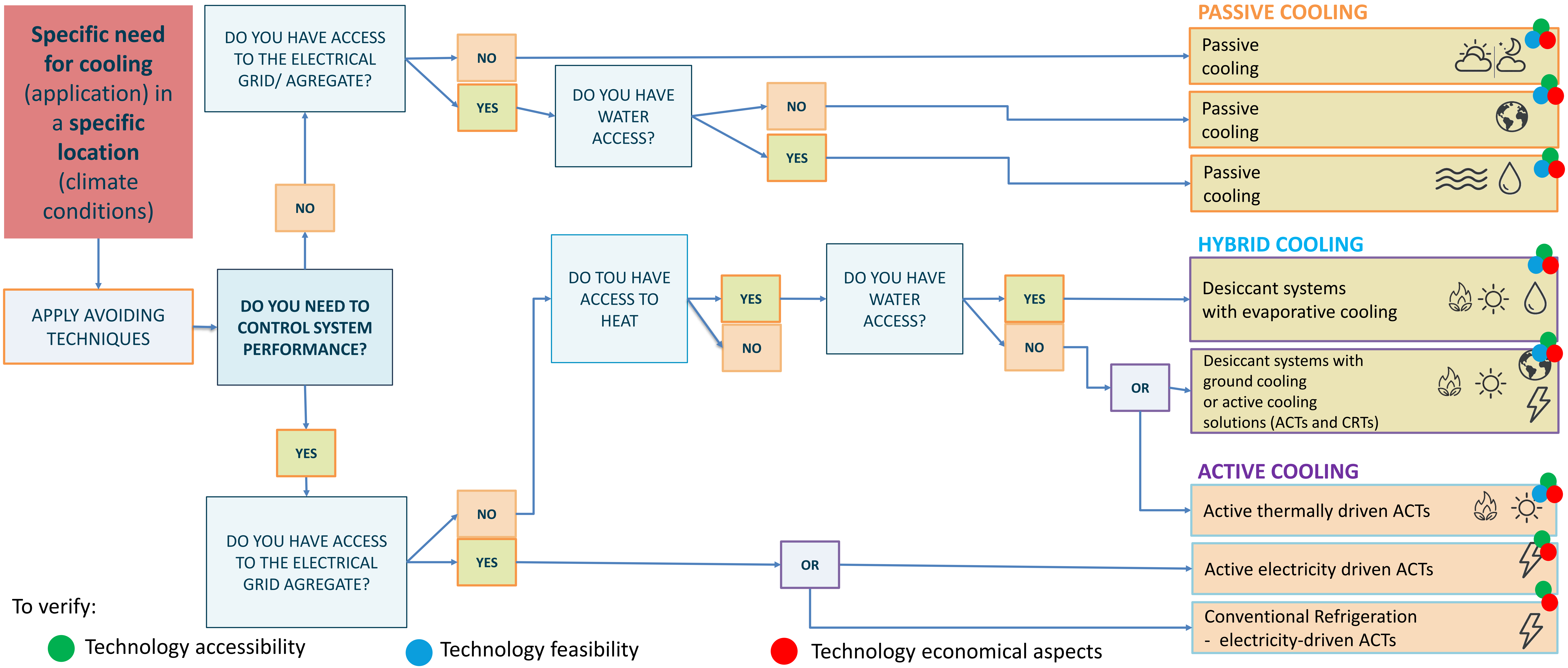
A systems approach can accelerate ACTs deployment and impact.



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Decision making while scaling in developing countries



Promising ACT solutions to watch:

- Q Gen Next Sustainable Technology, India *(video participation)*
- Magnotherm, Germany *(in-person)*
- Evaporative cooling project, Egypt

SUSTAINABLE
COOLING FORUM

Thank you

Anna Pacak
International Institute of Refrigeration
a.pacak@iifiir.org

Selin Goren
Carbon Containment Lab
selin.goren@cclab.org

Presentation

Mr. Timur Sirman

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Case Study: Hybrid Evaporative Cooling in Egypt

Alternative Cooling Technologies for Sustainable Refrigeration

Evaporative Cooling Concept

Evaporative cooling is based on a natural process:

- Water evaporates into the air
- Evaporation absorbs heat
- Air temperature decreases

This process converts sensible heat into latent heat, producing a cooling effect.

Main configurations:

- Direct evaporative cooling
- Indirect evaporative cooling
- Hybrid Indirect evaporative cooling (IEC-H)

Hybrid systems combine evaporative cooling with conventional cooling to enhance performance

Egypt Case Study & Project Overview

Egypt provides a strong context due to:

- High cooling demand and temperatures
- Climatic diversity
- Rapid urban expansion
- Strong engagement under MP

Within the HPMP framework, this project aimed to:

- Introduce a not-in-kind cooling approach
- Develop and test IEC-H systems
- Support local manufacturing capacity
- Evaluate technical and economic feasibility

Demonstration & Testing Approach

The project included:

- Development of IEC-H prototype units
- Testing across multiple climatic zones:

Cairo (CZ2) Hurghada (CZ5) Toshka/Aswan (CZ8)

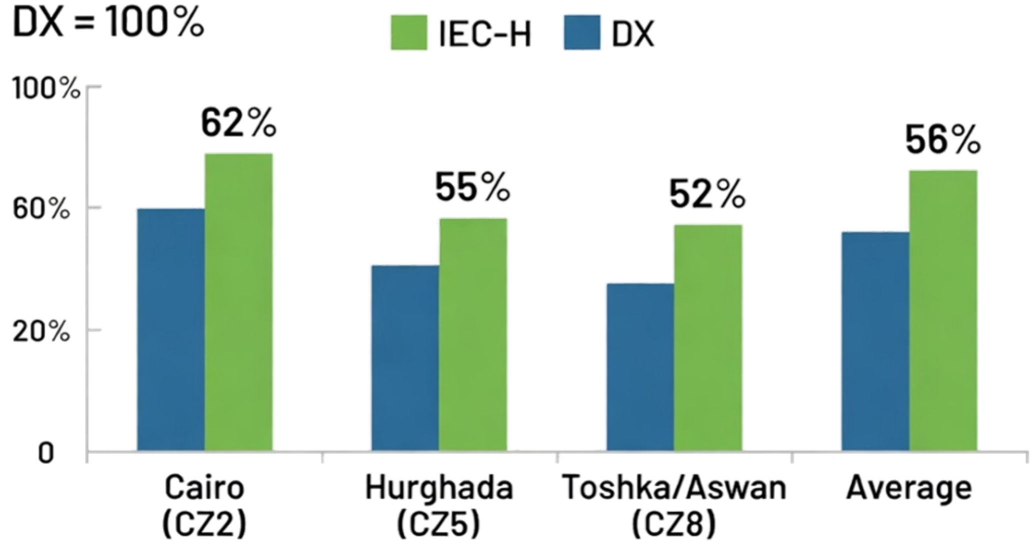
Testing approach

- 24-hour monitoring (temperature, humidity, energy use)
- Side-by-side comparison of IEC-H with DX systems

Evaluation focused on:

- Cooling capacity
- Energy consumption
- Operational performance

Energy Consumption: IEC-H vs Conventional DX Systems
(40-48% average savings in hot-dry conditions)



Assessment conducted under real operating validation beyond laboratory conditions

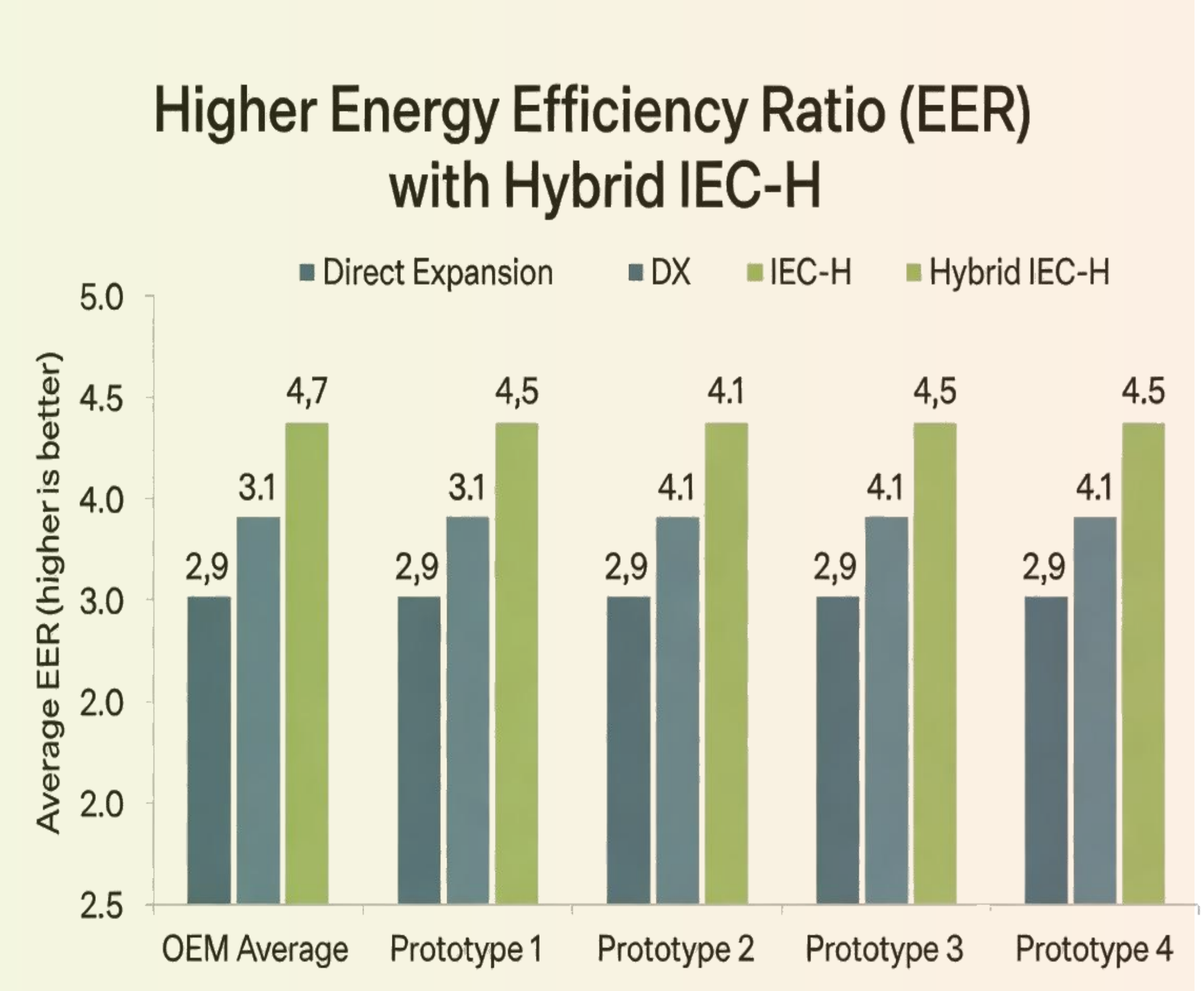
Key Results: Technical & Economic

Technical findings:

- Consistently lower energy consumption compared to DX systems
- Comparable or improved cooling capacity
- Stable and reliable performance observed across different climatic zones

Economic findings:

- Higher initial cost
- Lower operating costs
- Break-even period ≈ 3 years



Results confirm strong technical and economic potential for deployment in suitable conditions

Detailed results available in document UNEP/OzL.Pro/ExCom/96/32

Implementation Insights & Market Response

Implementation challenges:

- Prototype integration and system optimization
- Environmental conditions (dust, climate variability)
- Water use considerations

Key outcomes:

- Local manufacturers have started offering IEC-H units
- Demonstrated potential for technology transfer and market uptake

Lessons learned:

- No single solution fits all sectors
- Technology selection depends on technical, economic, and environmental factors

Innovation requires both policy support and practical demonstration efforts

Way Forward & Key Message

The project is ongoing, the next phase will focus on:

- Demonstration in the hospitality sector
- Expanded testing across additional climatic zones
- Development of guidelines and roadmap
- Exploration of complementary technologies (e.g. liquid desiccant systems and residential split application)

Hybrid evaporative cooling represents:

- A promising not-in-kind cooling pathway
- An opportunity for energy efficiency improvements
- A platform for innovation, technology diversification and market transformation
- Potential for replication in regions with similar operational conditions

This case study contributes to identifying sustainable cooling solutions aligned with the objectives of the Montreal Protocol

Support from MLF can accelerate scaling, capacity building and informed adoption

SUSTAINABLE COOLING FORUM

Thank you

Amir Nakhla
National Coordinator
a.nakhla@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Questions and Answers

SESSION 3: Alternative cooling technologies

Ms. Liazzat Rabbiosi
Montreal Protocol Unit
UNIDO

Ms. Anna Pacak
International Institute of Refrigeration

Ms. Selin Gören
Carbon Containment Lab

Mr. Amir Nakhla
Country office for Egypt
UNIDO

Mr. Timur Sirman
Magnotherm

Mr. Ayman Eltalouny
Multilateral Fund

Mr. Peter Warren
A2D Facility
UNIDO

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Partners: UK Government

A2D Accelerate to Demonstrate Facility

Accelerate-to-Demonstrate (A2D) Facility

Accelerating the Commercialization of Innovative Climate Solutions through Transformational Demonstration Projects

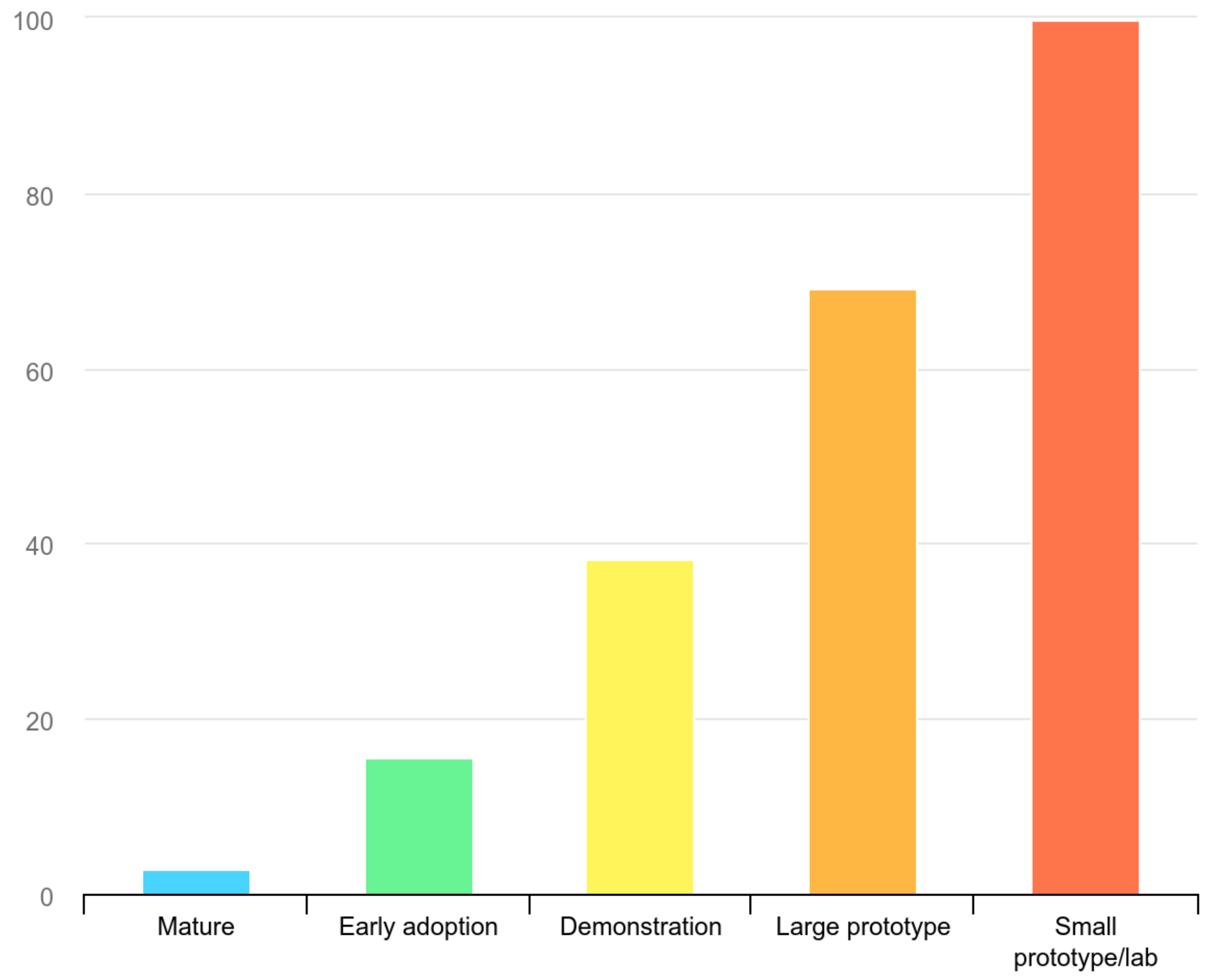
Importance of Climate Innovation and Demonstration Projects

- Accelerating the implementation and **commercialization of innovative climate technologies** is increasingly recognized as vital in global efforts to combat climate change and to meet the SDGs.

- The International Energy Agency (IEA) highlights that almost 35% of the emissions reductions necessary for achieving a global **net-zero scenario by 2050 will come from technologies that are still in the demonstration** or prototype phase.

- Alongside the important need for leveraging private sector finance, at least **USD 90 billion in public funding is needed globally by 2026** for clean energy demonstration projects to be commercially ready by 2030.

Relative increase in carbon dioxide emissions savings in 2050 by current technology maturity category:



Energy Technology Perspectives 2020. IEA, 2020.

UNIDO UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Partners: UK Government

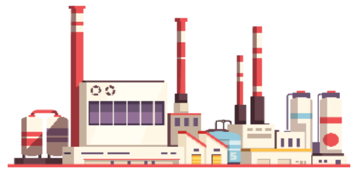
A2D Accelerate to Demonstrate Facility

A2D Facility Overview

Objectives

The A2D Facility aims to accelerate the commercialization of innovative climate solutions in developing countries by supporting catalytic and scalable 'lighthouse' demonstration projects in:

- Clean hydrogen
- Critical minerals
- Smart energy
- Industrial decarbonization



Initial Funding and Timescales

- **Initial contribution of ~USD 85 million** from the UK Government
- Initially operates from **April 2023 to March 2029**
- Global (**developing country-focused**) Facility
- **Grants of USD 1-5 million** per demonstration project for ~3-year projects
- **First cohort of demonstration projects** supported through first call-for-proposals in 2024 (in Kenya, Namibia, Nigeria, Nepal and Tanzania)
- **Second cohort of demonstration projects** supported through second call-for-proposals in 2025 (in Kenya, Namibia, Nigeria and South Africa).
- Main Sustainable Development Goals (**SDGs**)-of-focus:

Activities bringing **transformational solutions** to the market at scale.

Providing grant support for implementing transformational demonstration projects with strong scalability potential, and which create and **disseminate knowledge and experiences** to foster collaboration, learning and scalability. Planning-related activities for demonstration projects are out-of-scope.

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

A2D
Accelerate to Demonstrate Facility

A2D Facility-Supported Demonstration Projects (First Call-for-Proposals in 2024)

Smart Energy

Smart solar and storage microgrid for industrial-scale deployment at Laxmi Steel factory in Sunwal

Location: ***Nepal***

Peer-to-peer energy-sharing system to convert wasted renewables into community power

Location: ***Nigeria***

Industrial Decarbonization

Biomass gasification plant to power a Kenyan tea factory using local agricultural waste and biomass

Location: ***Kenya***

Clean Hydrogen

Ammonium sulphate fertilizer production facility powered by solar and clean hydrogen

Location: ***Namibia***

Critical Minerals

Local manufacturing of lithium-ion batteries for electric two-/three-wheeler motorcycles, and installation of charging infrastructure in urban and rural areas.

Location: ***Tanzania***

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

A2D Accelerate to Demonstrate Facility

A2D Facility-Supported Demonstration Projects (Second Call-for-Proposals in 2025)

Critical Minerals

Demonstration of Namibia's first green processing plant for critical minerals (Neodymium and Praseodymium) by using an innovative clean hydrogen furnace and off-grid solar power.

Location: ***Namibia***

Demonstration of a commercial-scale recycling facility and a network of 20 collection stations in Nigeria to recover critical minerals (Lithium, Cobalt, Nickel) from waste batteries.

Location: ***Nigeria***

Industrial Decarbonization

Demonstration of a zero-emission steam generation system for the food industry that replaces polluting coal boilers with a combination of solar thermal energy, heat pumps, and waste heat recovery.

Location: ***South Africa***

Clean Hydrogen

Production of Fertilizer and Medical Oxygen Supply from Renewable Hydrogen in Kenya

Location: ***Kenya***

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Partners: UK Government

A2D Accelerate to Demonstrate Facility

Further Information

- **A2D Facility Website:** Visit the website here
- **A2D Facility LinkedIn Account:** Follow the LinkedIn page here
- **A2D Facility Mailing List:** Join the mailing list here
- **A2D Facility Year 1 Annual Report:** Access the Annual Report here
- **A2D Facility Year 2 Annual Report:** Access the Annual Report here
- **A2D Facility Market Assessments:** Access the reports here
- **A2D Facility GESI Framework:** Access the GESI Framework here
- **A2D Facility ESMF:** Access the ESMF here

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Session 4

Financing sustainable cooling

Speakers' biographies

Agenda

SESSION 4: Financing sustainable cooling

Ms. Valeria Arroyave
Montreal Protocol Unit
UNIDO

Mr. Marco van Waveren Hogervorst
Climate Finance
UNIDO

Ms. Cristina Mariaca Orozco
Global Energy District Programme
UNIDO

Mr. Rusmic Musić
Global Cooling Programme
World Bank IFC

Mr. Kevin Basoa
Ministry of Environment
Chile

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

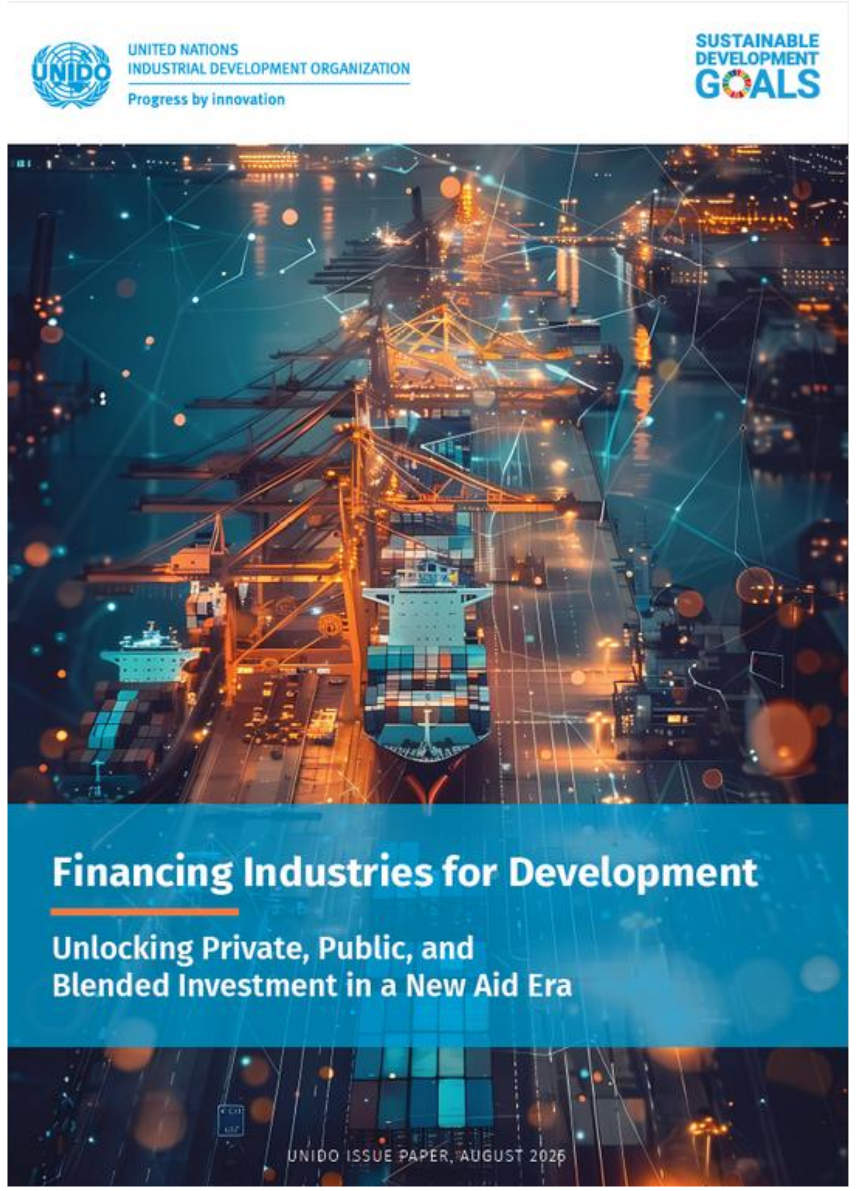
SUSTAINABLE
COOLING
FORUM

Financing Mechanisms for Scaling Up Sustainable Cooling

Investing in a Cooler Future for All

Financing Industries for Development - Key Messages

- **Industrial development is a means for transforming economies** and generating financial resources in a world that can increasingly less rely on Official Development Aid (ODA)
- Industrial development is increasingly **shifting from aid dependency toward mobilizing self-sustaining domestic and foreign finance**
- **ODA remains relevant**, but industrial development depends largely on domestically generated and raised capital
- Industry offers high returns but depends on **diversified financial systems**
- Financing tools **must respond to industrial transformation needs**



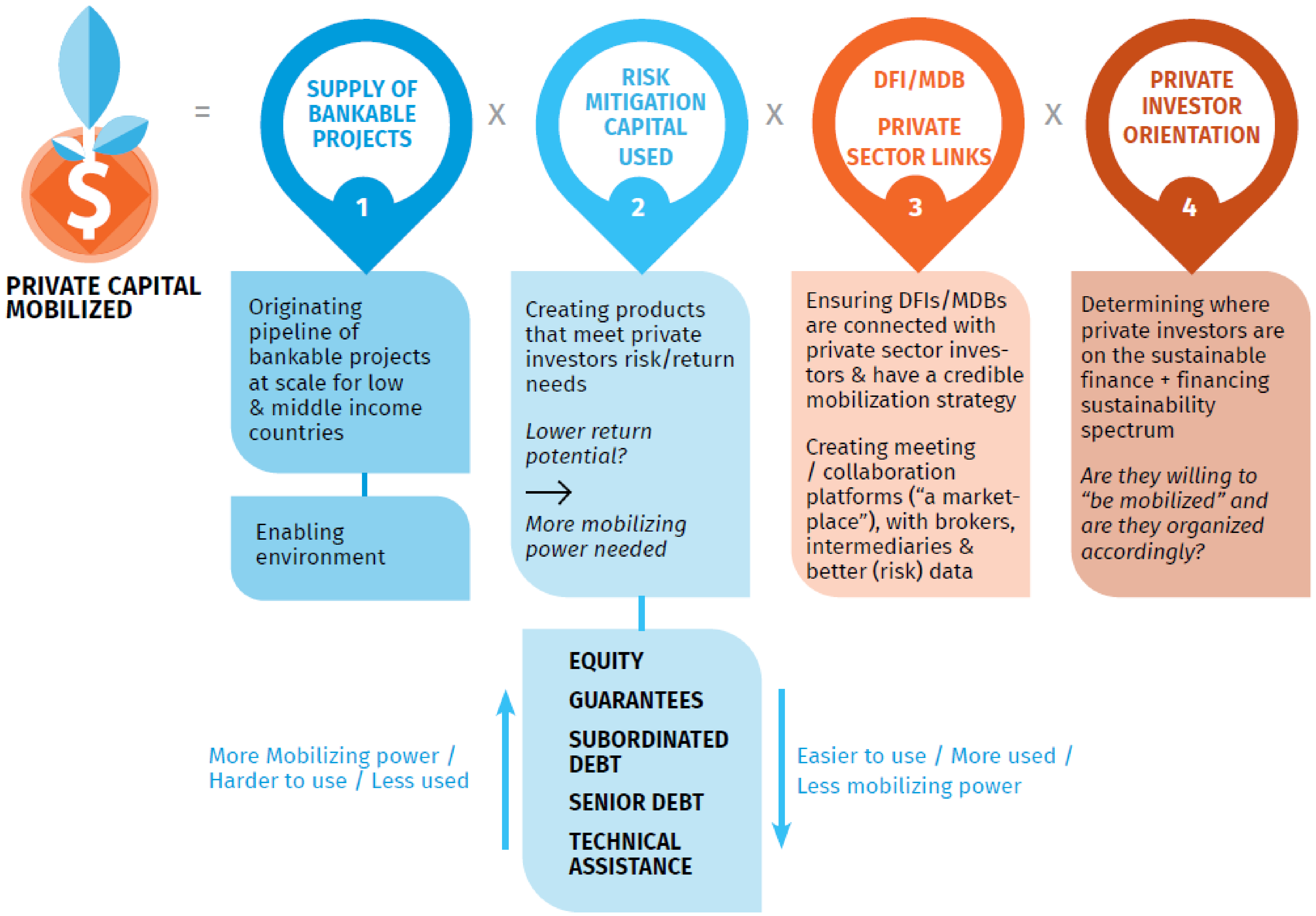
Building a New Era of Industrial Finance

A new era of industrial finance can be built— one that secures industrial development as a driver of inclusive, sustainable, and resilient growth

To advance this agenda, the following policy actions are critical:

- **Strengthen domestic investment**
- Deepen domestic financial markets
- Mobilize more FDI for industry
- **Scale up blended finance**
- Leverage remittances for industrial investment
- Improve investment data and monitoring
- Engage new investors
- **Strengthen the catalytic role of development agencies**
- Meaningful integration of marginalized and vulnerable groups

What enables private capital mobilization for impact?



UNIDO's role in climate and cooling finance

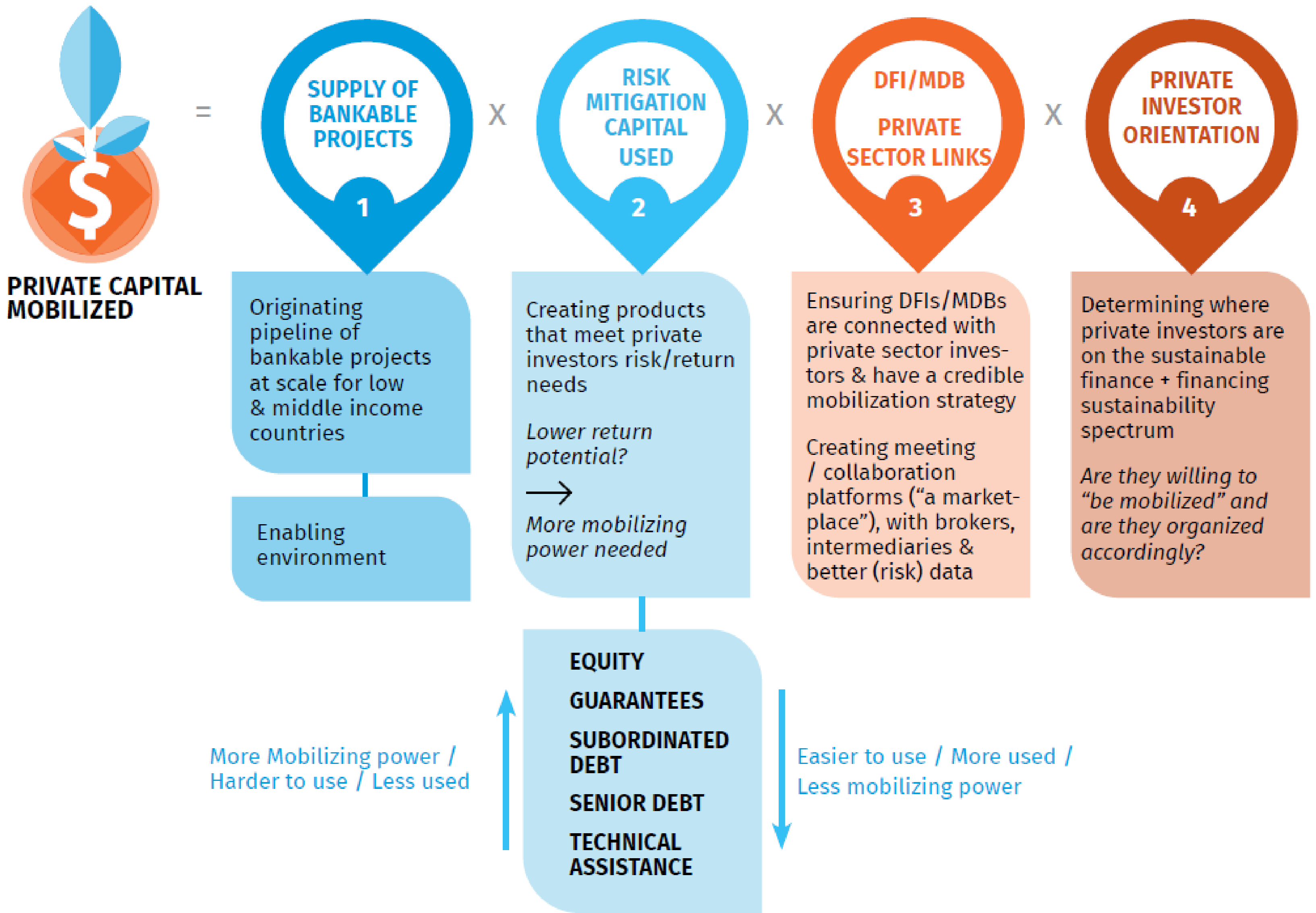
1. Project preparation and acceleration
   - Global Cleantech Innovation Programme
   - Private Financing Advisory Network (PFAN)
   - A2D facility

1. Strengthen policy frameworks

2. Co-design financial mechanisms
   - Loan Guarantee Fund
   - Renewable Energy Innovation Fund
   - Transformation Pathways Initiative

3. Connecting with DFIs/MDBs and private investc

4. Matchmaking
   - Global Matchmaking Platform
   - Invest in ACP Platform
   - ITPOs



Challenges and Recommendations – Investing in a Cooler Future for All

Challenges	Recommendations
Technology development time to reach proof-of concept	Focus on specific, locally appropriate technologies
Government policy	Continue engagement between cooling investors and project developers for knowledge exchange
Investor bias against small, localized solutions	Enable the PFAN Network to undertake advocacy for policy change
Lack of an engaged cooling investor community	Bundle and aggregate projects
Public awareness	Focus on private sector investors
Affordability	

Bankability – sample of innovative business models for cooling solutions

1 Cash sales

Customers pay the full price of the product upfront (e.g., FreshBox)

- Suited to aggregators as they can afford to pay the total cost of the products compared to SHFs whose monthly earnings are ~USD 180
- Off-grid cooling companies earn more revenue upfront to support scale but may lock out access to the first mile

EcoZen, Fresh Box, Promethean, Phocos, Steca, Sun Danzer

2 PAYGo

Customers pay an initial deposit of the product price and make regular instalment repayments (e.g., M-KOPA)

- Low-income customers can purchase off-grid cooling products they would not afford otherwise
- Limited use by off-grid cooling companies as M-KOPA is the only company providing this to traders

Koolboks, M-KOPA, PEG Africa, Sure Chill

3 Asset financing

Provision of small loans by off-grid cooling companies to customers for purchase of cold storage

- Adopted by companies such as Inspira Farms, who are providing loans of up to 80% of asset value at interest rates of 10 – 12%
- Companies are able to structure repayment around seasonality of the value chains they serve

Eja-Ice, Inspira Farms, Solar Now

4 Pay as you store

Customers are charged per day to store their produce in a section of a cooling unit (e.g., SokoFresh)

- Eliminates the burden of the upfront cost on low-income small holder farmers and small aggregators that may not afford to purchase these products
- Difficult for off-grid cooling companies to attain profitability

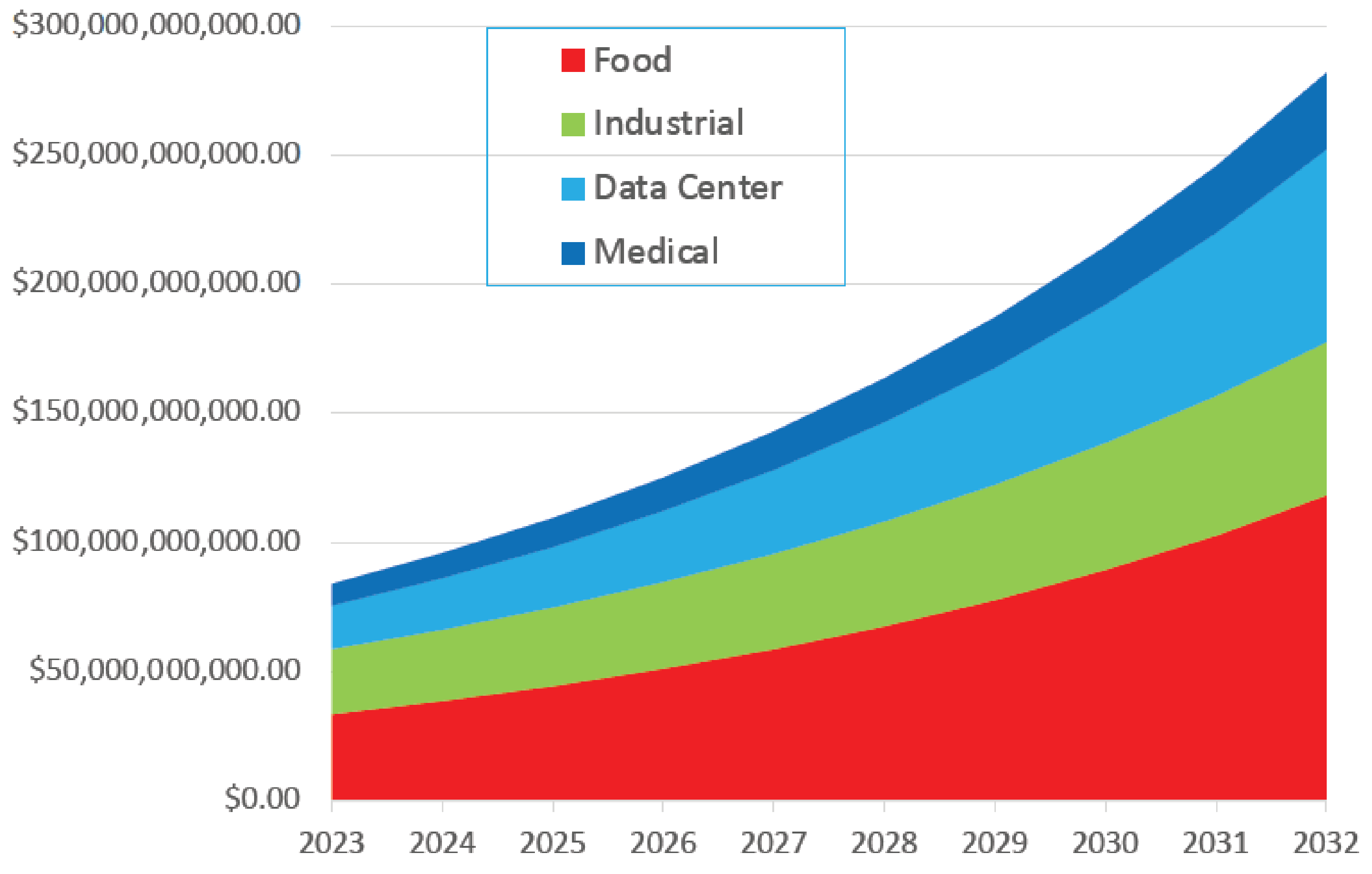
EcoZen, Cold Hubs, SokoFresh

ESCOs, Community Cooling Hubs are other emerging models in the cooling space

Source: Open Capital Advisors, East Africa / SELCO, India

Hot growth in cooling

- Food, Industrial, Data Centers & Medical are expected to grow from $84 billion to $282 billion over the next decade
- Compounded CAGR approaching 15%
- Digital transformation is accelerating



Source: Sustana

SUSTAINABLE COOLING FORUM

Thank you

Marko van Waveren Hogervorst
Climate Finance Expert
Division of Innovative Finance and IFIs
United Nations Industrial Development Organization
E-mail: m.vanwaverenhogervorst@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Progress by innovation

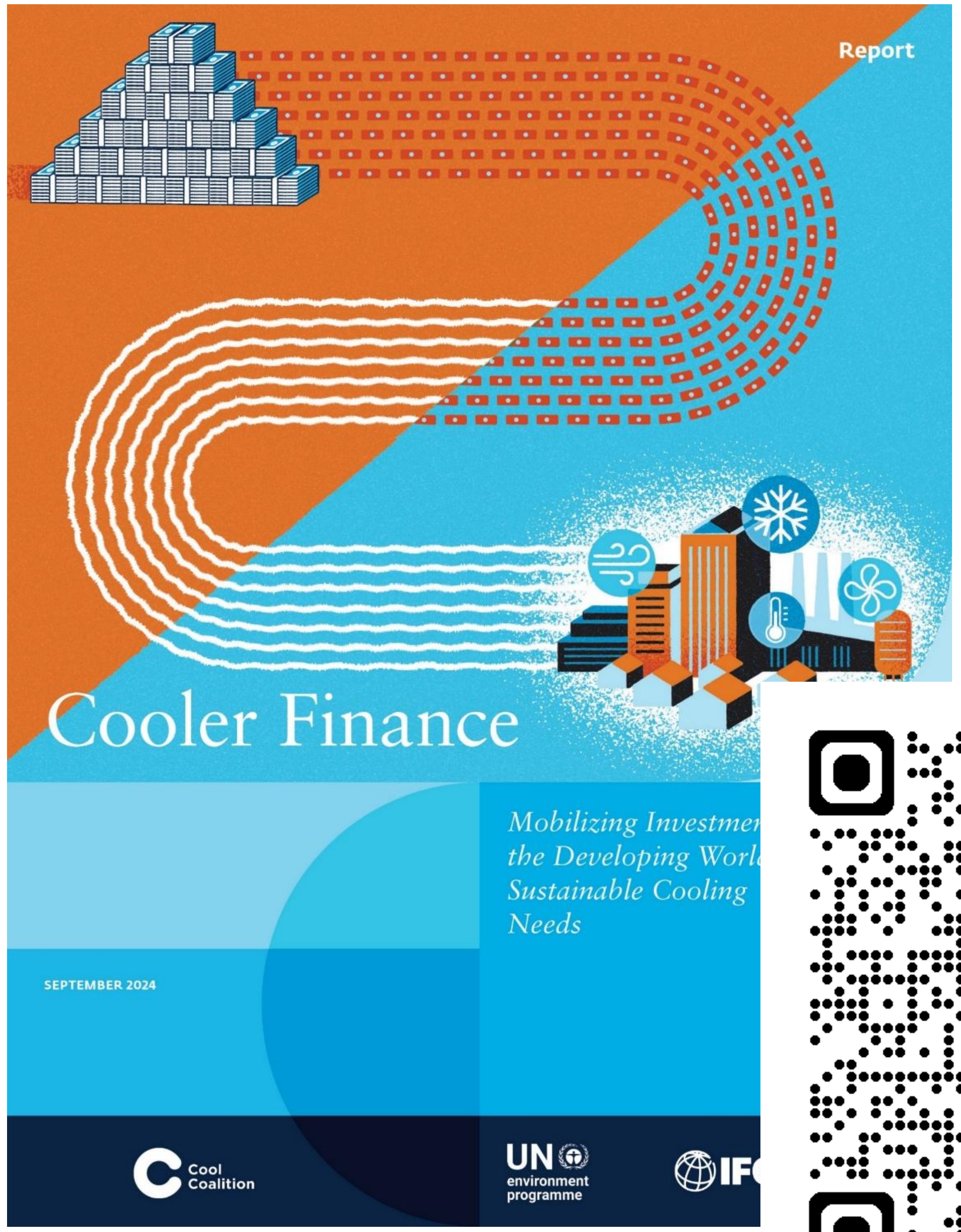
COOLING FORUM

Financing mechanisms for scaling up sustainable cooling

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

DOWNLOAD THE REPORT

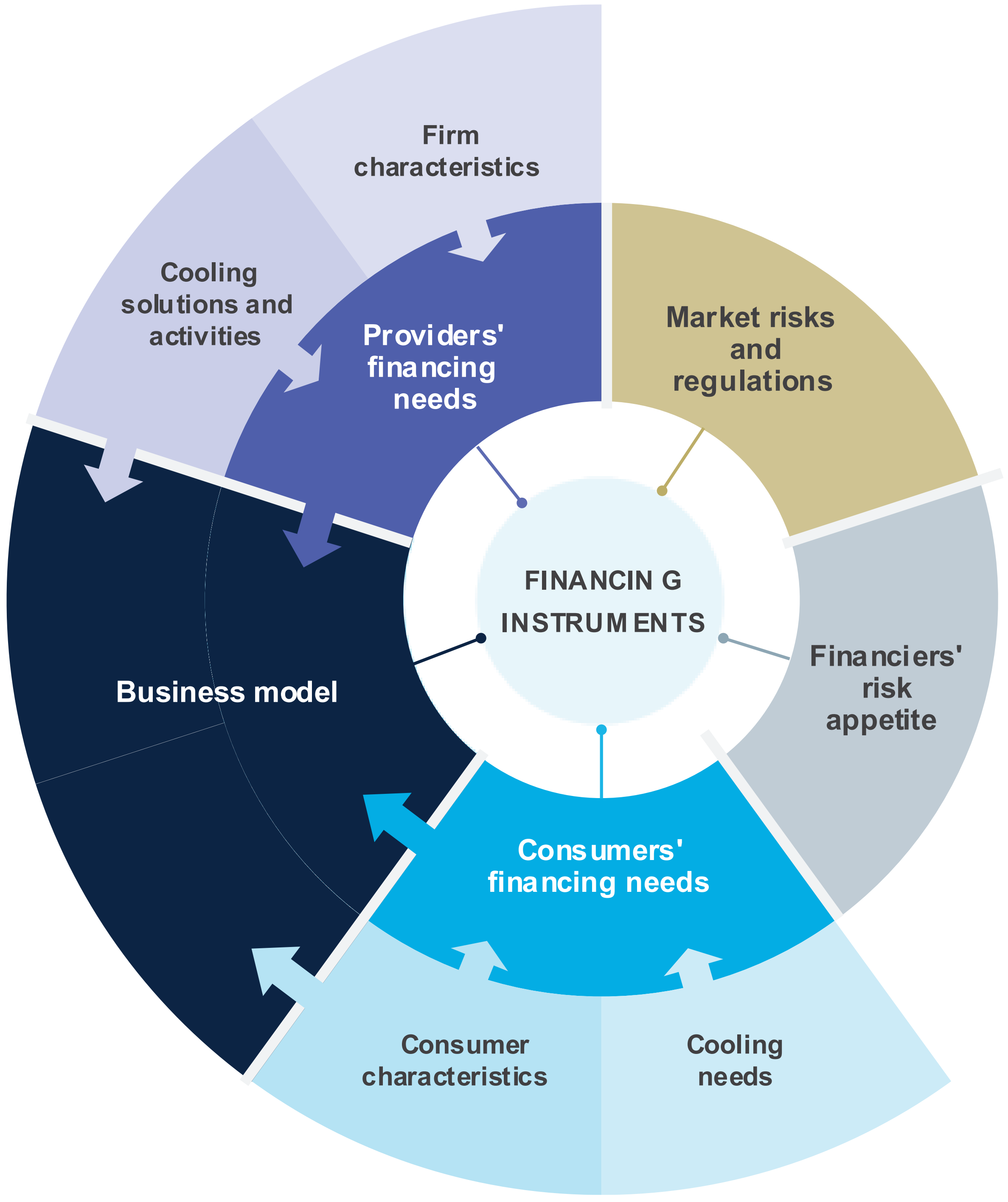


Main Obstacles to Finance:

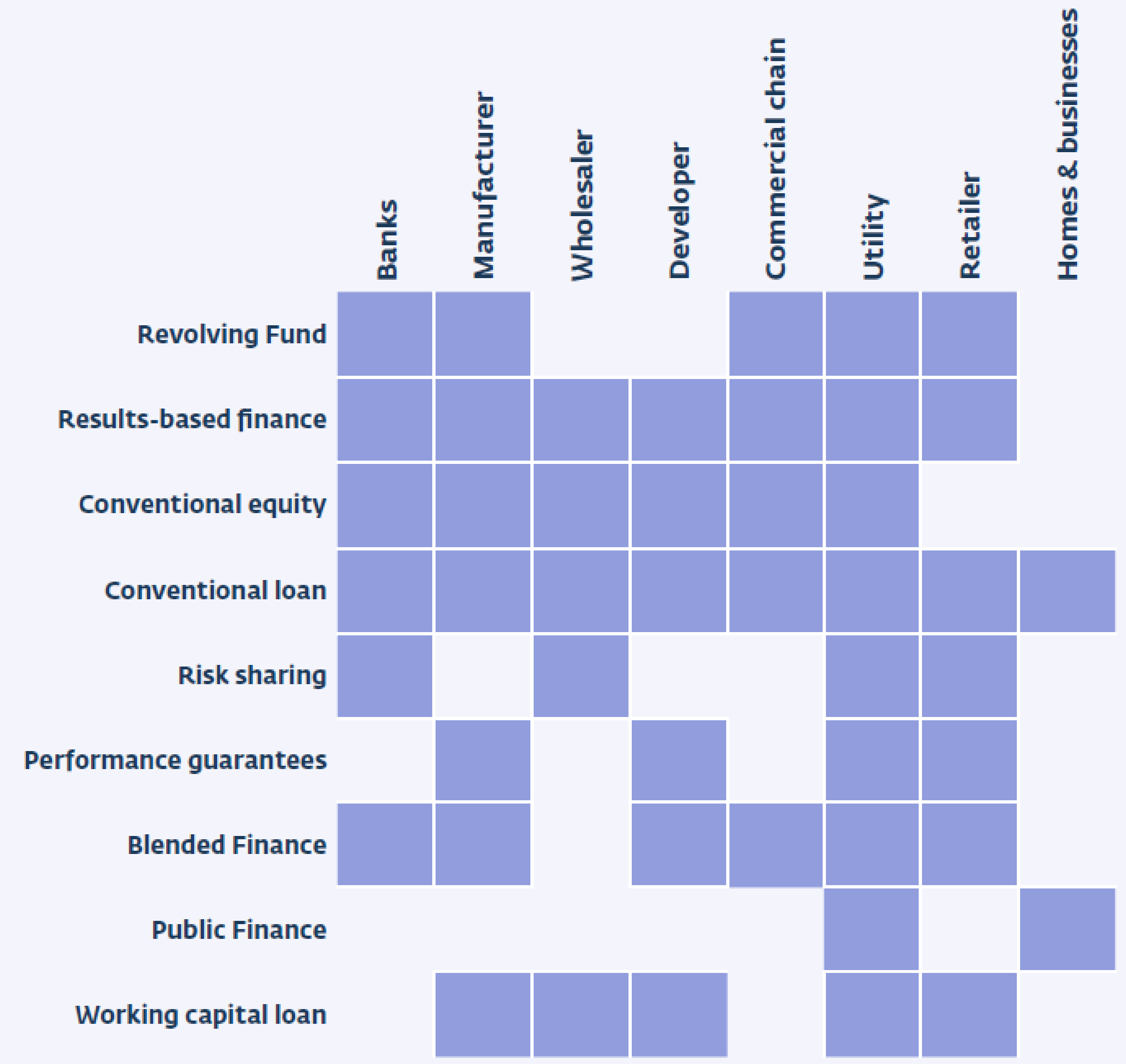
- Different category
- Different structure
- Own financing
- Part of broader agreements

- IFC and UNEP's flagship "Cooler Finance" report has looked at financial models

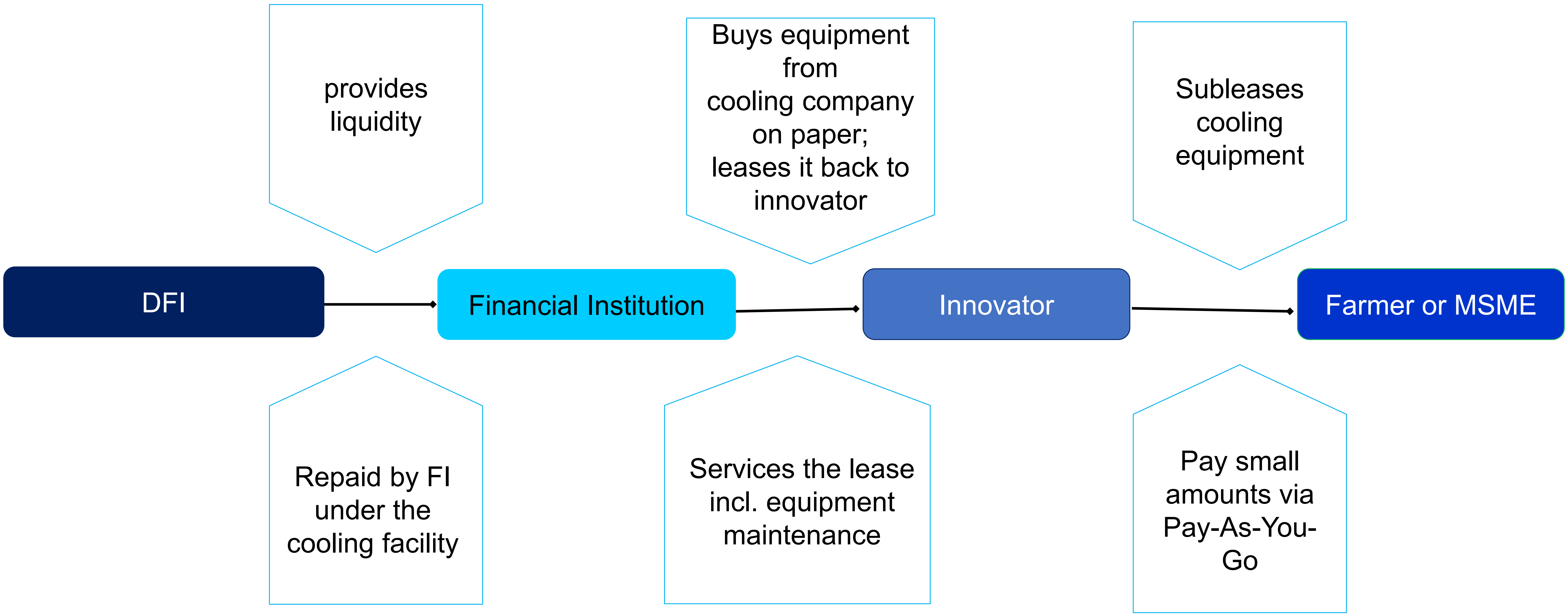
When it comes to cooling finance, "one size" does NOT fit all



Applicability of different financing instruments for different entities involved in cooling transactions or financing



Leasing models and pay-as-you-go can provide a way



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Global database of cooling innovators available as a public good

PLUSS

INNOVATOR

http://pluss.co.in/

Solutions

PCM technology in building HVAC
Phase change material (PCM) technology in Building HVAC is an innovative solution that stores cold energy during off peak hours and utilizes this energy to shave the peak cooling requirement. This ensures reduced operating cooling load on existing cooling systems. The product can also be as passive systems lined along the ceilings and walls to store free/excess cooling.

PronGO and thermoTab active – Cold Chain Delivery/Logistic Solutions
PronGO is an innovative passive cooling solution that uses Phase Change Material (PCM) technology to ensure precise temperature controlled transportation of temperature sensitive products in insulated boxes/containers ranging upto 48 hrs. or more.

thermoTab active is a PCM integrated active heat exchanger system that is used in reefer trucks and micro-cold room applications. This solution offers temperature control for upto 18 hours without need for fossil fuel based cooling systems.

PCM Integrated Hybrid Freezers and Coolers with Increased Energy Efficiency
Phase Change Material (PCM) based industrial Chest freezers and Chest coolers are energy efficient cooling devices that have an added advantage of longer temperature backup as compared to conventional devices.

PCMs are advanced materials that can store and release large amount of energy at a constant temperature without any external power source. This is achieved using the latent heat storage of these materials at a specific temperature.

Celsure Temperature Controlled Packaging for Pharmaceuticals and Diagnostics
Celsure is a range of packaging systems that maintains precise temperature for more than 120 hours. The packaging is based on a patented design using phase change material (PCM) technology and can meet varying temperature needs (frozen / chilled / ambient).

techemerge.org

Related **pilots**

ALL PILOTS

PILOT SUSTAINABLE COOLING
Artee / Pluss
Indian Innovator Pluss Advanced Technologies and Spar/Artee, a leading retail company in...
Innovator: PLUSS — Adopter: Spar

PILOT SUSTAINABLE COOLING
Kennie-O CCL, PLUSS and Integrated Motors...
In this project, Indian innovator Pluss is partnering with transport company Kennie-O...
Innovator: PLUSS — Adopter: KCCL

PILOT SUSTAINABLE COOLING
Amo Farm, PLUSS, and KSR Engineering
Two Nigerian companies, integrated poultry company Amo Farm and engineering company...
Innovator: PLUSS — Adopter: Amo Farm Sieberer Hatchery Limited

PILOT SUSTAINABLE COOLING
L&Z Integrated Farms, PLUSS, and Lange & Grant
Indian innovator PLUSS had developed an innovative solution that enhances polymer...
Innovator: PLUSS — Adopter: L&Z

PILOT SUSTAINABLE COOLING
Carrocerias el Sol & PLUSS
Solución innovadora de enfriamiento pasivo para oficinas y camiones refrigerados.
Innovator: PLUSS — Adopter: Carrocerias el Sol

PILOT SUSTAINABLE COOLING
Carrocerias el Sol & PLUSS
First responders the focus of climate-smart, cost-saving cooling innovation.
Innovator: PLUSS — Adopter: Carrocerias el Sol

PILOT SUSTAINABLE COOLING
Aliar & PLUSS
Colaboración sur-sur: innovación para la entrega segura de productos cárnicos...
Innovator: PLUSS — Adopter: Aliar

PILOT SUSTAINABLE COOLING
Aliar & PLUSS
South-South collaboration: smart, sustainable cooling innovations from farm to table.
Innovator: PLUSS — Adopter: Aliar

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

THANK YOU!

Rusmir Musić
WBG Global Cooling Lead
Washington DC

rmusic@ifc.org
LinkedIn profile

IFC's Sustainable Cooling Initiative is funded by the UK Government's Department for Energy Security & Net Zero

UK Government

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Financial Models for Energy District (ED) in Colombia

endistrict
GLOBAL ENERGY DISTRICTS PROGRAMME

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Departement of Economic Affairs,
Education and Research EAER
State Secretariat for Economic Affairs SECO

SESSION 4: Financing Mechanisms for Scaling Up Sustainable Cooling

Colombia's Energy District Roadmap

Strategic Vision

Transitioning from individual cooling to "Cooling as a Service" (CaaS).

Institutional Framework

Collaboration between MinAmbiente (UTO), MinEnergía, SECO (Switzerland), and UNIDO.

The Transformation

Phase 1 (Demonstration)

Phase 2 (Market Consolidation) and now GEDP (Global Scale).

The Focus

Showcasing two polar opposites:

A consolidated public-administrative center (Medellín) and a modern private urban development (Cartagena).

Fiscal Incentives and "Cooling as a Service" (CaaS) in Colombia

- **Framework:** Law 1715 (Tax exemptions: VAT exclusion, income tax deduction).
- **Revenue Streams:** Transitioning from selling equipment to selling thermal energy services.
- **Long-term Contracts:** Stability through service-level agreements (SLAs).

Blended Finance & Investment Framework

Capital Intensity: Energy District requires high upfront CAPEX for central plants and distribution networks.

The Blended Model: Strategic integration of:

International Cooperation (Grants/TA): De-risking early stages and feasibility studies.

Public Investment: Local government participation through urban planning (POT).+2

Private Equity: Long-term investment from utilities and specialized developers.

Cost Structure: Investment is split into development costs (permits/land), direct costs (plant/networks), and indirect costs (engineering/management).

SESSION 4: Financing Mechanisms for Scaling Up Sustainable Cooling

Case Study 1 - La Alpujarra (Medellín)

Profile: The first modern district cooling system in Latin America (since 2016)

Operator: EPM (Empresas Públicas de Medellín).Capacity: 3,600 TR (Tons of Refrigeration).

Reach: It supplies cooling to the Government of Antioquia, the Mayor's Office of Medellín, DIAN, and other government buildings.

Financial Highlight: Developed as a Public-Private partnership model where the utility (EPM) invests in infrastructure to sell energy services under long-term contracts.

Environmental Performance:100% elimination of ODS (Ozone Depleting Substances) in the buildings served.CO2 Mitigation: ~1,200 tons of CO_2 avoided annually.

Efficiency: 15% to 20% reduction in electricity consumption compared to conventional air conditioning.

Key Lesson: Proved that centralizing cooling reduces urban heat island effects and optimizes maintenance costs (OPEX) for public administration.

SESSION 4: Financing Mechanisms for Scaling Up Sustainable Cooling

Case Study 2 - Serena del Mar (Cartagena)

Profile: A "Dream City" project on the Caribbean coast, integrating a district energy model from its master plan.

Operator/Developer: Celsia.

Capacity: Initial phase of 1,200 TR, expandable as the development grows.

Clients: Centro Hospitalario Serena del Mar (CHSM) and commercial areas.

Business Model: "Off-site" production. Celsia owns and operates the plant, freeing the hospital/users from CAPEX and maintenance of cooling equipment.

The Caribbean Challenge: High humidity and salt spray (corrosion). The district system uses specialized industrial chillers with higher durability than individual units.

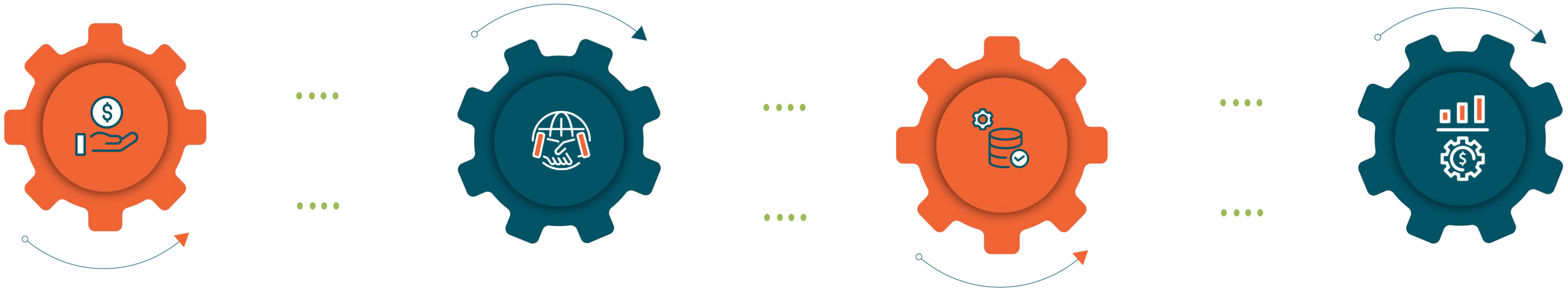
Financial Benefits: Space Optimization: Buildings save up to 30% of rooftop/basement space by removing individual chillers.

Reliability: 99.9% uptime for critical infrastructure (Hospital).

Comparison: Unlike the public-focused Alpujarra, Serena del Mar shows how private developers can use district cooling as a competitive advantage for high-end real estate and healthcare.

SESSION 4: Financing Mechanisms for Scaling Up Sustainable Cooling

Takeaways



Market Drivers & Economic Context

Colombia has a strong culture of energy savings: High electricity costs (~0.243 USD/kWh) make efficiency a financial priority.

Institutional Alignment & Governance

State Alignment: Strategic coordination at the national government level.

Public-Private Synergy: Strong alignment between the public and private sectors to facilitate urban projects.

Financial Bankability & Stability

Robust Project Sponsors: High-profile backers provide credibility and financial solvency to the initiatives.

Long-term Energy Contracts: Power Purchase Agreements (PPAs) and service contracts ensure predictable and secure revenue streams.

Technical Expertise & Implementation

ESCOs' Technical Contribution: Energy Service Companies provide high-quality technical knowledge and operational expertise.

SUSTAINABLE
COOLING FORUM

Thank you

Ms. Cristina MARIACA OROZCO
GEDP International Strategic and Technical Coordinator
Energy Systems & Industry Decarbonization Unit
Division of Energy and Climate Action
E-mail: H.Mariacaorozco@unido.org

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE
COOLING
FORUM

Questions and Answers

SESSION 4: Financing sustainable cooling

Ms. Valeria Arroyave
Montreal Protocol Unit
UNIDO

Mr. Rusmic Musić
Global Cooling Programme
World Bank IFC

Mr. Marco van Waveren Hogervorst
Climate Finance
UNIDO

Mr. Kevin Basoa
Ministry of Environment
Chile

Ms. Cristina Mariaca Orozco
Global Energy District Programme
UNIDO

DAY 2 – 9 APRIL 2026

DAY 2 – 9 APRIL 2026

Venue: Hofburg

Joint segment with the International Vienna Energy and Climate Forum

08.00 – 09.25 **Security Screening | Registration | Welcome Coffee**

09:30 – 11:25 **Opening Ceremony and Plenary**

The session will open the Vienna International Energy and Climate Forum (IVECF) and discuss powering prosperity, security and stability and pathways for system transformation and the role of sustainable cooling in climate, energy and industrial agendas.

11:30 – 18:15 **Roundtables and deep-dive sessions**

Participants are free to attend various meetings of IVECF. For the official programme of the IVECF please visit here and deep-dives here.

'Cooling and Climate' side-events

Venue: Prinz Eugen Saal

11:30 – 13:30 **Promotion of natural refrigerants in the cooling industry**

13:30 – 15:00 **Lunch**

14:30 – 15:30 **Second phase of A2D and its relevance to cooling**

16:00 – 17:00 **Empowering Women and Youth in Sustainable Cooling**

17:15 – 18:15 **Regional Initiatives to Enabling Energy Efficient Cooling**

How to get to the Hofburg Palace

Day 3 – back here at VIC, at 09:00

DAY 3 – 10 APRIL 2026

DAY 3 – 10 April 2026

Venue: Vienna International Centre | C/4-BR-D - Boardroom D

09:00 – 09:30 **Welcome coffee and networking**

09:30 – 10:30 **SESSION 5. Business model innovation**

The session will examine business aspects of the cooling sector and business models such as cooling-as-a-service (CaaS) and circular economy-based approaches built on lifecycle refrigerant management, opportunities provided by carbon markets and importance of safeguards, and extended producer responsibility scheme. The experts and practitioners from the field will discuss operational structures, financing arrangements on a legal and contractual basis and frameworks to ensure risk allocation and enforcement. The discussion will draw from ongoing projects of ODS banks management and refrigerant bank management plans to discern business models, their technical and economic viability, scalability, regulatory implications, as well as relevance for different market contexts and end user applications.

Moderator: Mr. Oluyomi Banjo, *UNIDO*

- **Circularity in cooling: recovery, recycling and reclamation and sound management of used and waste refrigerant**
  Mr. Krzysztof Grzegorczyk, *PROZON*
- **Demystifying carbon markets: opportunities for ozone depleting substances and HFC**
  Ms. Ayse Frey, *Energy Changes*
- **Cooling as a Service**
  Mr. Dimitris Karamitsos, *BASE*
- **Questions and Answers**

10:30 – 11:30 **SESSION 6. Adaptation in cooling: building resilience and closing the gap**

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

SUSTAINABLE COOLING FORUM

Welcome Reception

UNIDO UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Progress by innovation

Vienna Convention
MONTREAL PROTOCOL

Multilateral Fund for the Implementation of the Montreal Protocol

SUSTAINABLE COOLING FORUM

Rising to the Global Challenge

8-10 April 2026 | Vienna, Austria