

The Importance of Green Cooling

Ellen Michel, GIZ Proklima

OZONE
▶ COOL
* ZONE

30 Nov–12 Dec
COP28 UAE



Implemented by



Take a guess:

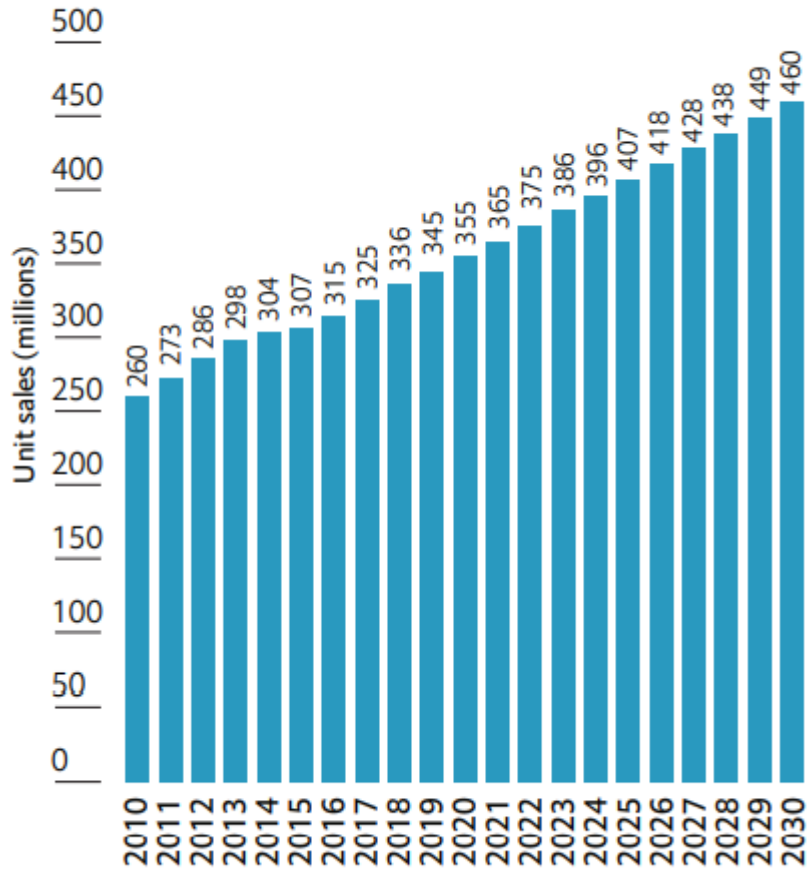
How many air conditioners will be sold per second until 2050?

- A) 1 B) 10 C) 20



Why cooling concerns us all

Global annual cooling sales (2010-2030)



Source: P&S Intelligence, Green Cooling Initiative, EIU analysis.

- 10 new air conditioners will be sold **every second** for the next thirty years ([IEA, 2018](#))

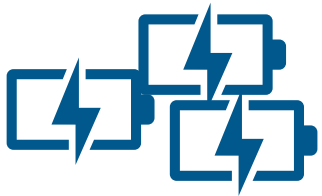


Why cooling concerns us all



Most of the currently used refrigerants, such as Hydrofluorocarbons (HFCs) have **very high global warming potentials (GWP)**

- CO₂: GWP of 1
- HFCs: GWP of up to 15.000



The **energy consumption of space cooling alone will more than triple** until 2050. This will be equivalent to today's total energy consumption of China and India combined. ([IEA](#)).



RAC emissions

$2/3 =$

energy consumption

$1/3 =$

released refrigerant

≈ 10 % of all global
greenhouse gas
emissions



Take a guess:

To how much additional temperature rise could the use of HFCs lead until 2100?



A) 0,1°C

B) 0,3°C

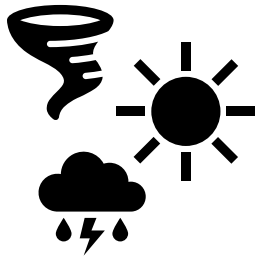
C) 0,5°C



Why cooling concerns us all



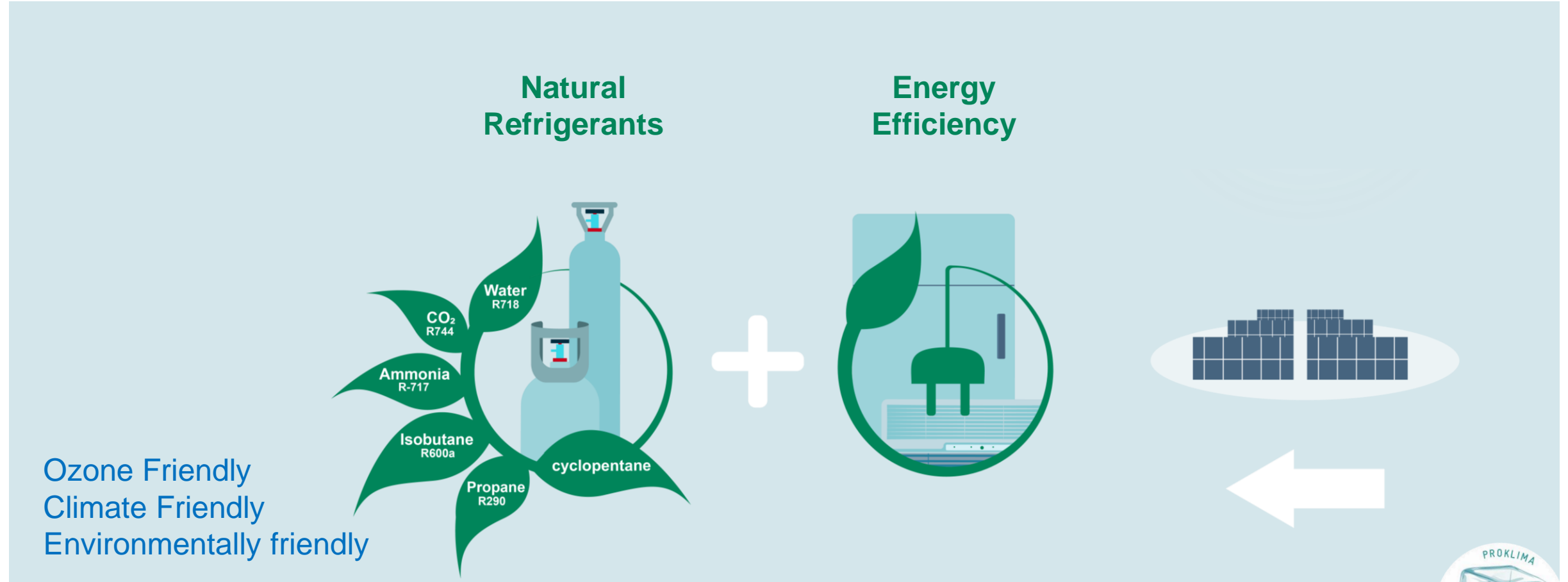
According to the [IPCC report 2022](#), the use of HFCs could lead to an **additional temperature rise of up to 0,5°C until 2100** if no measures are taken.



The global average temperature has risen by about 1,2°C in 2022. We already observe an increase in extreme weather events, rising sea levels etc. **Almost half of all people live in areas threatened by the climate crisis.**



Green Cooling:



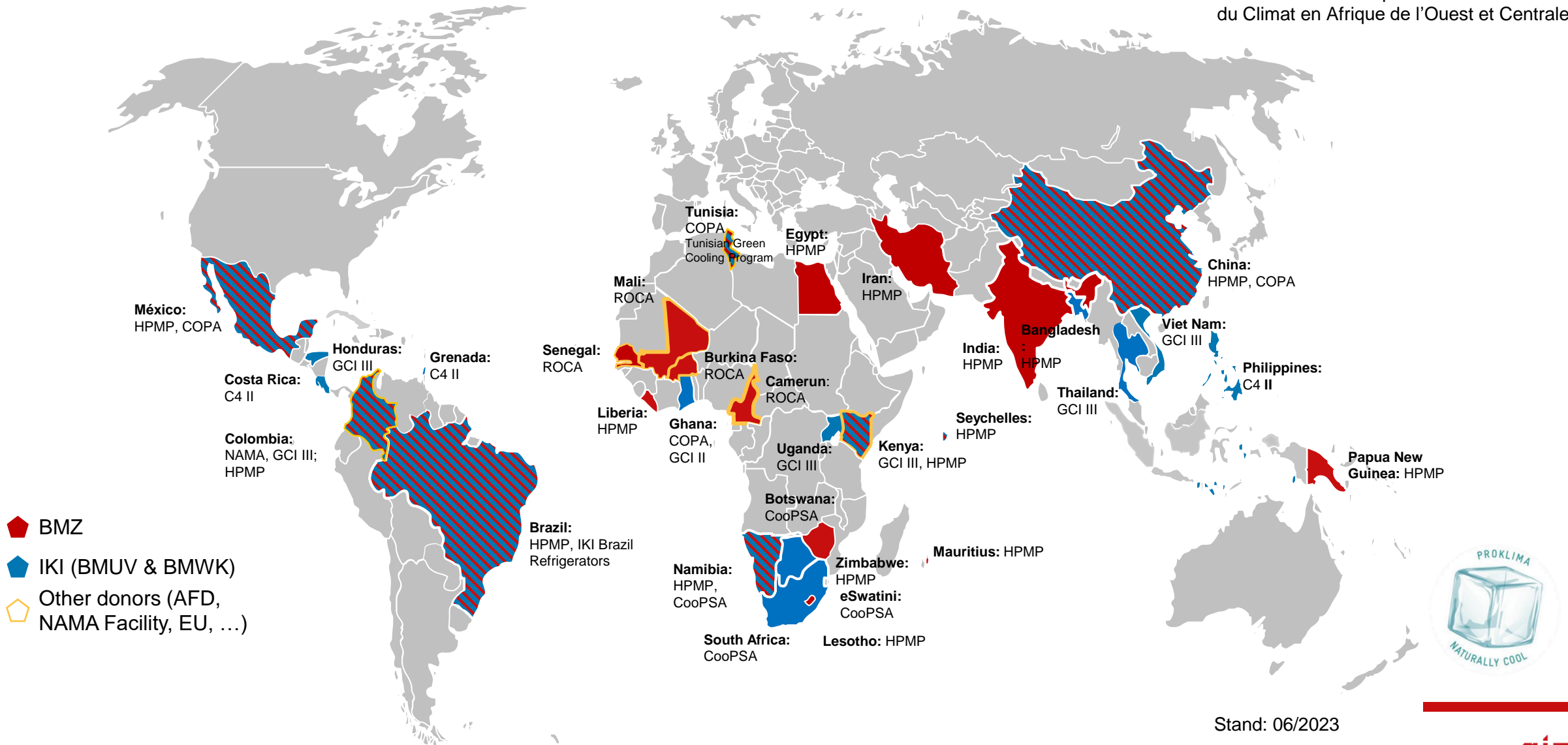
Green Cooling:



Proklima: Since 1995

More than 265 projects in +40 partner countries

COPA: Climate and Ozone Protection Alliance
GCI III: Green Cooling Initiative III
CooPSA: Cooling Programme Southern Africa
HPMP: HCFC Phase-Out Management Plan
ROCA: Refroidissement respectueux de l'Ozone et du Climat en Afrique de l'Ouest et Centrale



Stand: 06/2023

Working areas of Proklima

Policy advice



Support for comprehensive **cooling sector mitigation approaches**

Technology transfer



Cooperation with the private sector (e.g. production and application of climate-friendly air conditioning systems)

Capacity building



Enabling the spread of **Green Cooling** technologies worldwide by providing training on the **safe handling of natural refrigerants**.

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More information:

www.green-cooling-initiative.org



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giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Sustainable Cooling

Sophie Geoghegan

Environmental Investigation Agency

OZONE

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COP28
UN Climate Change Conference
 30 November - 12 December 2023
 Dubai, UAE



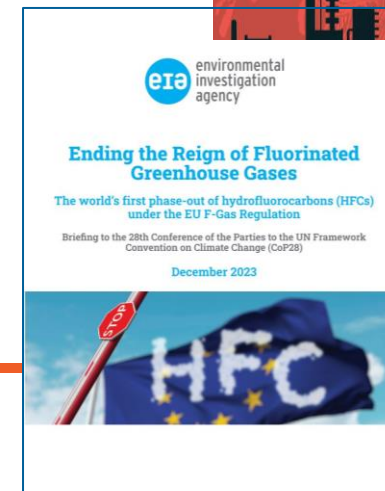
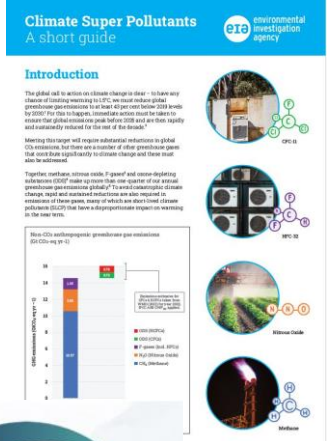
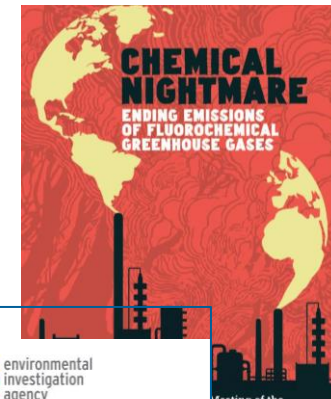
Campaigning for fast-action mitigation on:
SUSTAINABLE COOLING
ACCELERATED HFC PHASE-DOWN
OZONE DEPLETING SUBSTANCES
GLOBAL METHANE PLEDGE
FOSSIL FUEL TREATY
PLASTIC PRODUCTION REDUCTION

At the Environmental Investigation Agency, we investigate and campaign against environmental crime and abuse

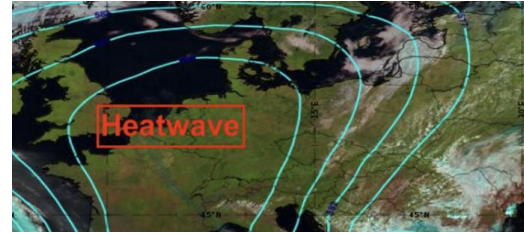
To tackle the pressing threat of climate change, we are working to eliminate powerful greenhouse gases including methane, nitrous oxide, and the ODS & F-gases widely used in the cooling sector.

We are also working to improve energy efficiency in the cooling sector, and to expose illicit trade in refrigerant greenhouse gases.

We also campaign on Forests, Oceans and Wildlife



Keeping Cool in a Warming World

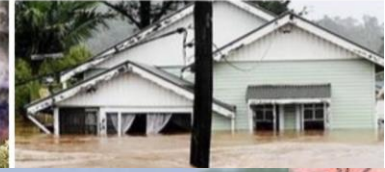


Extreme heat in North America, Europe and China in July 2023 made much more likely by climate change

25 July, 2023

HEATWAVE
ASIA, EUROPE, NORTH
AMERICA

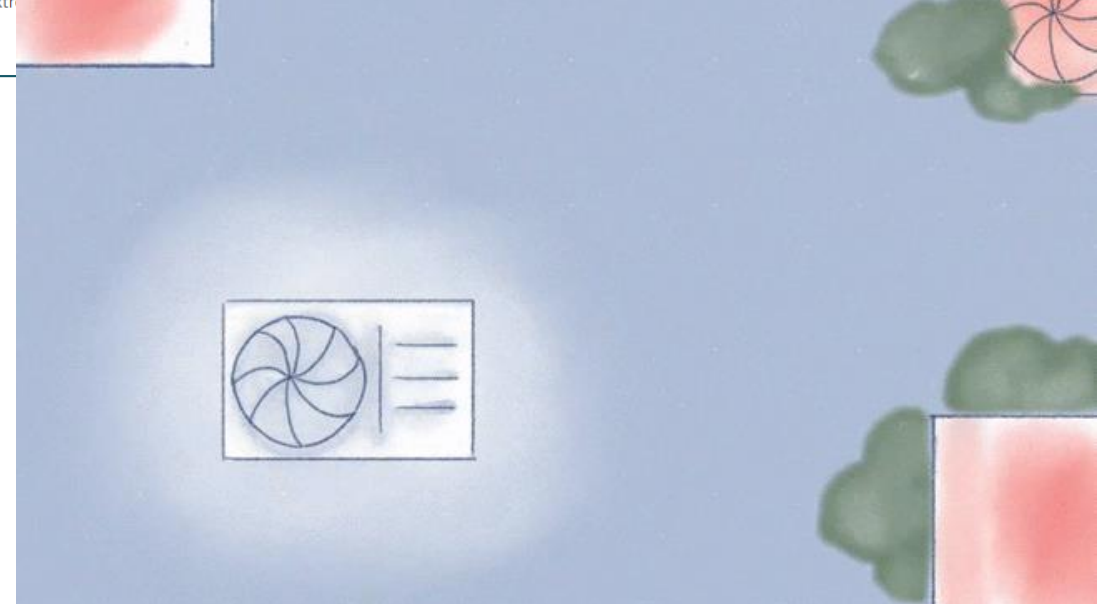
Following a record hot June, large areas of the US and Mexico, Southern Europe and China experienced extreme heat, breaking numerous temperature records.



This summer has been the hottest on record

Increasingly frequent and severe extreme heat events and heatwaves

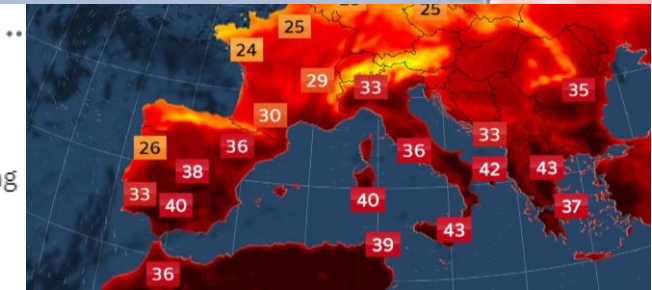
As emissions rise, global temperatures increase pushing up cooling demand leading to further emissions... a vicious cycle



IPCC @IPCC_CH · 19h

Earth just had its hottest three months on record confirms @WMO & @CopernicusECMWF

Every increment of warming results in rapidly escalating compounding & cascading hazards & related losses & damages.



What is Sustainable Cooling

CLEANING UP COOLING

AVOID

cooling where possible through better building and city design and behaviour change.



SHIFT

to cooling systems that don't use refrigerants or fossil fuel derived electricity



A

B

C

D

E

F

G

A

NH₃

R717

GWP
0

CO₂

R744

GWP
1

C₃H₈

R290

GWP
3

IMPROVE

existing cooling technologies for highest energy efficiency and natural refrigerant uptake

Sustainable Cooling as adaptation

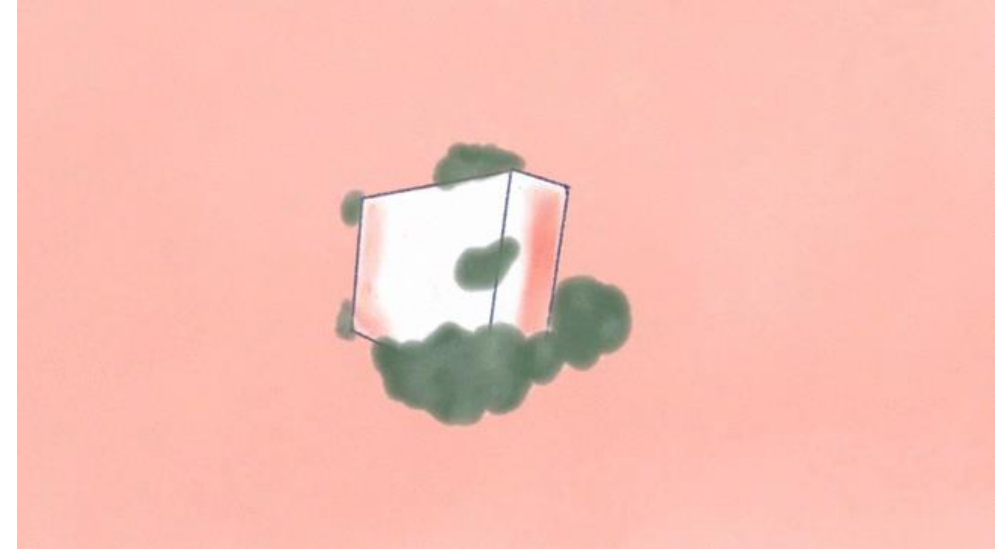
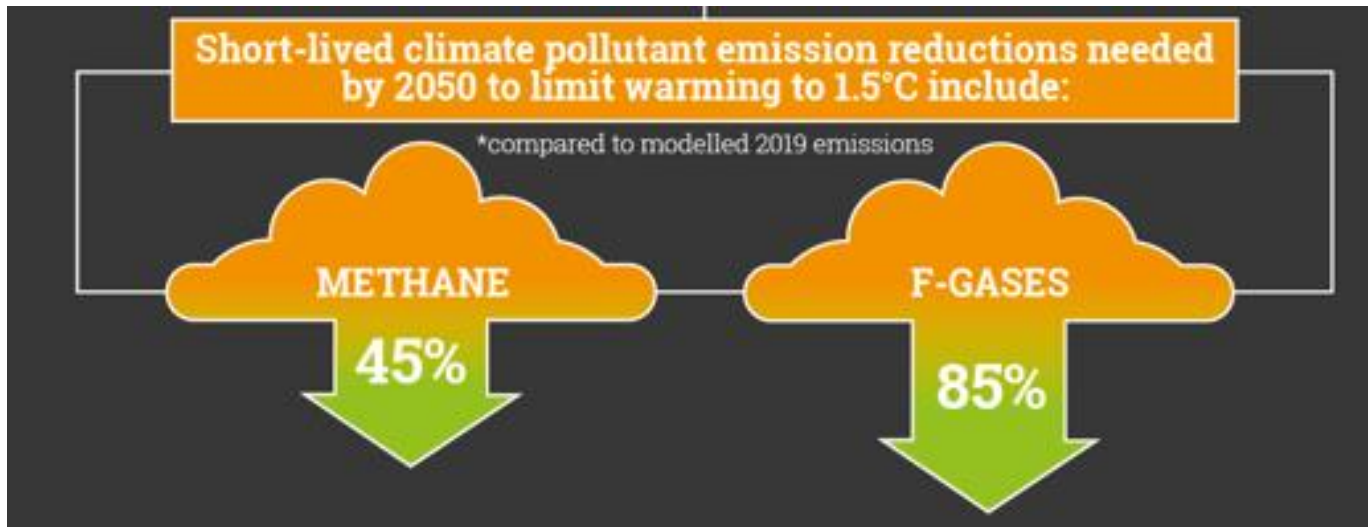
- As the world warms, demand for cooling increases
- The IEA estimates cooling demand will triple by 2050
- According to the IPCC, up to 76% of the global population could be exposed to deadly heat stress by 2100
- We need cooling for our health, productivity, food and medicine
- How do we deliver cooling to all sustainably?

How do we keep cool without warming the planet?



Sustainable Cooling as Mitigation

- Cooling already accounts for 7% of global emissions and cooling demand will triple by 2050
- F-gases are super polluting short lived climate pollutants
- F-gas emissions have increased 254% since 1990 and are responsible for 0.1°C of warming so far
- F-gas emissions need to be reduced 85% by 2050 to limit warming to 1.5°C, according to the IPCC



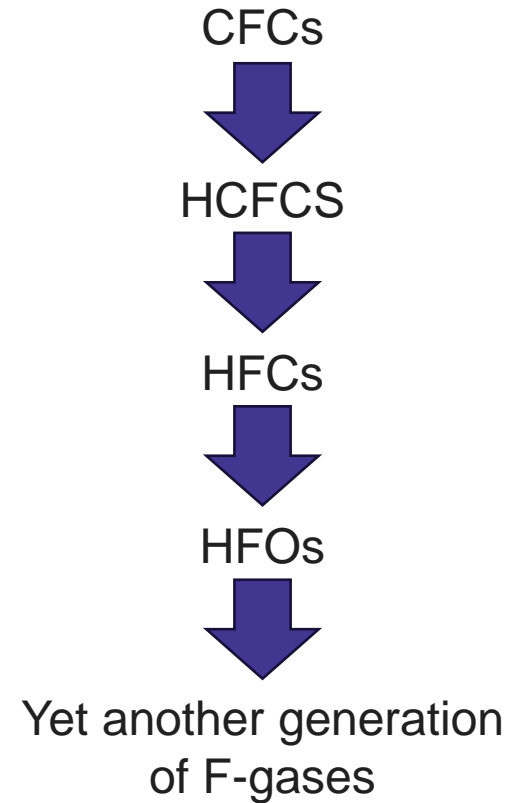
What is a sustainable refrigerant

Climate

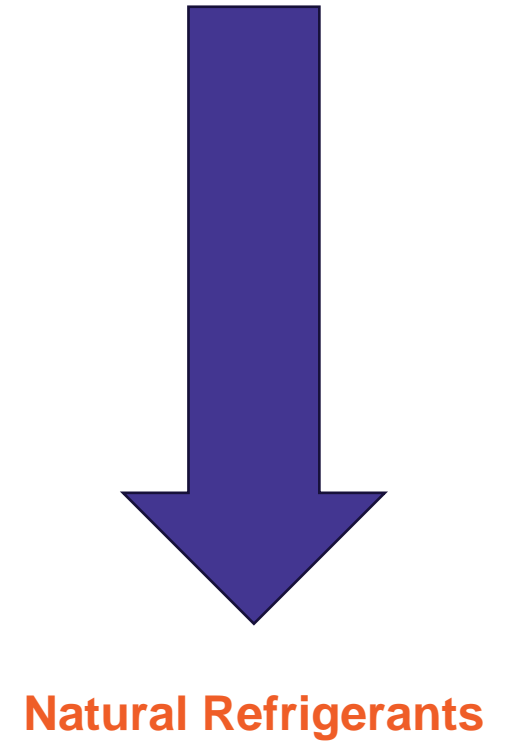
- Emissions
- Global Warming Potential
- Manufacture emissions
- End of life recovery
- Energy efficiency



Chemical Treadmill



Getting off the Treadmill

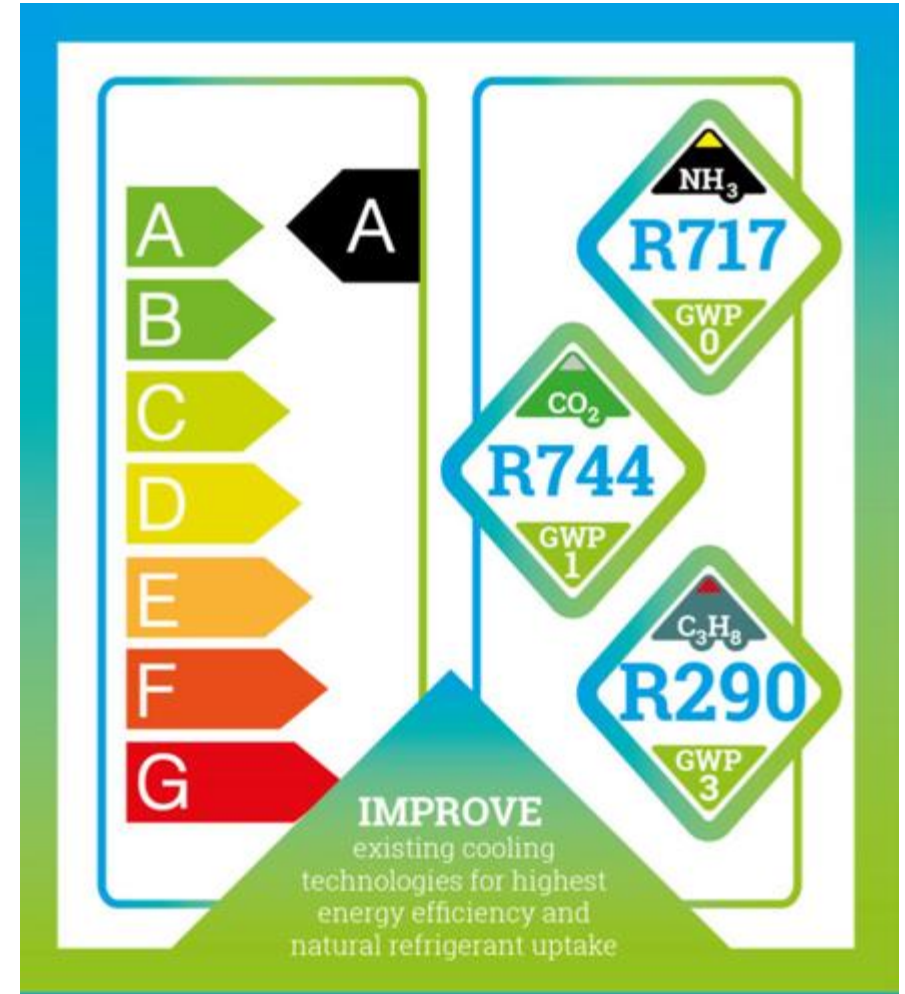


Energy Efficiency

Natural refrigerants are as efficient, if not more, than F-gases they are replacing

- **With today's technology** it is possible to reach better energy performance with CO₂ TC compared to HFCs in climates with **temperatures up to 45°C**
- **CO₂ also offers opportunities for heat recovery = free heat!**
- Propane is thermodynamically superior to HFCs and HFOs
- Propane heat pumps show very high COPs

The refrigerant transition and energy efficiency improvements must go hand in hand



Pathway to Sustainable Cooling

Market sector examples

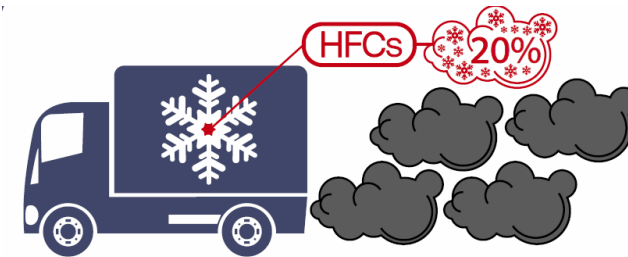
Heat Pumps

- ✓ Key to decarbonize heating (and cooling)
- ✓ Increasingly using natural refrigerants
- ✓ (CO₂, propane and ammonia)
- ✓ High COPs for propane heat pumps
- ✓ High demand growth
- ✓ More players entering the market



Transport Refrigeration

- ✓ Key to reducing cold chain emissions
- X Still using high GWP F-gases
- X (HFC-404A, HFC - 134a, HCFC-22)
- X High refrigerant leakage rate
- X High demand growth
- X Few players dominating the market



Leaking HFCs from transport refrigeration systems account for around 20% of the vehicle's total greenhouse gas emissions

● MONTREAL PROTOCOL
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Thank you for listening!

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Technology Focus: refrigeration and air conditioning with NatRef

Thomas Trevisan, Deputy Manager for Public
Affairs – Ozone, Climate, Energy and
Chemicals

1 December 2023, Ozone Cool Zone, GIZ Event



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Scaling the Clean Cooling & Heating Economy



A global industry label recognizing the best in class for natural refrigerants

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Curated natural refrigerant products and services with news

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Understand the latest market trends, technologies and players

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Comprehensive natural refrigerant textbook now available in print, digital and multiple copies

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ATMOsphere is a global market accelerator with a mission to clean up cooling and heating.



<https://atmosphere.cool/>



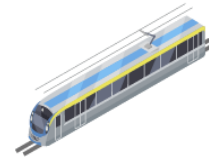
Factories



Airports



Boats



Trains



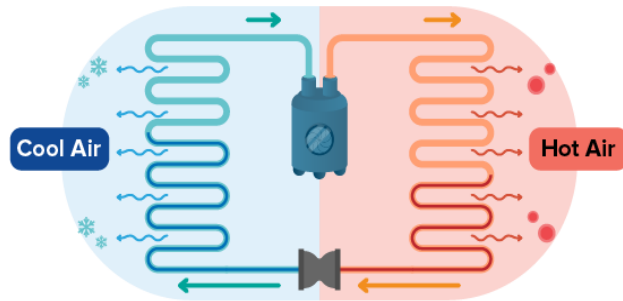
Cargo ships



Hospitals



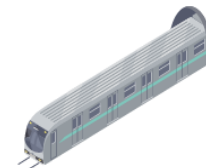
Office buildings



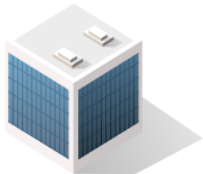
Trucks



Vans



Metros



Data centers



Fish markets



Supermarkets



Butcher



Single homes



Cars



Buses



Mechanical control of temperatures is **EVERYWHERE** and requires:

- a lot of power (RACHP around 25-30% of global electricity consumption)

- a lot of refrigerants (problematic for different environmental common goods...)

Deep dive into the world of refrigerants

Halogenated substances

CFCs, HCFCs, HFCs, HFOs..

- Ozone hole – Montreal Protocol
- Global warming – Kigali Amendment
- Persistent chemicals – [?] Amendment/ Stockholm Convention



- Substances not produced by nature -> hence, synthetic
- Useful in the past when environmental problems were less of a concern

Natural heat carriers

- NO Ozone hole
- NEGLIGIBLE global warming
- NO persistent chemicals



- Substances that comply with nature's biogeochemical cycles -> hence, natural
- Inherent concerns well managed by industry

Technology availability today: chillers

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMosphere



A variety of applications that can be covered with naturals and low GWP solutions!



Office buildings

Refrigerants	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)
Naturals (different)	Negligible	No
R-1234ze	4.94 - 1.37	Yes, HFO-1234ze: CHF=CHCF3
R-1233zd(E)	14 - 3.88	Yes, HCFO-1233zd(E): CHCl=CH-CF3
R-452B	2006 - 2275	Yes, HFC-125: CF3-CHF2 HFO-1234yf: CH2=CFCF3



Data centers

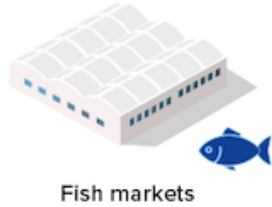


Hospitals



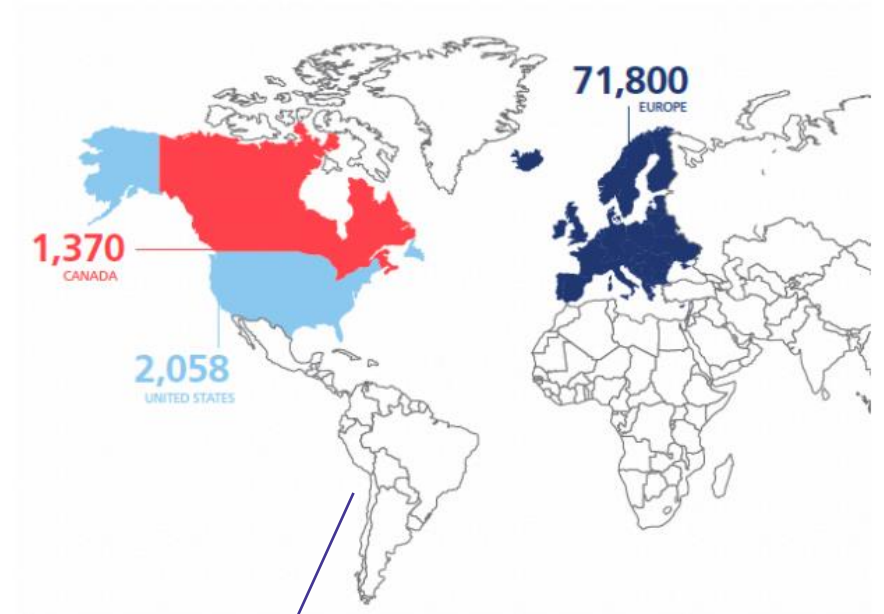
Factories

Technology availability today: stationary refrigeration



Refrigerants	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)
Naturals (different)	Negligible	No
R-455A	502 - 580	Yes, HFO-1234yf: CH ₂ =CF ₂ CF ₃
R-450A	1611 - 1742	Yes, HFC-134a: CF ₃ -CH ₂ F HFO-1234ze: CHF=CHCF ₃
R-407A	4538 - 4890	Yes, HFC-125: CF ₃ -CHF ₂ HFC-134a: CF ₃ -CH ₂ F

Transcritical systems in selected regions. Source: ATMOsphere



Around 500 systems installed in LATAM as of 2023!

Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOsphere

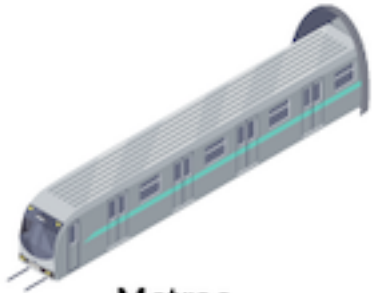
Technology availability today: mobile air conditioning



Trucks



Buses



Metros

Refrigerants	Global warming potential (IPCC Sixth AR – 20 and 100 years)	PFAS (OECD)
Naturals (different)	Negligible	No
R-1234yf	1.81 - 0.501	Yes, HFO-1234yf: CH ₂ =CFCF ₃
R-134a	414 - 1430	Yes, HFC-134a: CH ₂ FCF ₃

Generally higher leakage rate compared to stationary systems (up to 15% yearly charge) -> more likely to contribute more due to also number of systems deployed worldwide!

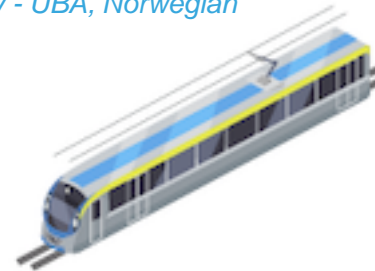
Sources: European Commission, German Environmental Agency - UBA, Norwegian Environment Agency, UNEP, RTOC 2022 AR, ATMOsphere



Vans



Cars



Trains

References:

- European Commission: https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases_en
- German Environment Agency – UBA: <https://www.umweltbundesamt.de/publikationen/persistent-degradation-products-of-halogenated>
- Norwegian Environment Agency: <https://www.miljodirektoratet.no/globalassets/publikasjoner/M917/M917.pdf>
- Universal PFAS Restriction Proposal: <https://echa.europa.eu/es/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b>
- UNEP RTOC 2022: <https://ozone.unep.org/system/files/documents/RTOC-assessment%20-report-2022.pdf>
- ATMOsphere: R744.com, Hydrocarbons21.com, Ammonia21.com, and upcoming Market Report: <https://atmosphere.cool/reports/>

Contact Information:



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Energy and Chemicals

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Thank you for listening!



COP 28

Dubai- UEA

**Theme: The Importance of Green Cooling Fighting the Climate Crisis
-Case of Tunisia-**

Youssef HAMMAMI, Coordinator of National Ozone Unit of Tunisia

Contents

- Tunisia's commitment to international agreements Bilateral
- The path traced by the updated NDC
- The Importance of Green Cooling Sector Fighting the Climate Crisis
- Capacity building of RAC technicians and servicing enterprises
- Bilateral cooperation projects

Tunisia's commitment to international agreements

Montreal Protocol

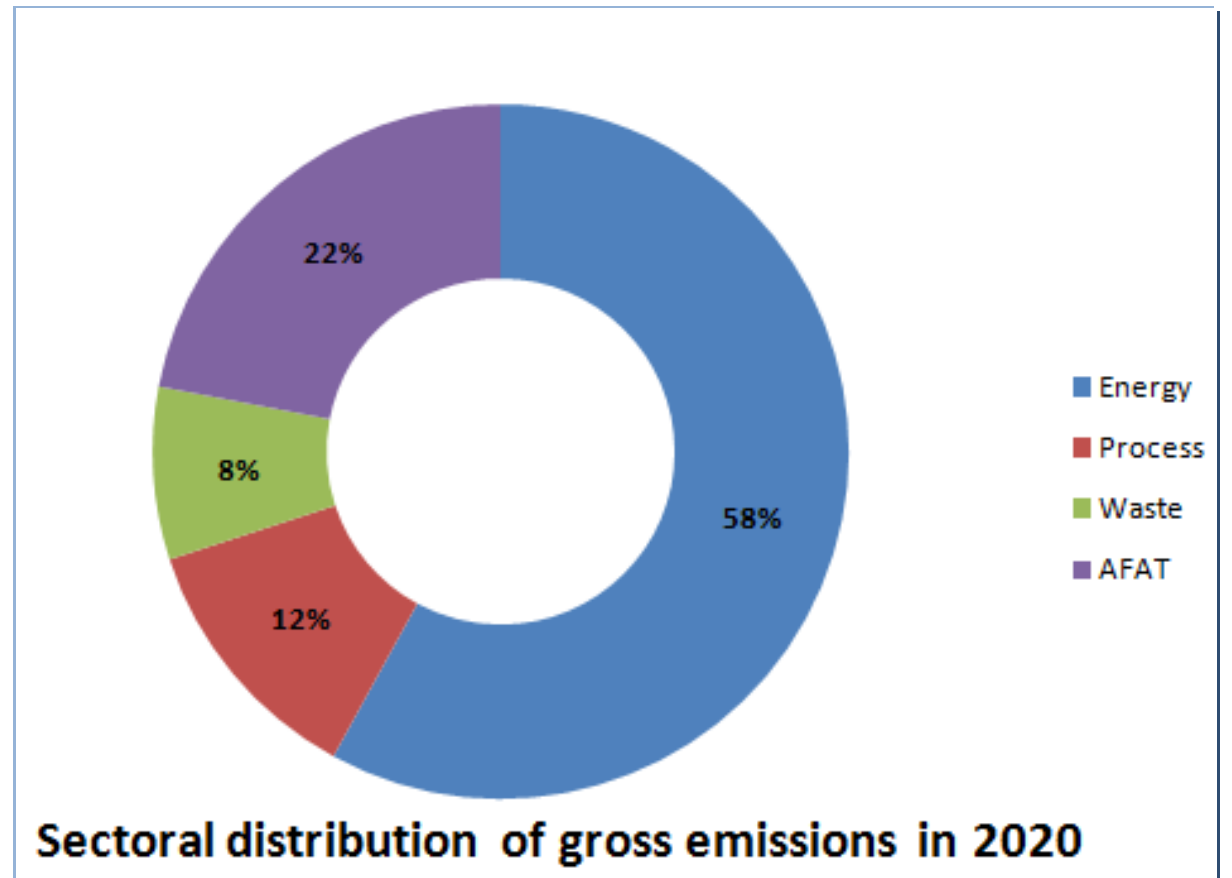
- Tunisia has joined the Montreal Protocol in 1989,
- Tunisia ratified all amendments to the protocol (Kigali amendment: 2021),
- Tunisia is committed to reducing the consumption of HFC substances by 80% by 2045.

UNFCCC

- Tunisia ratified the Paris agreement in 2016.
- By ratifying the Paris Climate Agreement in 2016, Tunisia committed to formulating and communicating to the UNFCCC its National Low Carbon Development Strategy for 2050.
- The cooling sector is a key for this commitment

Sectoral distribution of greenhouse (GHG) gas emissions

- The energy sector and the process represent 70% of all emissions in Tunisia (2020),
- The importance of Green Cooling to reduce the GHG emissions (Energy consumption & Process)



The path traced by the updated NDC (October 2021)

In its updated CDN (2021), Tunisia now aims to reduce its net carbon intensity by 45% by 2030 compared to 2010.

- **Energy sector objective:** Reduce the carbon intensity of the energy sector in 2030 by 44% compared to 2010. This would be achieved essentially through a reduction in primary energy intensity by 3.6% per year on average between 2020 and 2030,
- **Objective of the industrial processes sector:** Reduce the carbon intensity of the industrial processes sector in 2030 by 12% compared to that of 2010, through GHG mitigation measures targeting the cement sector, nitric acid, and use of **HCFCs/HFCs (cooling sector)**.

The strategic vision advocates a massive reduction in emissions from all process sources, by committing today to the development and adoption of disruptive technologies that are **less carbon intensive**; including those for the uses of **HCFCs/HFCs (refrigerants)**.

Conclusion: The Importance of Green Cooling Sector Fighting the Climate Crisis.

- **Process:** fluorinated refrigerants emissions (direct emission)

Reduce/avoid **direct** emission (adopt best practices for handling F- refrigerants)

- **Energy consumption:** indirect emissions caused by the energy consumption of refrigeration appliances

Reduce/avoid **indirect** emission (reduce energy consumption by using **natural refrigerants**)

Capacity building of RAC technicians and servicing enterprises

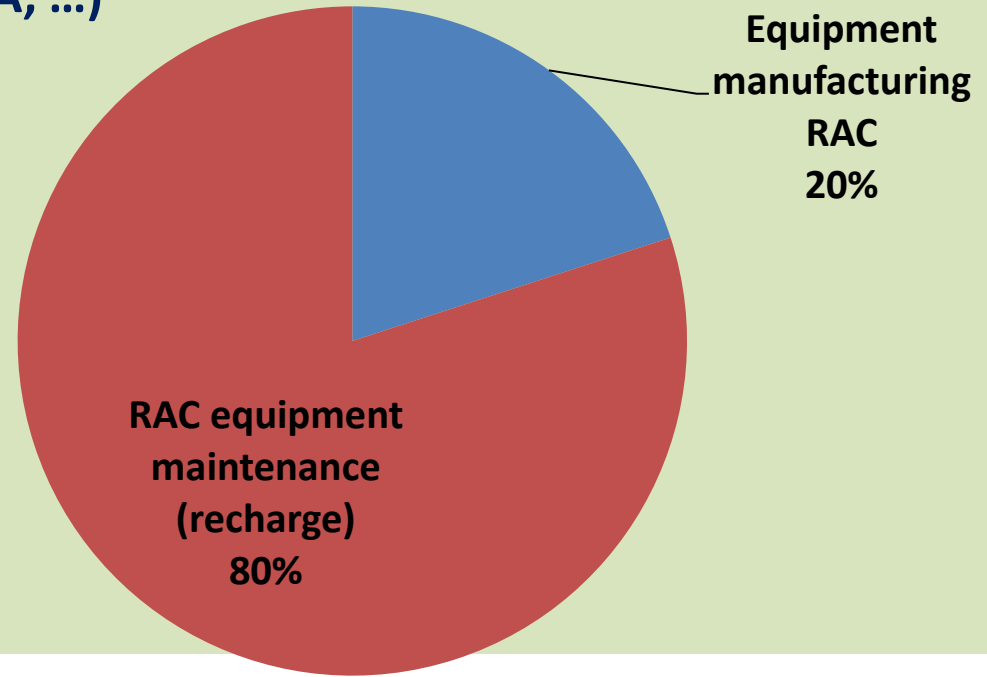
HCFCs/HFCs uses sector in Tunisia

HCFCs/HFCs substances used in Tunisia :

- HCFC-22 (Refrigeration, Air Conditioning): 98%
- HCFC-141b (solvent in 2 companies: 13 TM): 2%
- HCFC-22 are used in the Manufacture/maintenance of RAC equipment sector.
- > 90% HFCs are used in RAC sector (HFC-134a, HFC-404A, ...)

➔ Interest of the Certification of technicians and companies of services in the RAC sector.

Certification is an important component of the HPMP project



Distribution of use of HCFCs/HFCs

RAC Trainers Certification (2016-2023)

- **Certification on best practices for handling F-gas (F-refrigerants)**
- **Total number of certified trainers: 112**
- **Certification body: Veritas (Italy), certification according to European regulation 303/2008,**
- **Category of certification: Category I,**
- **Certification validity: 10 years.**

RAC Trainers Certification: Practical Session



- Certification of 112 RAC trainers (6 ATFP training centers) according to European regulations: (EC 517/2014, EC 842/2006)



**Closing
a certification
session**

Publication of the Certification Training Manual (end of 2021)





**FLUIDES FRIGORIGÈNES
NATURELS ET INFLAMMABLES**

MANUEL DE FORMATION

**Manuel sur les bonnes pratiques de service
en réfrigération et climatisation**

**Training and Technical Capacity Building Activities
(RAC Technicians)**

Achievements: 2021 -2023

Strengthening the technical capacities of technicians operating in the RAC sector.

- ✓ **More than 30 training sessions carried out in 2021 - 2023.**
- ✓ **More than 300 RAC technicians trained in 2021 -2023**



Conduct of training sessions for RAC technicians



Conduct of training sessions for RAC technicians



Conduct of training sessions for RAC technicians (2022)



Brazing under nitrogen flow



Electronic leak detection



Recovery of fluorinated refrigerants

The HCFC phase-out and management project (HPMP) also makes it possible to avoid the following equivalent quantity of CO2 annually:

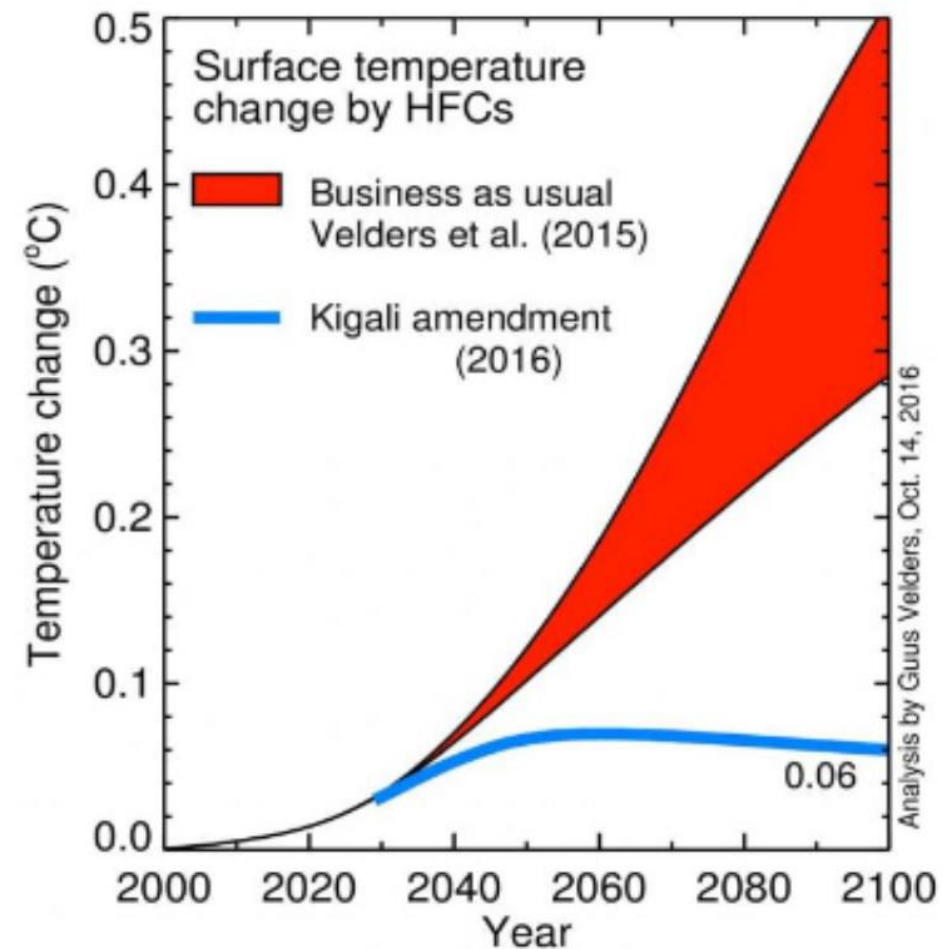
Substances	Quantity to be phase-out (MT)	GWP	CO2 éq avoid (en MT)
HCFC (R-22)	725	1800	1 305 000

Until 2021: reduction equivalent to 700,000 MT of CO2eq

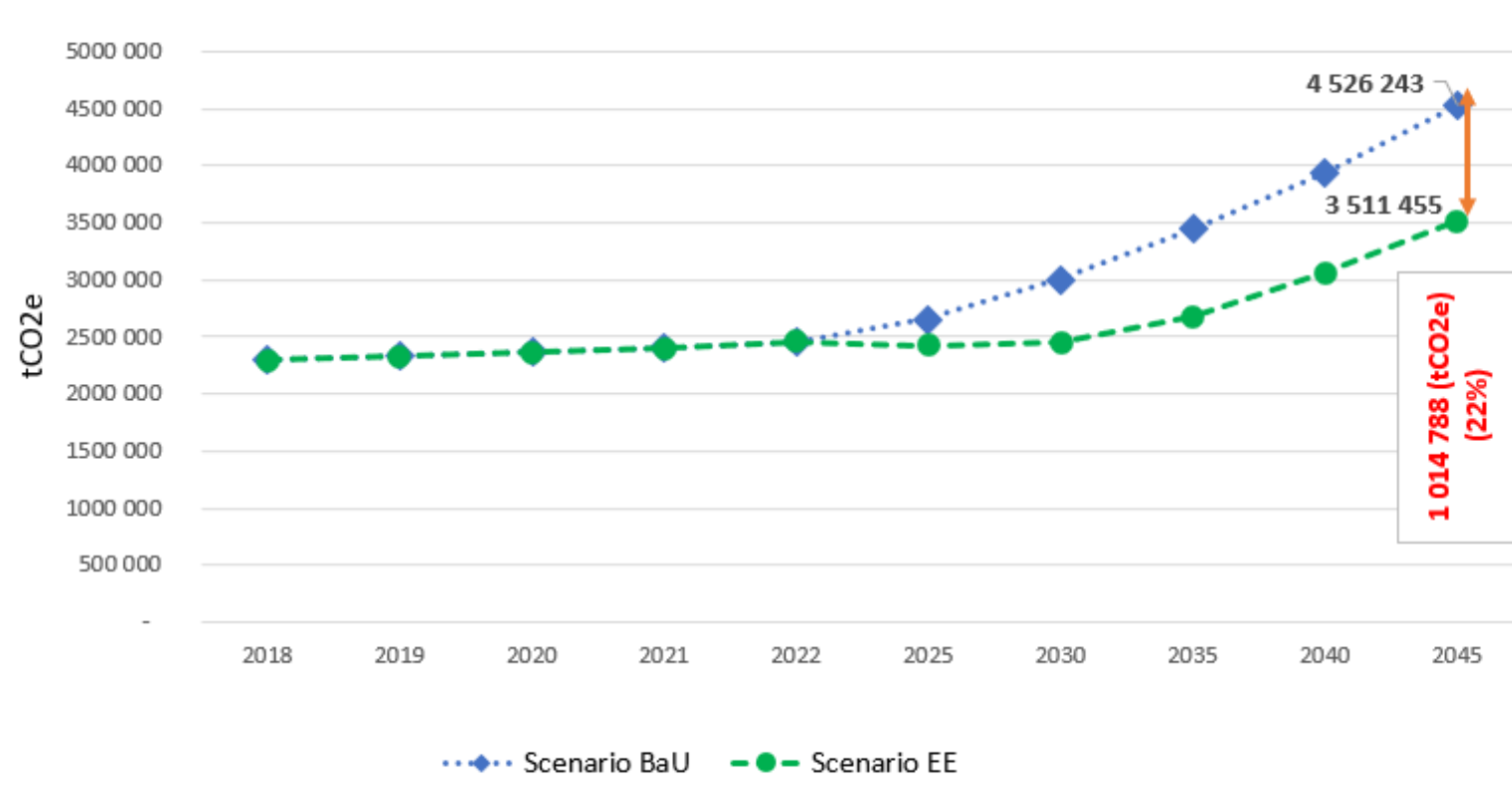
► **Contribution to the fight against Climate Change**

Kigali Amendment

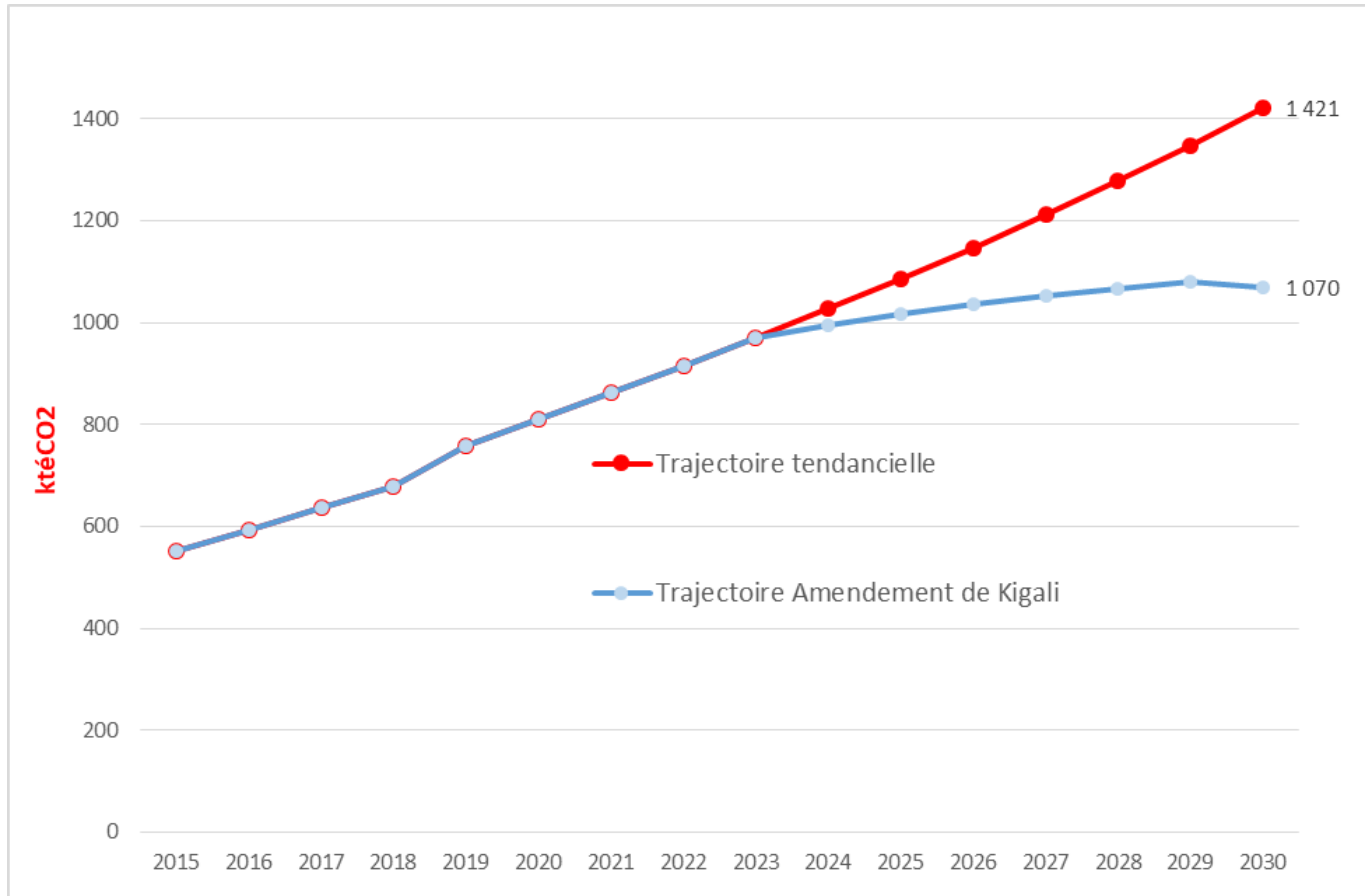
- HFCs Consumption base line: 1,5 M TCO₂eq
- 2024-2028: freeze of the consumption
- 2045: phase down of HFCs (reduction 80 % of HFCs)
- HFCs represents about 4 % of GHG in Tunisia,
- Cooling sector consumes 30% of all energy in Tunisia
- KIP (Kigali Implementation Programme):
the objective is to have a national strategy for the reduction of HFC substances in order to comply with the requirements of the Kigali amendment



Impact of energy efficiency (EE) measures on the evolution of electricity consumption in the refrigeration and air conditioning sector (CO₂eq)



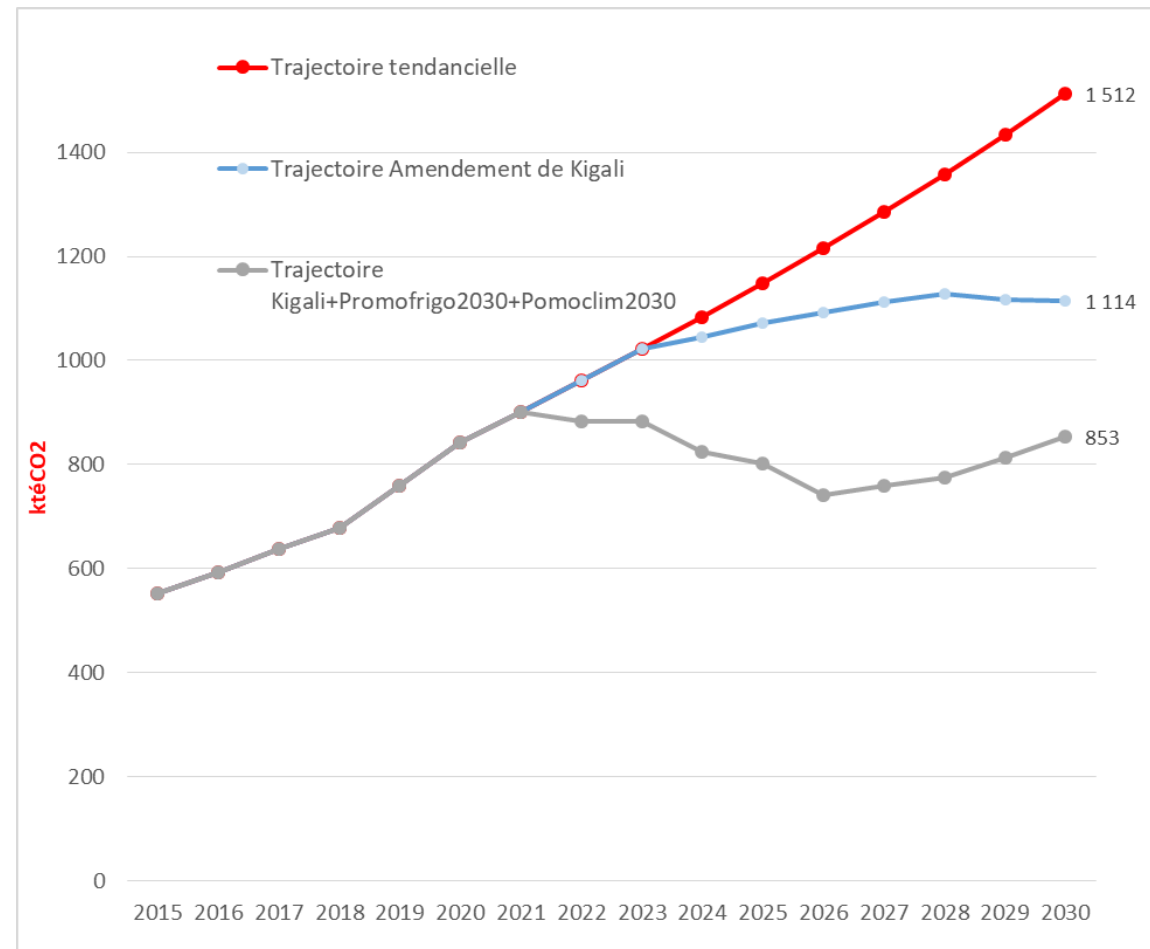
Review of strategic orientations in terms of mitigation of HFCs (emissions in ktéCO₂)



PROMOFRIGO and PROMOCLIM projects targeting HFC stocks

- **PROMOFRIGO** is a specific national program aimed at **replacing old refrigerators** (more than 10 years old) **with class 1 refrigerators**. Promofrigo should rely on a financial mechanism based on a subsidy and an FTE (Energy Transition Fund) credit. .
- **PROMOCLIM** would be a national program aimed at **replacing old Air Conditioners** (more than 10 years old, and generally of class greater than or equal to 4) **with class 1 appliances**. This program has not started either, but it was supposed to rely on a financial mechanism based on a grant and an FTE credit.

Prospects for the evolution of GHG emissions due to HFCs according to three scenarios with the assumption of an extension of PROMOFRIGO until 2030 (ktéCO₂)



Bilateral cooperation projects in the green cooling sector

COPA Project (Climate and Ozone Protection Alliance)

- In 2022, Tunisia joined the Alliance for Climate and Protection of the Ozone Layer, jointly managed by GIZ, UNIDO and UNDP.
- Partner countries: (China, Ghana, Colombia, Tunisia)
- This project aims to:
- Support partner countries to better manage HFC and ODS banks
- Establish a global initiative on ODS/HFC banking management to make a committed and substantial contribution to emissions reductions in the sector, while integrating it into the NDCs of Alliance partners.
- Short-term objective (project duration): Promote international dialogue and exchanges on the management of ODS and HFC banks and attract additional financing for the implementation of mitigation projects in this sector.
- Long-term objective: a demonstrable reduction in emissions from ODS and HFC banks of 5 Gt CO₂eq

« Tunisian Green Cooling Program ».

Under NDC implementation (Paris Agreement)- GIZ

- ✓ Training in the handling of **Natural Refrigerants**,
- ✓ Development of a guide on alternatives to HCFCs and HFCs in the refrigeration and air conditioning sector,
- ✓ Acquisition of tools/equipment for training on **Natural Refrigerants**: reinforcement of vocational training centers
- ✓ Energy efficiency (EE) in the tertiary AC sector
- ✓ Energy efficiency (EE) in the building sector

Cool Up Programme

Tunisia became a member of the Cool Up Programme project in 2022, this new project is managed by: Guide House Germany GmbH (Germany Ministry of the Environment).

Partners:

Tunisia /Egypt/Jordan/Libanon/Turkiye

Cool Up Program Overview (Needs and Goals):

- **Policy:** Support the implementation of the Paris Agreement (via the NDCs) and the objectives of the Kigali Amendment
- **Financial:** Develop financial models to drive sustainable cooling
- **Technical:** Enable **natural refrigerants** and **energy-efficient solutions** to mitigate the growing demand for cooling

Thank you for your attention

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13 CLIMATE
ACTION



Green technology in RAC sector – R290

Dou Yanwei

China Household Electrical Appliances Association

2023.12

1. Refrigerants used in RAC sector in China

HCFC-22



The first refrigerant used in China RAC



Fixed speed

HFC-410A
(50%HFC-32
+50%HFC-125)



Around 2005/2006 used in China RAC



Mainly inverter

HFC-32



Recent years



First in Japan;
Recent years, it is widely used in China

HC-290



Europe;
China

1. Refrigerants used in RAC sector in China

	Advantage	Disadvantage
HFC-410A	Mature	Policy risk
HFC-32	Efficiency	Patent, policy risk
HFO	Environment	High cost
HC-290	Environment	Flammability
CO ₂	Environment	High cost, cooling efficiency

2. Why we recommended R290

National Plan



Carbon peak by 2030

Carbon neutral by 2060

Kigali Amendment



Freeze by 2024

10% reduction by 2029

30% reduction by 2035

50% reduction by 2040

80% reduction by 2045

HCFC-22

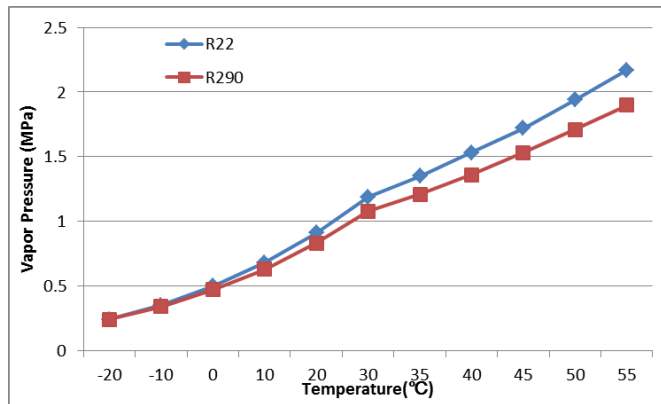
HFC-410A

HFC-32

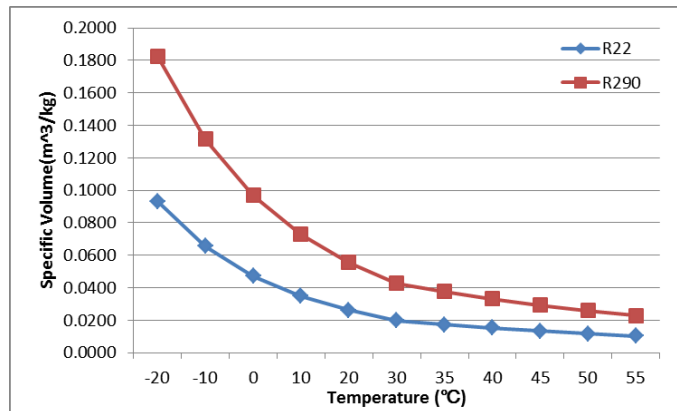
HC-290

3. R290 Refrigerant

Cooling performance



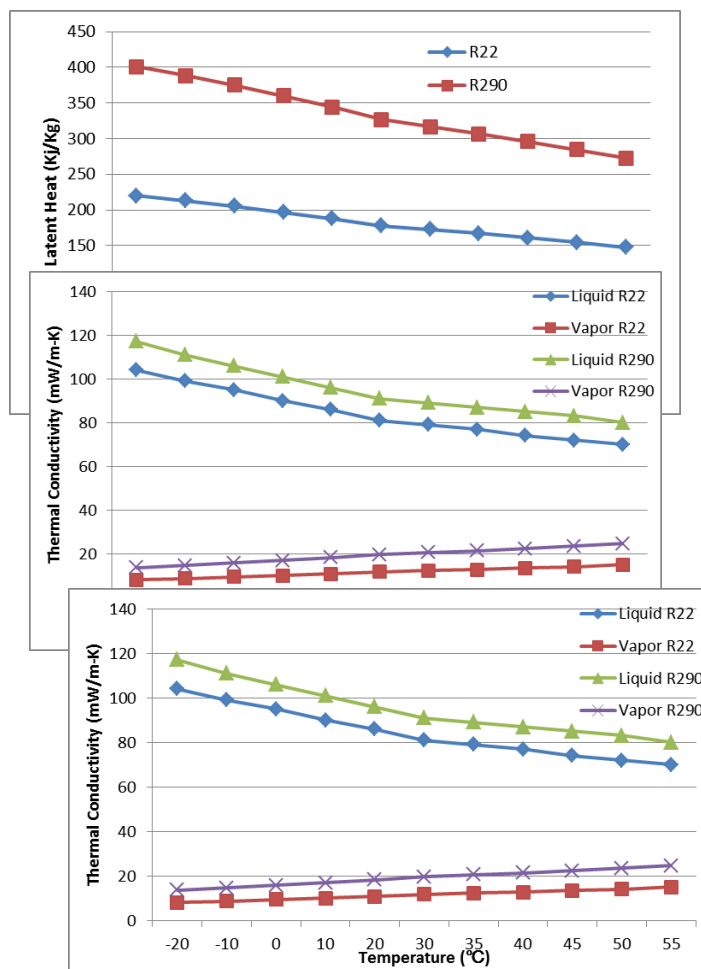
- 1) Advantage of R290;
- 2) $<20^{\circ}\text{C}$, The vapor pressure is similar between R22 and R290;
- 3) $>30^{\circ}\text{C}$, R290 vapor pressure is lower than R22's;
- 4) The component's pressurization would not need to be changed.



- 1) Disadvantage of R290;
- 2) The specific volume of R290 is higher than R22's;
- 3) The mass flow of R290 will be lower than R22's at the certain displacement of compressor

3. R290 Refrigerant

Cooling performance



- 1) Advantage of R290;
- 2) The latent heat of R290 is about 1.8 times higher than R22;
- 3) Thermal conductivity of R290 is higher than R22;
- 4) Viscosity of R290 is lower than R22

R290 has good refrigeration performance!

2022	GB 21455-2019	Grade 1	KFR-26GW/G2-A1N7
			KFR-35GW/G2-A1N7
2023	GB 21455-2019	Grade 1	KFR-26GW/G3-A1N7
			KFR-35GW/G3-A1N7

Midea has developed the first grade split AC according to China EE standard

3. R290 Refrigerant

Environmental performance

151,000,000

**Nominal domestic sale:
90,230,000**

Export: 60,770,000

Split AC

Cabinet AC

EU

Countries do not
accept flammable
refrigerants

Countries
selected
R32

HC-290

HFC-32

HC-290

HFC-410A

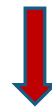
HFC-32

3. R290 Refrigerant

Environmental performance

1) : Do not consider the development of industry

HFC-410A



98,000,000 CO2 tons



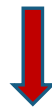
64%

HFC-32

In this scenario, 64% of CO2 equivalent tons reduced compared with situation in 2020

2) : annual growth rate at 0.5%

HFC-410A



93,500,000 CO2 当量吨



61%

HFC-32

In this scenario, 61% of CO2 equivalent tons reduced by 2045 compared with situation in 2020

3. R290 Refrigerant

Environmental performance

One unit

HCFC-22 → HC-290

1.78 CO2 tons

× 150 millions units

266,865,000

→ HC-290

1.76 CO2 tons

HFC-32 → HC-290

0.54 CO2 tons

One unit runs one year

Years to achieve the same CO2 reduction

Grade 3 → Grade 1
4.00 → 5.00

0.18 CO2 tons

10 years

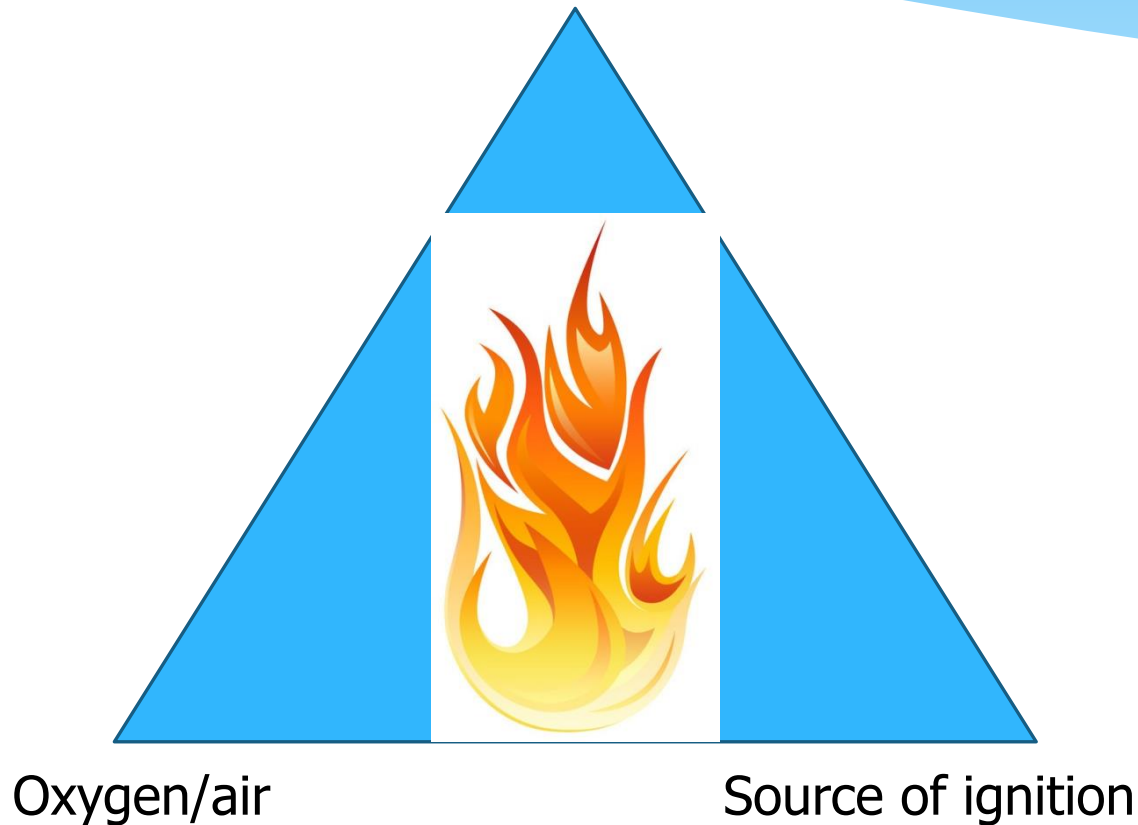
10 years

3 years

3. R290 Refrigerant

Safety

Flammable material



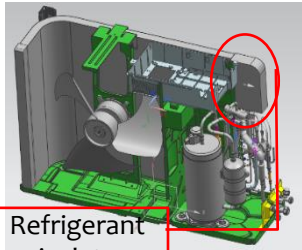
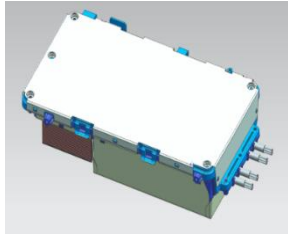
Necessary condition

- ✓ Certain concentration of flammable gas
- ✓ Certain concentration of oxygen
- ✓ Certain ignition energy

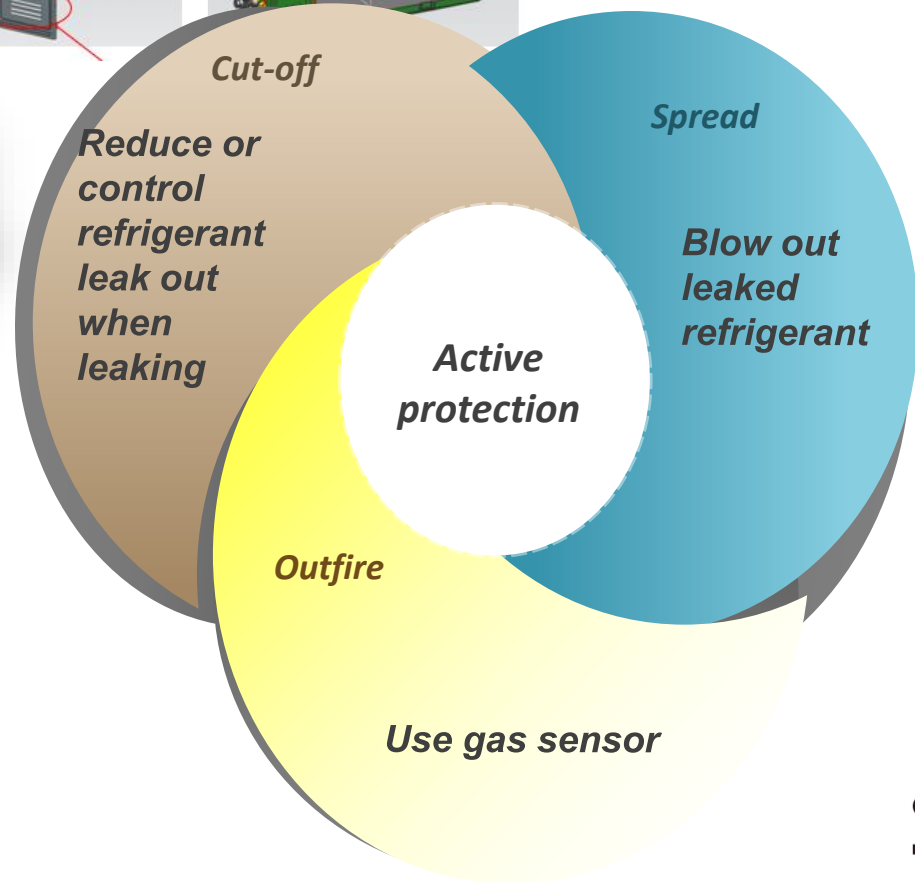
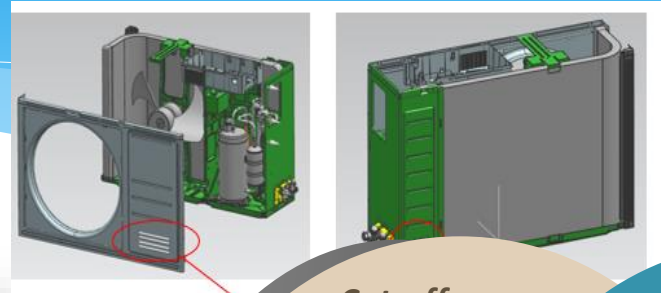
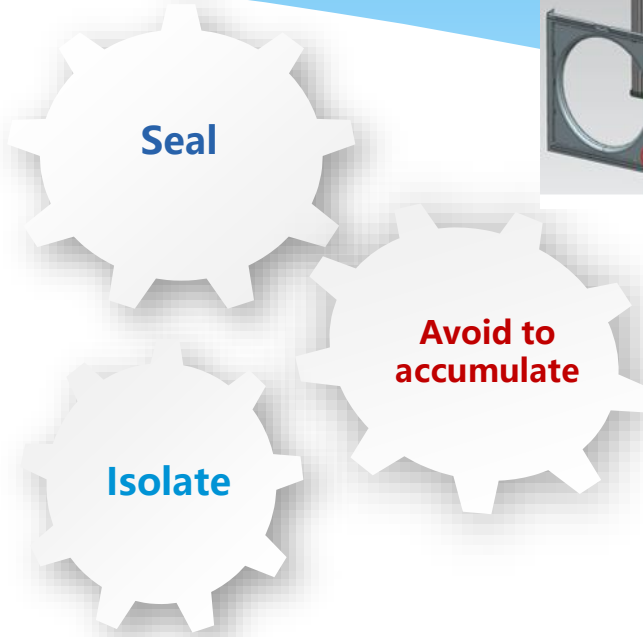
Sufficient condition

3. R290 Refrigerant

Safety



Refrigerant isolate structure



4. Summary

- ① R290, as alternative, follows up the requirements of MP;
- ② It will also contribute to mitigate climate change to use R290 in RAC sector;
- ③ The flammability can be well handled by the suitable technologies.

Thanks for your attentions!

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