CASE STUDIES IN ENERGY EFFICIENT COOLING SYSTEMS

Wednesday, 10th of July 2024

Room 7-AB

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Event Agenda

- **Prof Fabio Polonara** - UNEP Technology and Economics Assessment Panel (TEAP-RTOC) – **Coordination - Introduction**
- **Yosr Allouche** - International Institute of Refrigeration (IIR) – “**Refrigeration and Sustainability: Pathways to Emissions Mitigation**”
- **Adlain Eyarmwen Nkie Akan** - Vice-President U-3arc Union of African Actors in refrigeration and air conditioning – AFRICA – “**Air Conditioner Split Systems in Africa**”
- **Marco Buoni** – Centro Studi Galileo and AREA Air conditioning and Refrigeration European Associations of contractors – EUROPE – “**Maintenance and Repair for the Optimization of Energy Efficiency in the Latest Technologies**”
- **Rajendra Shende** – Green TERRE Foundation – INDIA – **Concluding Remarks & Looking Forward**
- **Discussion and Debate**

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Introduction

Prof Fabio Polonara

UNEP Technology and Economics Assessment Panel (TEAP-RTOC)

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Opportunities and Challenges of the Refrigeration Sector

Dr- Eng. Yosr Allouche

Incoming Director General (October 2024), International Institute of Refrigeration (IIR)

Associate Professor in Refrigeration, Norwegian University of Science and Technology (NTNU)

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OEWG 46 SIDE EVENT
CASE STUDIES IN ENERGY EFFICIENT COOLING SYSTEMS
09/07/2024

REFRIGERATION AND SUSTAINABILITY: PATHWAYS TO EMISSIONS MITIGATION

Dr- Eng. Yosr ALLOUCHE
Incoming Director General (October 2024), International Institute of Refrigeration (IIR)
Associate Professor in Refrigeration, Norwegian University of Science and Technology (NTNU)

Who we are?

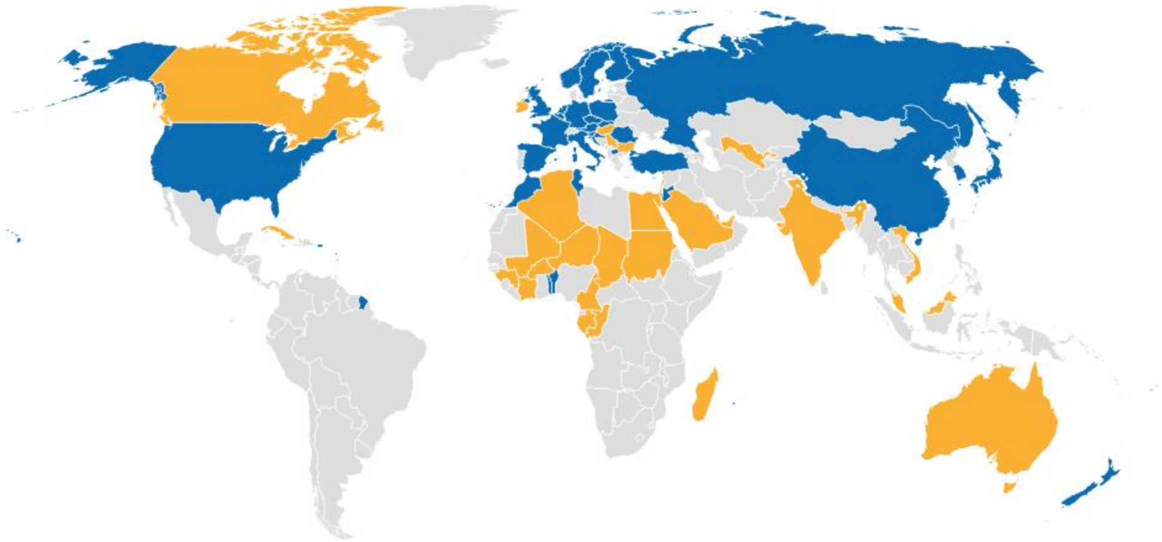
Mission

- IIR is an intergovernmental organisation fostering collaboration and enhancing knowledge on all aspects of refrigeration and heat pumps technologies and their applications to contribute to a sustainable future for all.

Vision

- Sustainable refrigeration and heat pumps for all.

IIR Member Countries



59 Member countries

+1000 Private and Corporate members

+300 Experts

(from blue coloured countries)

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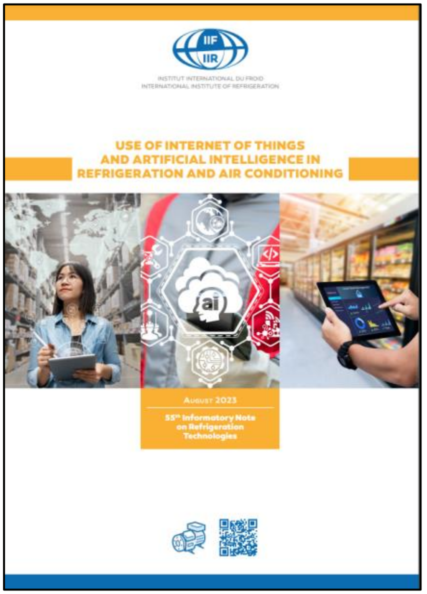
Example of our publications

Technical and Policy Briefs


COLD CHAIN TECHNOLOGY BRIEF

FISHING VESSEL APPLICATION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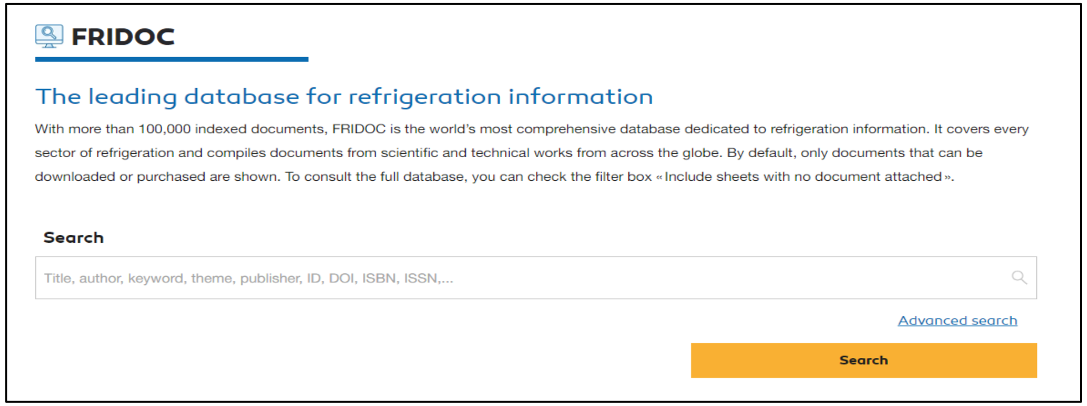
USE OF INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE IN REFRIGERATION AND AIR CONDITIONING

AUGUST 2023

55th Informatory Note on Refrigeration Technologies

FRIDOC: conference proceedings and database

+100,000 documents


FRIDOC

The leading database for refrigeration information

With more than 100,000 indexed documents, FRIDOC is the world's most comprehensive database dedicated to refrigeration information. It covers every sector of refrigeration and compiles documents from scientific and technical works from across the globe. By default, only documents that can be downloaded or purchased are shown. To consult the full database, you can check the filter box «Include sheets with no document attached».

Search

Title, author, keyword, theme, publisher, ID, DOI, ISBN, ISSN,...

Advanced search

Search

Books


Technological options for retail refrigeration ...

Author(s) : FOSTER A., HAMMOND E., BROWN T., et al.
Date : 2018
Languages : English
Formats : PDF

View →

Recommendations for the Processing and Handling...

Author(s) : IIF-IIR, BØGH-SØRENSEN L.
Date : 2006
Languages : English
Formats : PDF, Hard copy

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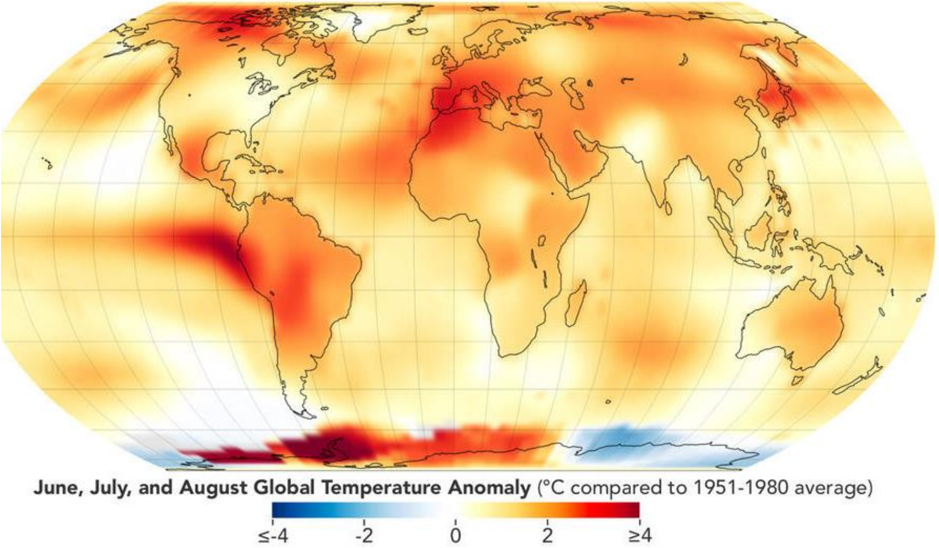
Refrigeration and Cold Chains: Vital infrastructure

- GHG emissions at alarming levels, in 2023:
- The global average carbon dioxide concentration was ~ 420ppm > boundary 350 ppm [NASA].
- The hottest summer since 1880 [NASA].
- **62,000 deaths** in Europe caused by extreme heats [Nature]
- India has the largest population in the world (1.4 billion) to exceed **1.5 billion** by 2030. Africa with the highest rate of growth (sub-Saharan Africa to double by 2050).
- In 2022, **2.4 billion people**, largely women and residents of rural areas, **did not have consistent access to food** [Unicef, 2023], yearly **25,000 people die from hunger** [FAO 2022].
- Each year, 12% global food is lost due to lack of cold chains. Can feed 950 million people in the world [IIR, 2020].

Temperature Matters!


June, July, and August Global Temperature Anomaly (°C compared to 1951-1980 average)

Refrigeration and Cold Chains are no more a luxury → A vital infrastructure

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Food Cold Chains: The IIR estimates

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THE ROLE OF REFRIGERATION IN WORLDWIDE NUTRITION

MARCH 2020
6th Informatory Note on Refrigeration and Food

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THE CARBON FOOTPRINT OF THE COLD CHAIN

APRIL 2021
7th Informatory Note on Refrigeration and Food

- Refrigeration consumes 20% of global electricity demand, which would double by 2050 [IIR, 2019].
- An **improved cold chain**: An increase in the performance/number of refrigeration equipment (low GWP) per capita at the level of the cold chain currently existing in high income countries.

Designation	Value (current cold chain)	Value (improved cold chain)	Unit
Food losses due to a lack of refrigeration	526	236	Mt
CO_2 emissions associated with these food losses	1,004	76	Mt eq CO_2
CO_2 emissions from equipment	261	589	Mt eq CO_2
Total CO_2 emissions associated with the cold chain considered	1,265	665	Mt eq CO_2

→ Reduction in global food losses (due to a lack of refrigeration) by 55%.

→ Reduction of the global emissions of the current CC by 600 Mt CO_2eq (> 47%) [IIR, 2021]

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Three priority actions

Reducing Energy demand for Refrigeration

Energy efficiency

Environmentally Friendly Refrigerants

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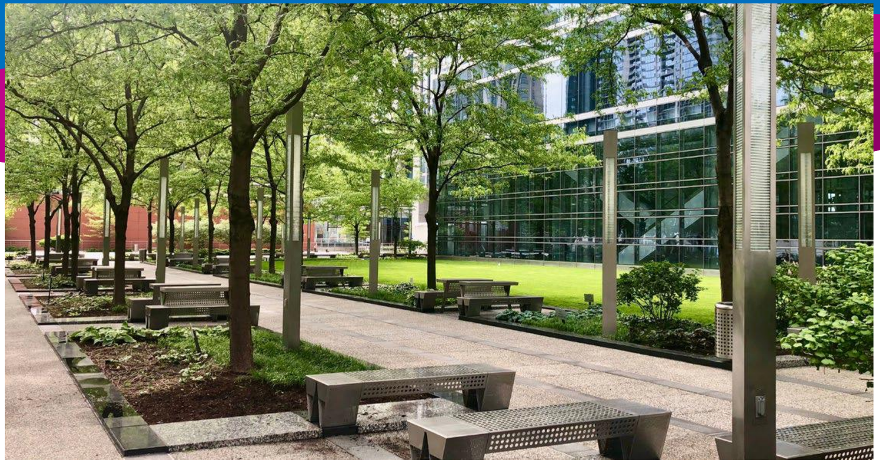
Reducing Cooling Demand



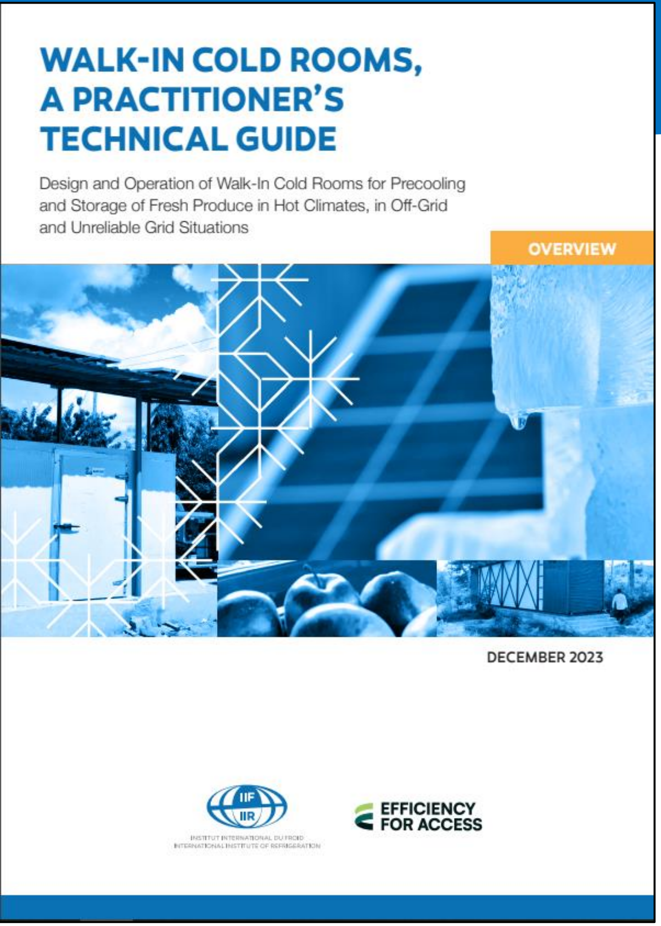
- Reduce cooling loads while maintaining indoor thermal comfort.
- Techniques: improved insulation, reflective surfaces, shading (nature and building design), natural ventilation, orientation, urban design….

→ **Building Energy Codes**: a regulatory instrument tool for governments is crucial.

- Passive cooling: Reduce the demand for cooling by 24% and savings on new equipment US$3 trillion and emissions by 1.3 billion tons CO_2e by 2050 [Global Cooling Watch, 2023]
- Retails: Doors in display Cabinets

The potential for Renewables

ADVANCING SUSTAINABLE **AGRI**CULTURE THROUGH OFF-GRID ENERGY AND **COOL**ING SOLUTIONS IN AFRICA



WALK-IN COLD ROOMS, A PRACTITIONER'S TECHNICAL GUIDE

Design and Operation of Walk-In Cold Rooms for Precooling and Storage of Fresh Produce in Hot Climates, in Off-Grid and Unreliable Grid Situations

OVERVIEW

DECEMBER 2023

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EFFICIENCY FOR ACCESS

Download the guide for Free

SOPHIA

Sustainable Off-grid solutions for Pharmacies and Hospitals In Africa

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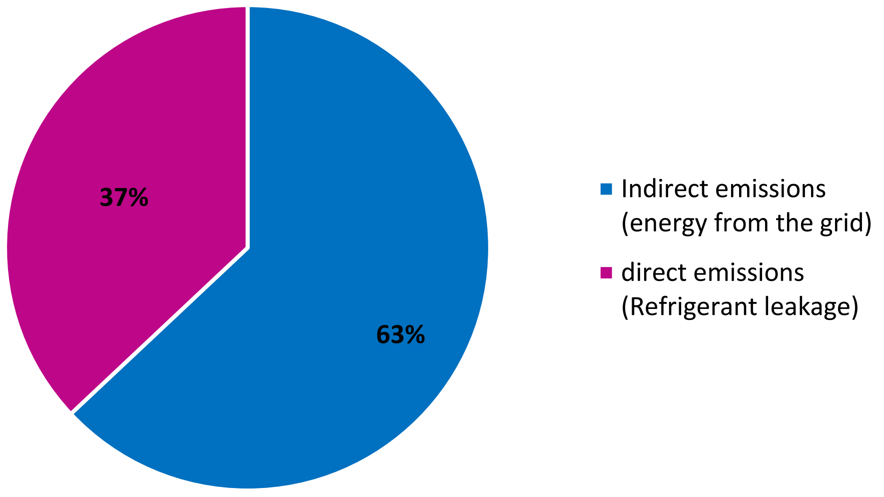
Energy Efficiency

- Energy efficiency relates the desired result with resources used to get it “Doing more with less” (EU, 2005)
- Energy savings (reduction in energy consumption: spend less to get the same result)
- Lower environmental impact (reduction in greenhouse gases and other pollutants)
- Energy security (less dependency on imported energy)
- Reduced energy costs

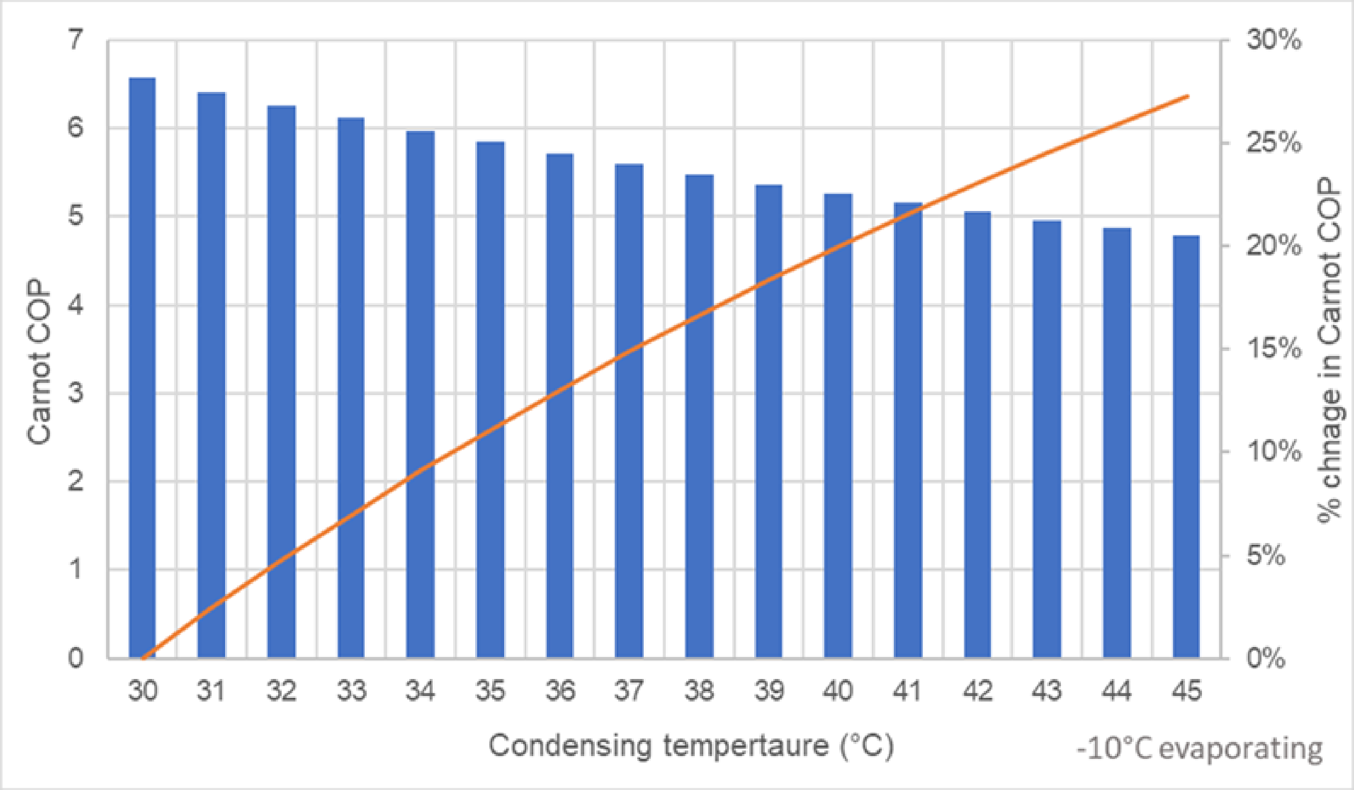


Global split of GHG emissions from refrigeration systems

[IIR 2017] The Impact of the Refrigeration Sector on Climate Change

Energy Efficiency: It is also about adaptation!

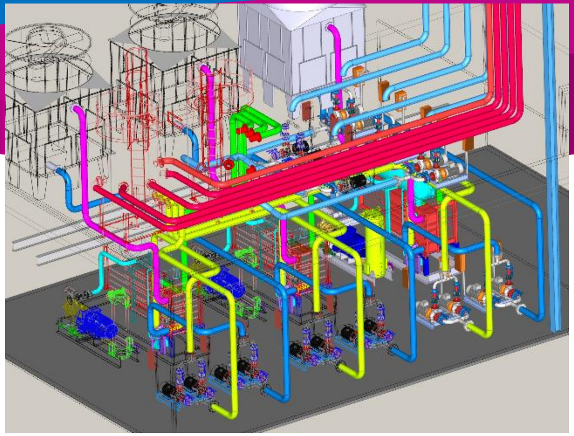
- Coefficient of performance (COP)
- Carnot COP: ratio of useful cooling provided to work (energy) required
- $COP_{Carnot} = T_{evap}/(T_{con}-T_{evap})$
- For every 1K increase in ambient temperature the COP decreases by ~1.5-2.5% (assuming evaporating temperature remains the same)



Energy Efficiency: It is also about adaptation!

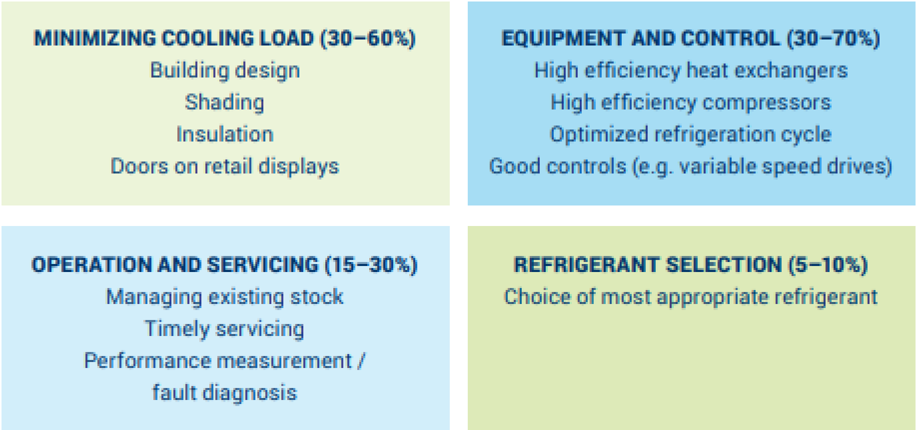
- Designed to operate at a maximum ambient temperature
- In the past this might have been 28/30°C (for UK)
- In the future needs to be 34-40°C
- Impact of operating above design condition:
  - Greater energy consumption
  - Increased carbon emissions
  - Less cooling capacity
  - Potential issues with components, oil
- Future impacts of warmer world:
  - More breakdowns/failures
  - Less resilience/reliability
  - If higher humidities – greater need for defrosting, higher infiltration loads

Energy Efficiency: Opportunities and potential improvements



A holistic approach to maximise the efficiency:

- Heat recovery (e.g. CO_2 transcritical systems)
- Thermal energy storage (Sensible or Latent PCMs)
- Selection of appropriate equipment type and size, with high efficiency cycles and components e.g. Frequency inverters to improve efficiency of compressors (40%-60% energy consumption)
- Use of appropriate controls/strategies to maximise efficiency under all operating conditions
- Application of good installation, operating and maintenance practices to support high efficiency operation throughout the life of the equipment.



MINIMIZING COOLING LOAD (30–60%) Building design Shading Insulation Doors on retail displays	**EQUIPMENT AND CONTROL (30–70%)** High efficiency heat exchangers High efficiency compressors Optimized refrigeration cycle Good controls (e.g. variable speed drives)
OPERATION AND SERVICING (15–30%) Managing existing stock Timely servicing Performance measurement / fault diagnosis	**REFRIGERANT SELECTION (5–10%)** Choice of most appropriate refrigerant

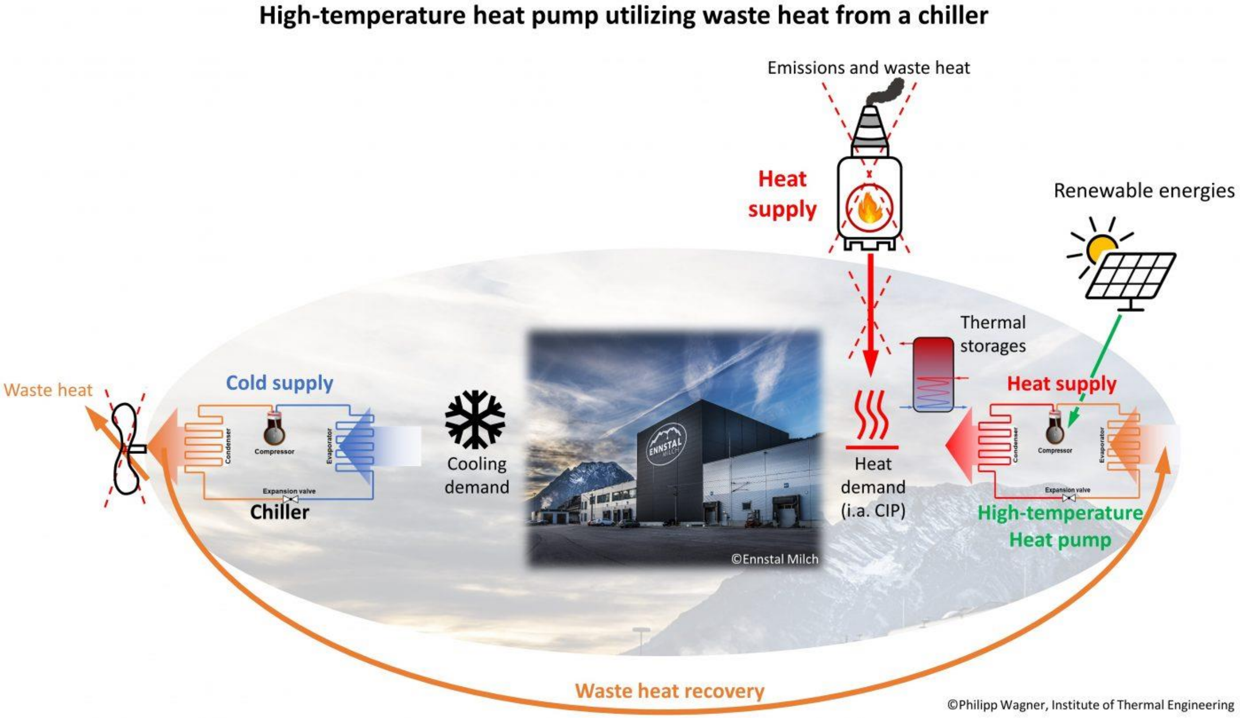
Potential for RACHP efficiency improvements (with indicative savings ranges)

[UNEP 2018] The Importance of Energy Efficiency in the Refrigeration, Air-conditioning and Heat Pump Sectors

Demo Dairy Austria: High-temperature heat pump At Ennstal Milch dairy

- Supply of the cleaning-in-place process by upgrading the waste heat from a chiller with a high temperature heat pump
- Temperature levels of up to 90°C
- Reduction of the energy demand approx. 3 MWhth/day
- CO_2 reduction compared to a gas boiler approx. 600 kg/day

High-temperature heat pump utilizing waste heat from a chiller



©Philipp Wagner, Institute of Thermal Engineering

©Ennstal Milch

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Energy efficiency: Barriers and intervention needed

Barriers

- Information barriers (limited access to information for end user).
- Financial and market failure (preference to low CAPEX and handle Opex).
- Behavioural (unaware of maintenance regimes).
- Limited competencies on energy efficient operations.
- Governance barriers (lack of resources, capacities and expertise to enforce new policies and regulations).

Interventions for a rapid phase out of inefficient equipment

- Regulations (building energy codes, MEPS, stop dumping)
- Incentives (Fiscal policies)
- Information (equipment energy labels and capacity-building programmes)

✗

No for Dumping!

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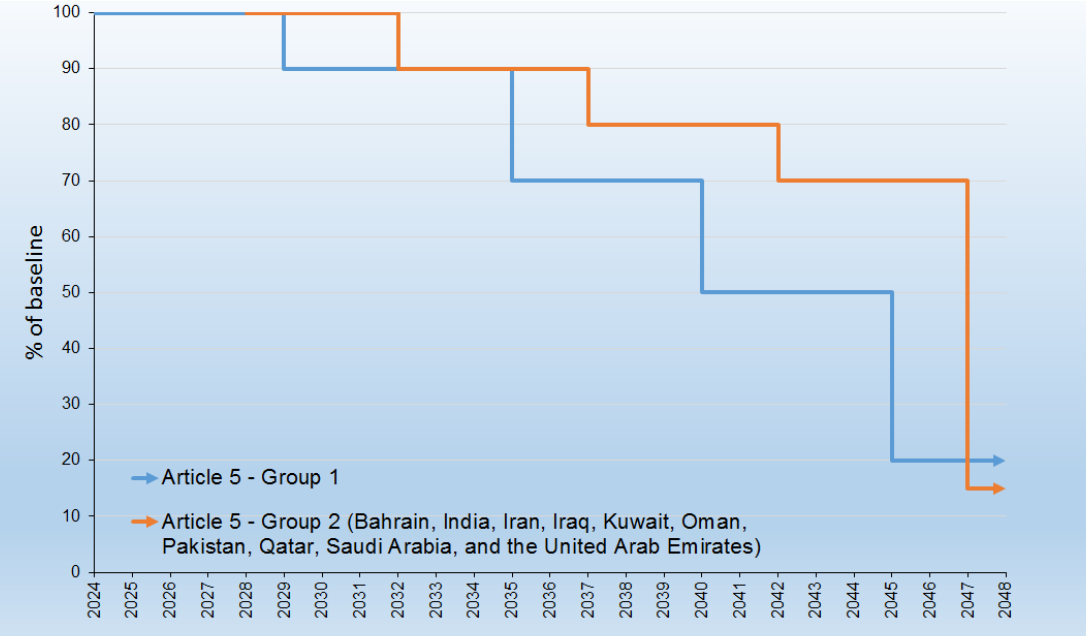
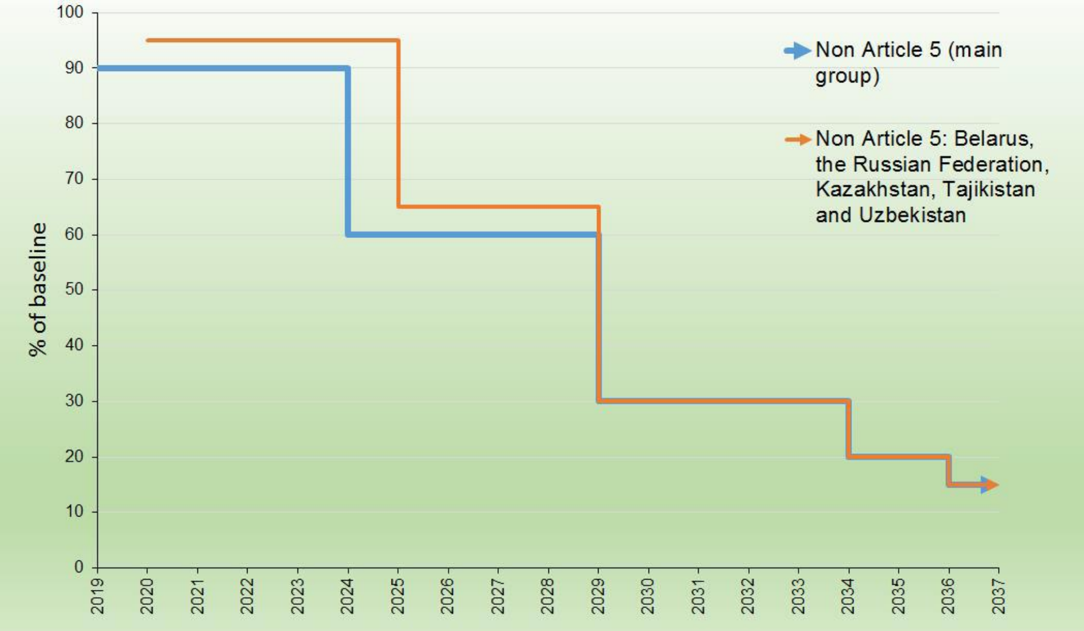
Refrigerants

The Kigali amendment has already been ratified by more than 150 countries, soon by all, as the Montreal Protocol already.





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Refrigerants

- Additional policy actions, beyond the goals of the Kigali Amendment to achieve the HFC phase down at a faster rate .

- Regional regulations are ambitious and firmer plans e.g. F-Gas III new restrictions (total HFC phase out), PFAS…

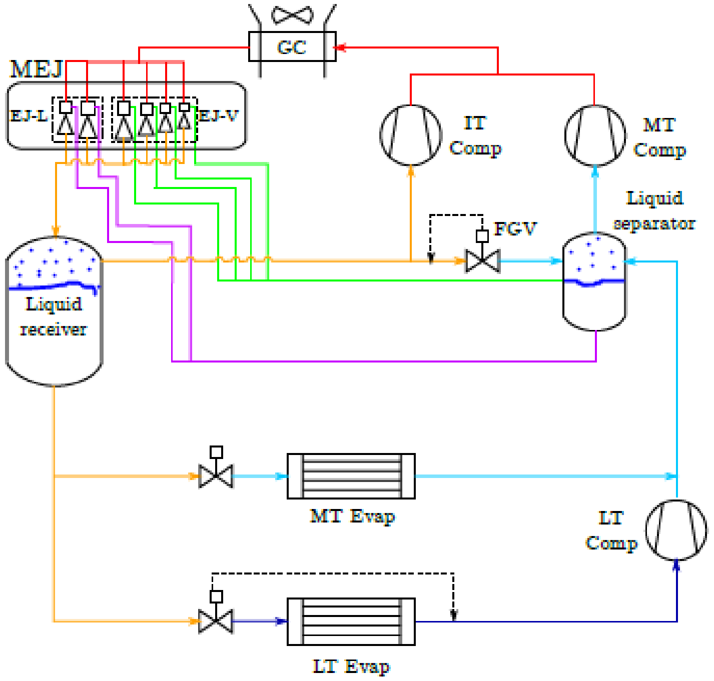
- Rapid uptake of environmentally friendly refrigerants in all new equipment and better refrigerant life-cycle management to prevent leakages and EoL emissions.

- Training from now on the safe use of natural refrigerants is crucial.

The CO_2 « Equator »… disappearing

**Energy saving in South Europe

Flooded evaporators and liquid ejectors



Flooded evaporator→ can allow for an increased evaporation temperature of 5K

KPI	Porto de Mos	Reference
Total Specific Energy Demand TSED	1.44 kWh/m^2	5.52 kWh/m^2
Total Primary Energy Demand TPED	3.60 $kWh_{primary\ energy}/m^2$	13.8 $kWh_{primary\ energy}/m^2$
Peak Power Duration PPD	0.12 $kWh/kW_{installed}$	0.28 $kWh/kW_{installed}$
Average Electric Power Demand AEPD	20.5 kW	68.9 kW
LT load @ LT evaporation temperature	9.0 kW @ -31°C	-33°C
MT load @ evaporation temperature	47.4 kW @ -5.1°C	-15°C
AC load @ evaporation temperature	7.2 kW @ +1°C*	n.a.
Energy efficiency ratio EER	3.1	n.a

4270 m2 supermarket in **Porto de Mos (Portugal) amb T30°C** Multipack EU project
168 h- Energy consumption in reference shop 3.8 times higher

	Trento	Reference HFC site
MT cabinets – Electrical Energy [$MWh\ year^{-1}$]	41.1	86.4
LT cabinets – Electrical Energy [$MWh\ year^{-1}$]	59.3	83.9
MT+LT R404A Refrigeration Unit [$MWh\ year^{-1}$]	-	244.0
CO2 unit (MT+LT Refrigeration) +Heating+Cooling [$MWh\ year^{-1}$]	262.2	-

2200m2 supermarket in **Trento (Italy) amb T30°C** Multipack EU project

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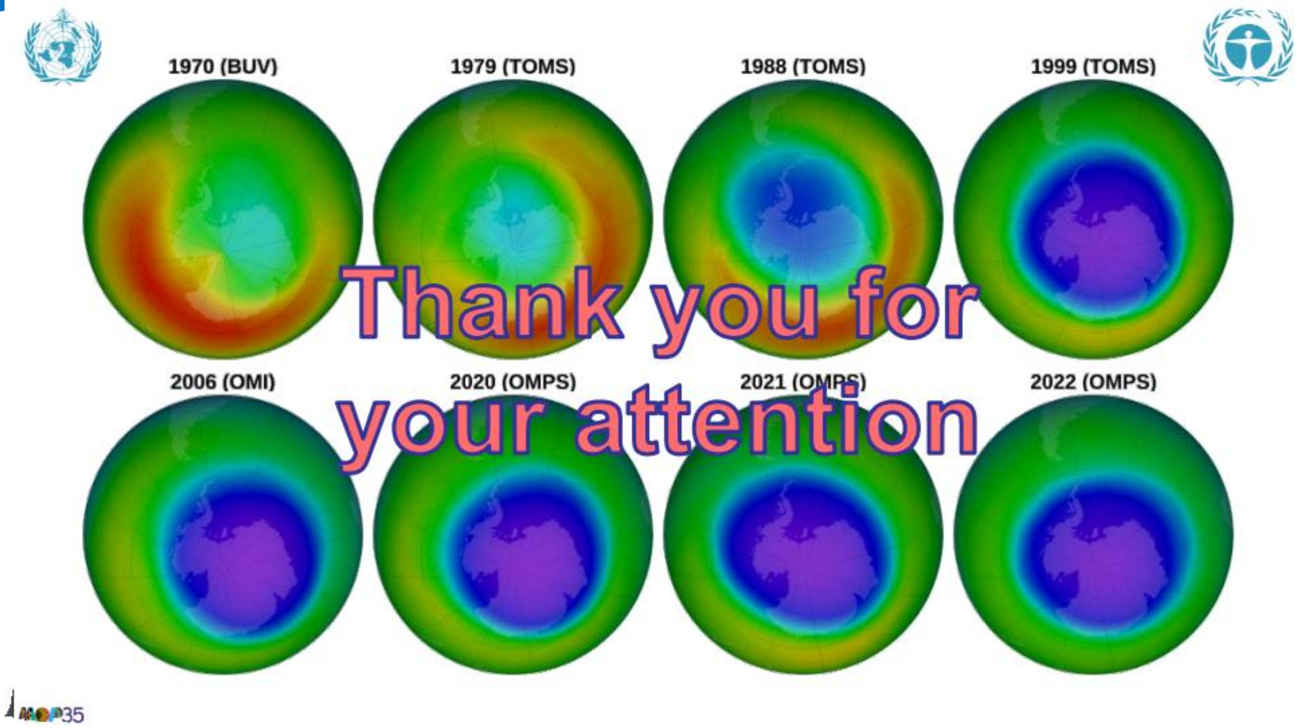
Conclusions

- A global collaborative approach is needed!
- Accessibility and implementation of HFC alternatives in A5 parties will be critical for further progress.
- Climate actions through commitments on the phase down of HFCs and an increasing energy efficiency are clear.
- We did it for Ozone layer, let's do it for climate!



Thank you for your attention

A depiction of the ozone layer above Antarctica as it existed through years Image: NASA. Presented at MOP 35

[Synthesis of the 2022 Assessment reports of the Scientific Assessment Panel, the Environmental Effects Assessment Panel and the Technology and Economic Assessment Panel]

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Join our Working Group!

The CREED Working Group: Cooling and Refrigeration Energy Consumption and Emissions Database

Global Cooling Pledge:
2050: Cut cooling related emissions by 68%.
2030: enhance energy efficiency by 50%

Objectives

- ***Goal 1:*** *Showcase existing efforts and lessons learned from current emissions modelling*
- ***Goal2:*** *Create a momentum of collective actions toward the refrigeration sector emissions*

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Thank you!

Air Conditioner Split Systems in Africa

Mr. Adlain Eyarmwen Nkie Akan

Vice-President U-3ARC

Union of Associations of African Actors in Refrigeration and air Conditioning

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Air Conditioner Split Systems in Africa

INDEX

1. Energy efficiency:
   Has it any sense outside the Western countries?
2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.
3. Fight against the export of air conditioners to Africa
4. Draft solutions

Air Conditioner Split Systems in Africa

1.Energy efficiency: has it any sense outside the Western countries?

- Energy efficiency refers to the ability of a system or appliance to achieve the desired efficiency (such as cooling in the case of air conditioners) while minimizing energy consumption.
- Simply put, an energy-efficient air conditioning system ensures efficient cooling without excessive energy waste.
- Africa in general and in particular sub-Saharan Africa has a proven energy deficit, hence the need for energy-efficient equipment.

Air Conditioner Split Systems in Africa

1.Energy efficiency: has it any sense outside the Western countries?

- Protecting our environment concerns us all because the world is global and globalizing, we must behave responsibly to ensure a better future for the next generations.
- An energy concept that is valid for one continent must be valid for all others and its implementation must not be discriminatory.
- When implementing a program to eliminate certain substances such as the Montreal Protocol or strategies to mitigate climate change, care must be taken to ensure that the problem does not migrate from one continent to another.

Air Conditioner Split Systems in Africa

2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.

- According to a recent report, 35% of individual air conditioners sold in ten African countries are low-energy air conditioners. Air conditioners containing R22 represent 47% of the market, while 49% contain R410A.
- Introduction of minimum energy performance standards (MEPS) and prohibition of air conditioners using high GWP refrigerants could prevent such environmental dumping*

Air Conditioner Split Systems in Africa

2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.

- China is the largest exporter of air conditioners in R22 (57%), followed by Egypt (11%), the United States (3%), Nigeria (1.6%) and South Korea (0.6%). The largest markets for low-energy air conditioners are Nigeria and Egypt.
- Through partnerships and joint ventures with non-African individual air conditioner manufacturers, Egypt and Nigeria have the capacity to mass produce, assemble and export individual air conditioners to the rest of the African market.

**Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa.*

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Air Conditioner Split Systems in Africa

2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.

- The top four sources for the low-energy individual air conditioner market in the target countries are:
- 26%: non-African companies that export energy-efficient individual air conditioners incorporating obsolete air conditioning technologies.
- 23%: joint ventures between small African assemblers and large manufacturers of individual non-African air conditioners that assemble individual air conditioners with lower energy efficiency than marketable products on the national territories of the non-African partner of the participating company. *

***Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa.*

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Air Conditioner Split Systems in Africa

2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.

- 18%: Independent African individual air conditioner assemblers who import components and assemble low-energy individual air conditioners.
- 6%: local subsidiaries of non-African companies assembling individual air conditioners in Africa and using imported components for products whose effectiveness is too low to be sold on the domestic market of non-African companies.
- These products are sold under the brand of the non-African company. *

**Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa.*

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Air Conditioner Split Systems in Africa

2. Obsolete and energy-intensive air conditioners: their export to Africa vs the protection of the environment.

- The Collaborative Labelling and Appliance Standards Program (CLASP) recently released a report examining the split air conditioner market in 2018 in 10 countries that represent 96% of the African market: Algeria, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania and Tunisia.
- In this report, "low energy efficiency air conditioners" were defined as individual air conditioners with an energy efficiency ratio (EER) below the minimum threshold of 3,0 W/W. Since an ERA of 3.0 W/W is the minimum threshold for most countries that export air conditioners to African countries, these products could not be sold in the countries where they are manufactured*.

*****_Environmentally Harmful Dumping of Inefficient and Obsolete Air Conditioners in Africa._

Air Conditioner Split Systems in Africa

3. Fight against the export of energy intensive air conditioners in Africa

- Low-energy individual air conditioners are more energy intensive and more expensive for consumers and governments. Consumers pay higher electricity bills and countries pay more for electricity generation facilities, imported fuel, electricity transmission and distribution infrastructure.
- The transition to energy-efficient individual air conditioners can reduce this burden on consumers and governments. For example, a World Bank study of the market for individual air conditioners in North Africa estimated that the avoided investment cost per unit could reach an average of $234 in 2030. This money could be saved by establishing and strengthening MEPS and banning individual air conditioners containing HCFCs and high GWP refrigerants.

Air Conditioner Split Systems in Africa

3. Fight against the export of energy intensive air conditioners in Africa

- Some African countries have implemented energy efficiency standards and bans on second-hand (used) equipment. However, many African countries have not yet implemented any policy against environmental dumping for new products.
- In September 2019, United for Efficiency (U4E) released a model of energy efficiency standards and labelling guidance to help governments in developing and emerging economies establish or strengthen their regulations. The adoption of the U4E Model MEPS in 2022 could result in a cumulative reduction in greenhouse gas emissions between 2022 and 2030 of 40 Megatons of CO2 eq. in the target countries.

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Air Conditioner Split Systems in Africa

4. Draft solutions

The CLASP report suggests that African policymakers take steps to end the environmental dumping of low-energy, obsolete individual air conditioners. Actions could include:

- Ratification of the Kigali Amendment to the Montreal Protocol and adoption of implementation policies.
- The development and implementation of MEPS and labelling policies in line with the main exporting countries of individual air conditioners.
- Strengthening of institutional arrangements

Air Conditioner Split Systems in Africa

4. Draft solutions.

1. Review of tariffs on individual air conditioners to ensure compatibility with energy efficiency targets.
2. The ban on importing second-hand, low-energy-efficient individual air conditioners, even retrofits. Publicize and enforce this ban.
3. The organization of group buying and buying clubs to group requests and purchases at affordable prices of individual air conditioners with high energy efficiency and low GWP.
4. Proper recycling and disposal of obsolete individual air conditioners.
5. BAN THE PRODUCTION OF NON INVERTER SPLIT AIR CONDITIONERS

Air Conditioner Split Systems in Africa

THANK YOU www.u-3arc.org vice-president@u-3arc.org

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Maintenance and Repair for the Optimization of Energy Efficiency in the Latest Technologies

Marco Buoni

Director of the Centro Studi Galileo &

Past President of AREA - Air conditioning and Refrigeration European Association

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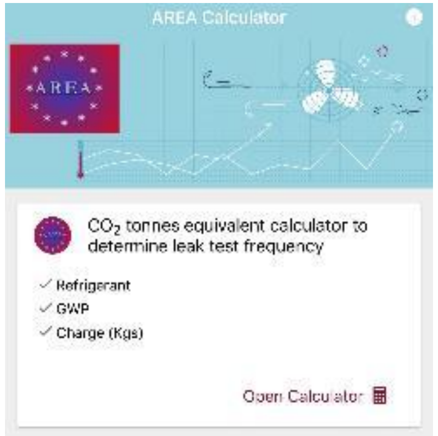
About Centro Studi Galileo

Online communication:

- **I&F Blog** for spreading RAC news and facts
- Monthly **newsletter** to 60.000 technicians
- **Websites** for training courses
- **Social medias**
- **AREA app**



AREA Calculator

CO$_2$ tonnes equivalent calculator to determine leak test frequency

✓ Refrigerant
✓ GWP
✓ Charge (Kgs)

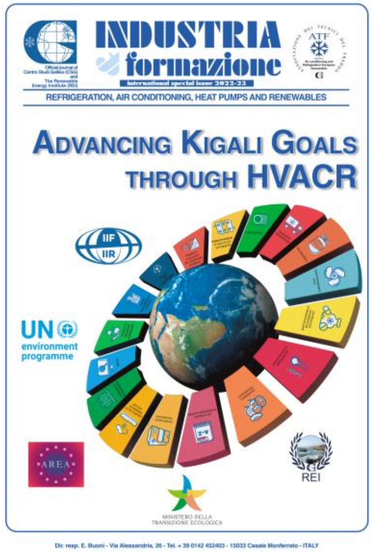
Open Calculator

International presence:

- **Training courses** in Italy and globally (300 trainings every year to 3000 technicians)
- **International Special Issue** I&F

Presented in
MOP and **COP**

INDUSTRIA formazione
International special issue 2019-20
REFRIGERATION, AIR CONDITIONING, HEAT PUMPS AND RENEWABLES
SUSTAINABLE COOLING FOR A HEALTHY FUTURE
SPECIAL SECTION ON FOOD COLD CHAIN AND THE MONTREAL PROTOCOL



INDUSTRIA formazione
International special issue 2022-23
REFRIGERATION, AIR CONDITIONING, HEAT PUMPS AND RENEWABLES
ADVANCING KIGALI GOALS THROUGH HVACR

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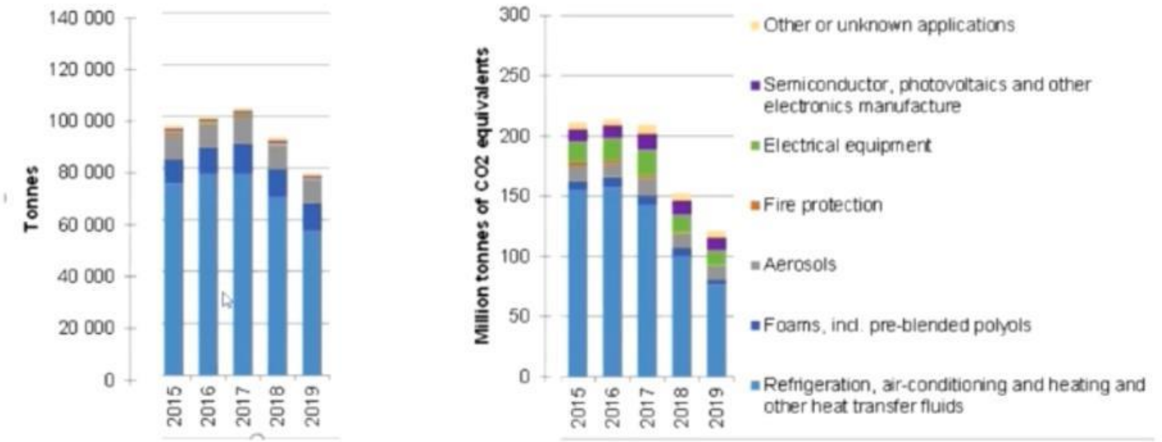
Kigali assessment – Can Europe be an example?

- For phase down
- For using alternative refrigerants
- For using not refillable cylinders
- Leak Checks and Periodical inspections
- Training and certification schemes – training equipment
- Register, Record Keeping, online database

Training for “Kigali

Fgas Regulation and the Certification is working (500.000 certified technicians in EU):

- less leaks, more controls on the system, periodical inspections
- more competence, skilled personnel and companies
- better equipped, calibration, recovery, reuse, reclaimed refrigerant
- lower quantities of high GWP refrigerants in the market
- higher quantities of alternative refrigerants (mainly flammables)



Source: EEA 2020 report on fluorinated greenhouse gases

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Official Training Provider

We need a certification on top of what we have, which is working
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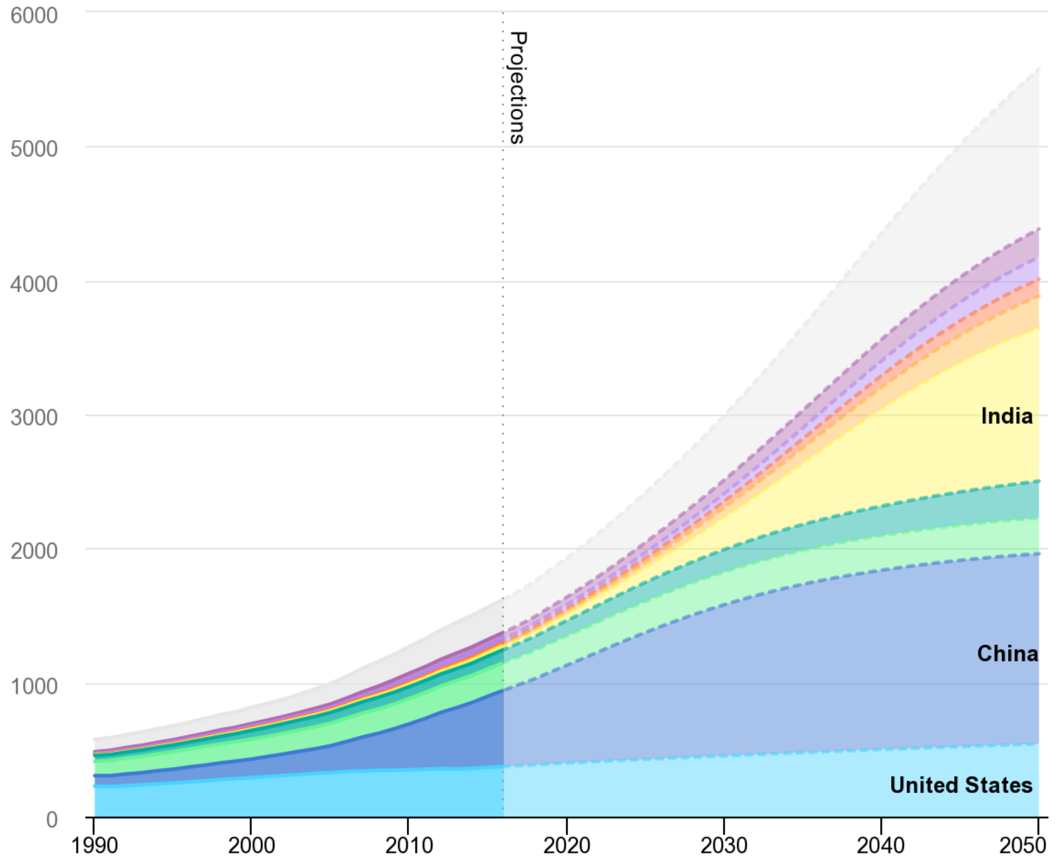
Opportunities for energy-efficient air conditioning

- By 2050, around 2/3 of the world's households could have an air conditioner. China, India and Indonesia will together account for half of the total number.
- IEA, Global air conditioner stock, 1990-2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-air-conditioner-stock-1990-2050

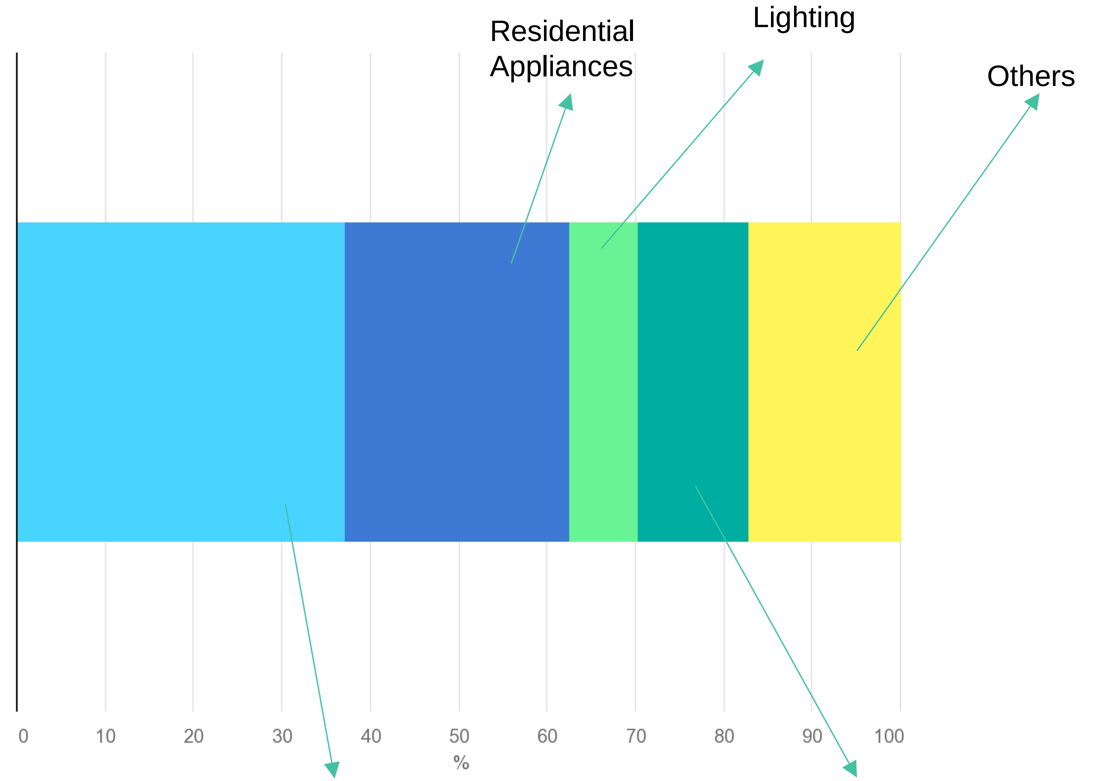


Training in installing and maintaining systems keeping the high designed efficiency

Cooling is the fastest growing use of energy in buildings

- Without action to address energy efficiency, energy demand for space cooling will more than triple by 2050 – consuming as much electricity as all of China and India today.
- IEA, Share of global electricity demand growth to 2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/share-of-global-electricity-demand-growth-to-2050
- The problem is, today's consumers are not buying the most efficient ACs, but the cheaper, MEPs (minimum energy performance standards) would be welcome
- The average efficiency of air conditioners sold today is less than half of what is typically available on the shelves – and one third of best available technology.

Year 2050



Share of electricity demand growth - Space cooling 37%

Share of electricity demand growth - 12,4%Heating

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Refrigerant leakage and its impact on energy efficiency

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Making a case for reducing leakage

- Reducing leakage makes business, financial and environmental sense. The benefits to business include:
  - Compliance with legislation including the F Gas regulation;
  - Improved “green” credentials;
  - Reduced production down time / increased sales fixture availability / improved staff comfort as a result of improved reliability;
  - Less health and safety risk from refrigeration or air conditioning – directly from refrigerant emissions and, for food applications, indirectly as a result of improved reliability.
- In addition there are financial benefits:
  - Less refrigerant cost;
  - Less service cost;
  - Lower costs associated with plant down time;
  - No loss of energy efficiency associated with reduced refrigerant charge. These costs may need to be offset against increased maintenance or some additional capital expenditure, but usually the difference is positive.
- The environmental benefits are in parallel with the benefits identified above and include:
  - More efficient operation of RAC systems and hence lower emissions of CO2 at the power station;
  - Lower emissions of greenhouse gases.
- **With Alternative refrigerants, which are mainly flammables, leakage are potentially dangerous and a source of fire ignition and propagation**

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Financial, energetic, environmental, safety & reliability: Alternative Refrigerants & Leakage

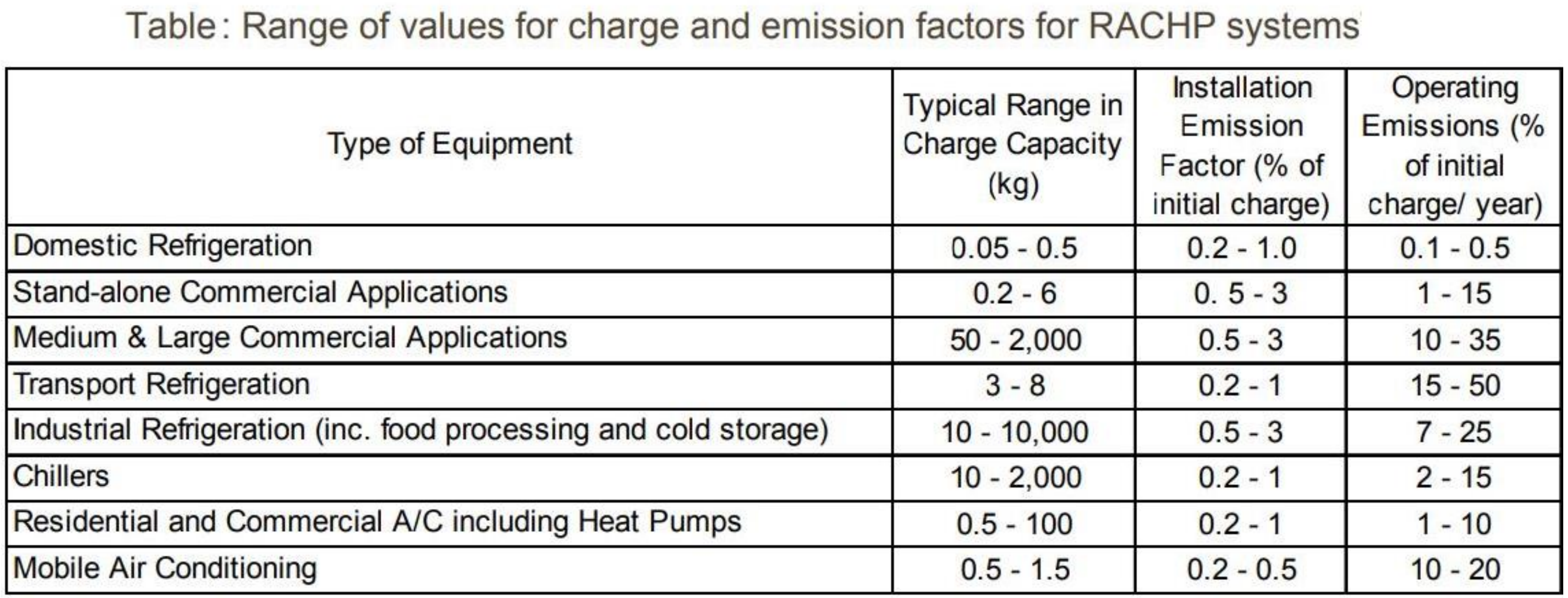

Table: Range of values for charge and emission factors for RACHP systems

Type of Equipment	Typical Range in Charge Capacity (kg)	Installation Emission Factor (% of initial charge)	Operating Emissions (% of initial charge/ year)
Domestic Refrigeration	0.05 - 0.5	0.2 - 1.0	0.1 - 0.5
Stand-alone Commercial Applications	0.2 - 6	0. 5 - 3	1 - 15
Medium & Large Commercial Applications	50 - 2,000	0.5 - 3	10 - 35
Transport Refrigeration	3 - 8	0.2 - 1	15 - 50
Industrial Refrigeration (inc. food processing and cold storage)	10 - 10,000	0.5 - 3	7 - 25
Chillers	10 - 2,000	0.2 - 1	2 - 15
Residential and Commercial A/C including Heat Pumps	0.5 - 100	0.2 - 1	1 - 10
Mobile Air Conditioning	0.5 - 1.5	0.2 - 0.5	10 - 20

Source: IPCC, Guidelines for National Greenhouse Gas Inventories

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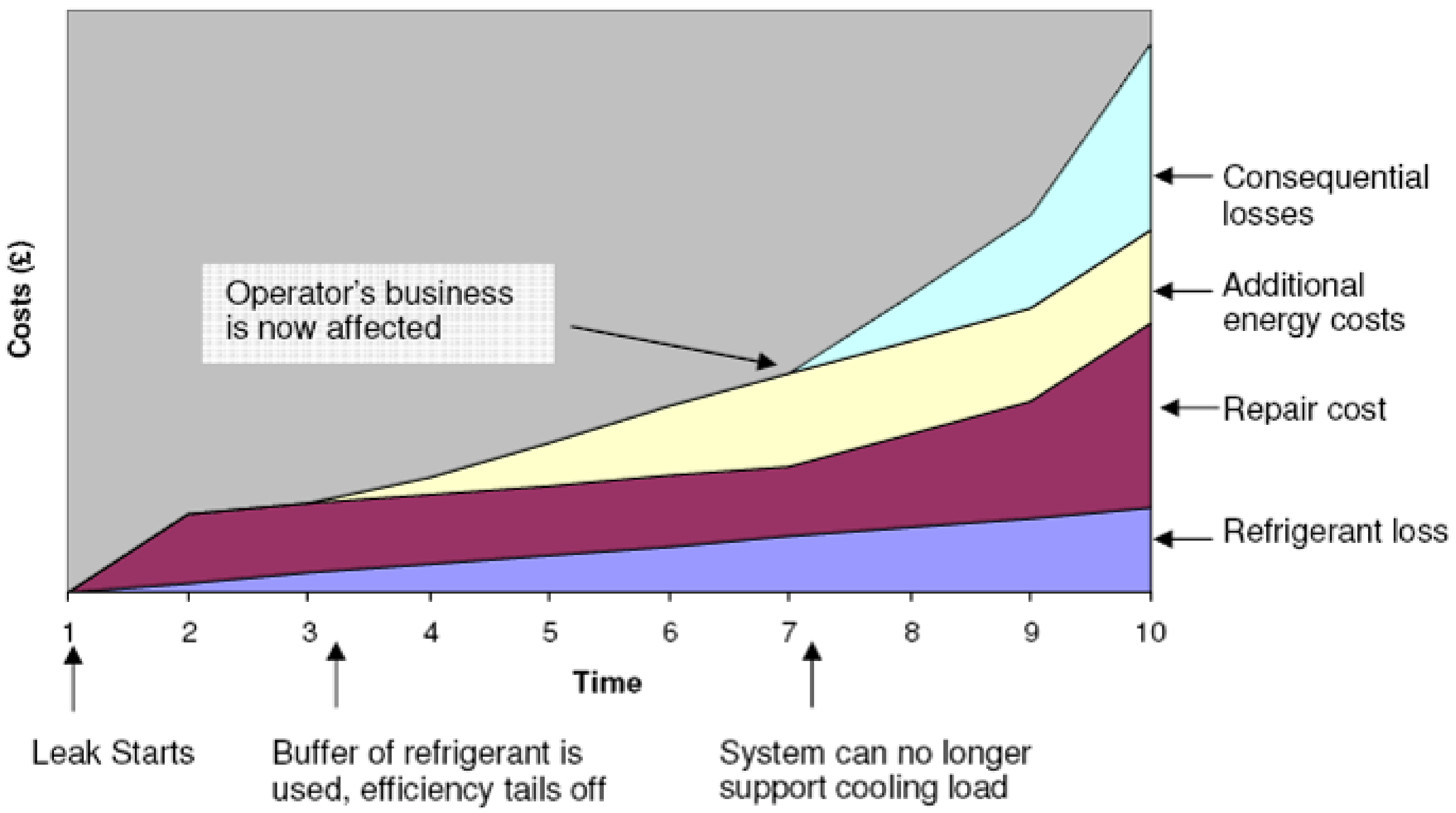
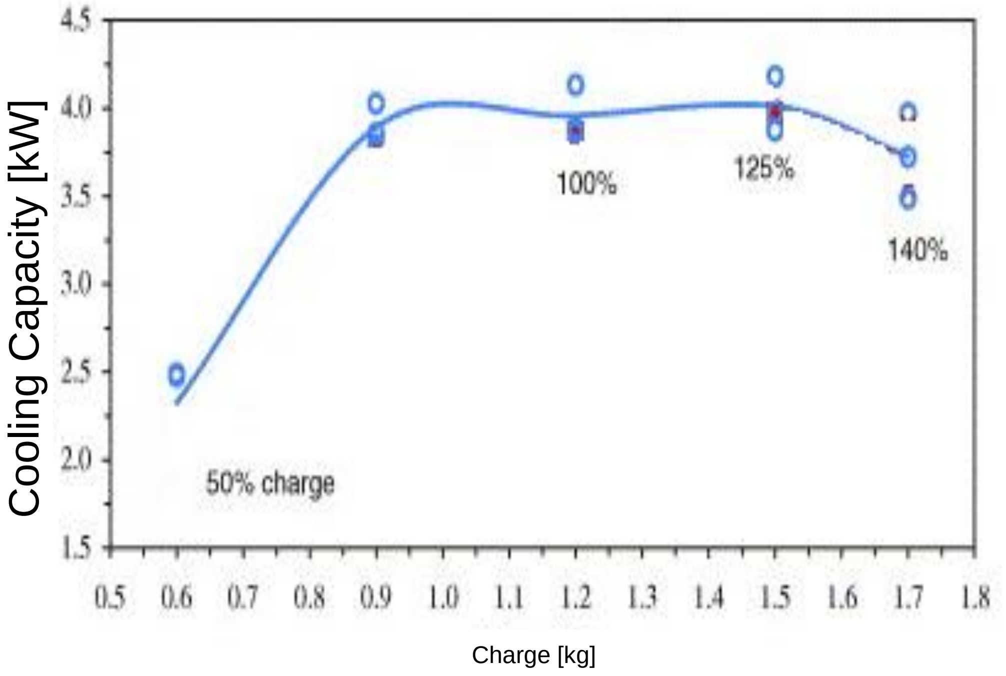
Financial and Energetic cost

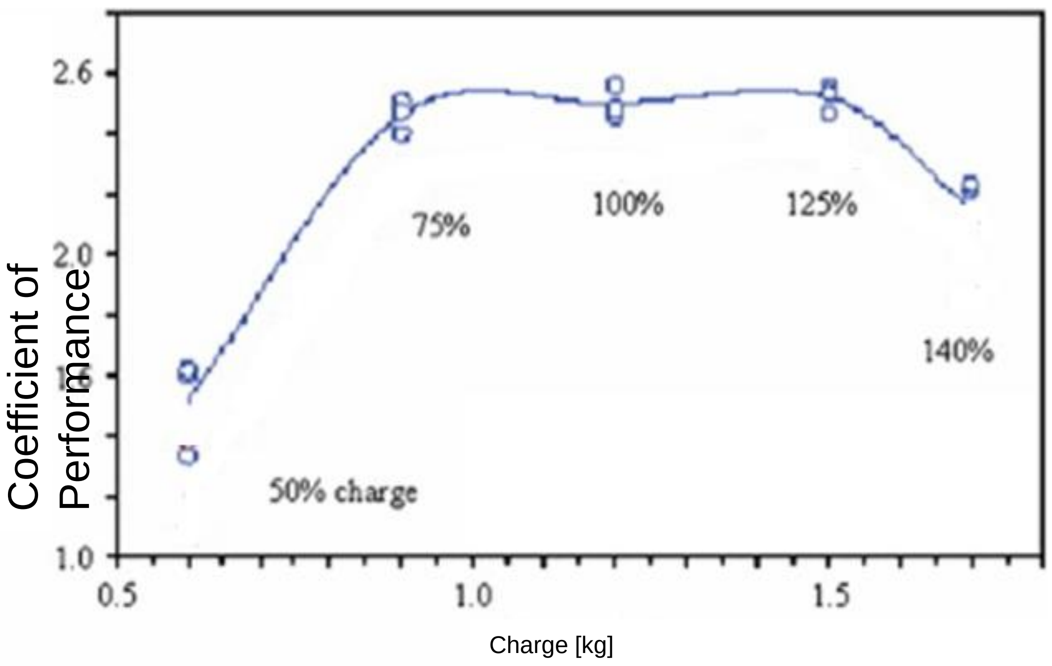
Source: IIR informative notes

Cost of a Refrigerant leak



Research on one system type to determine the effect of leakage on one system





Source: Grace, I.N., Datta, D. and Tassou, S.A. (2005), Sensitivity of refrigeration system performance to charge levels and parameters for on-line leak detection. Applied Thermal Engineering, 25 (2005),

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Reduction of leakage due to increase in competence and EU Fgas regulation

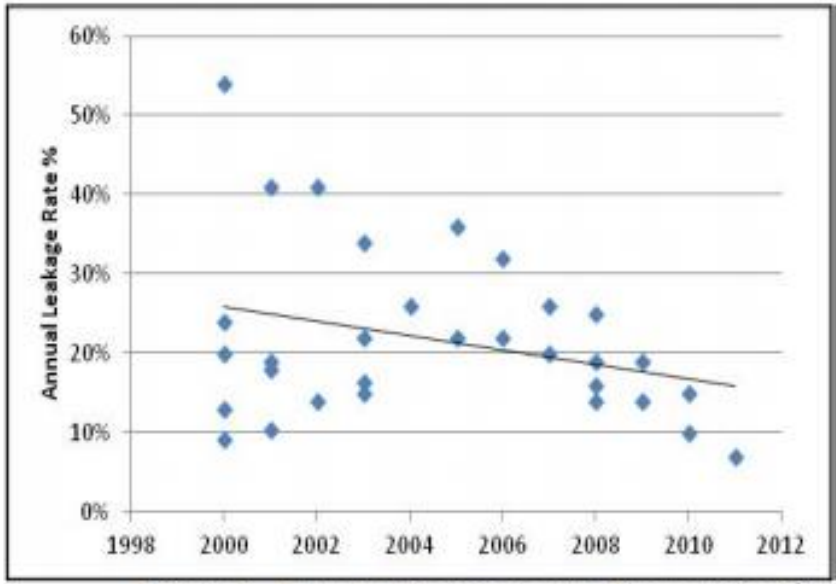

Figure 1. Reported leakage rates from studies[2]

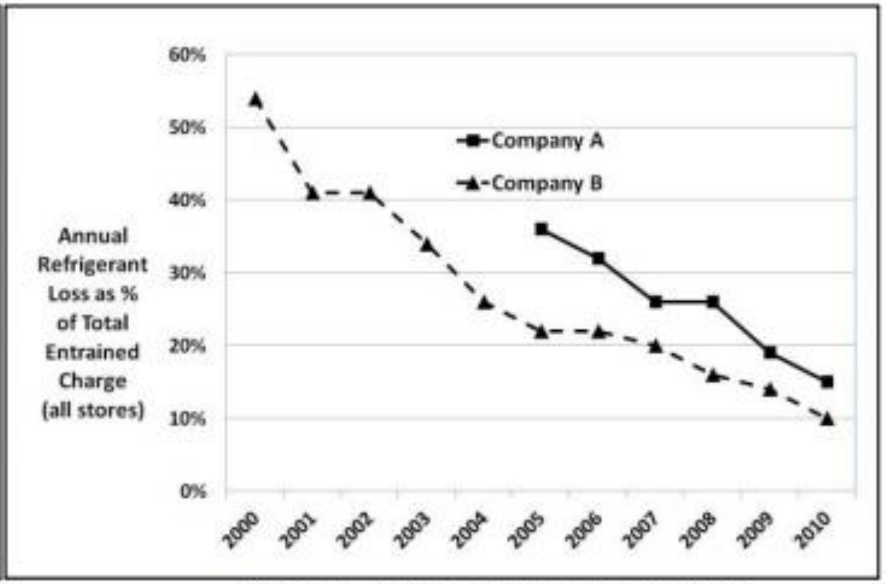

Figure 2. Leakage rates reported by two end users (supermarkets)[3]

Source fig.1: Updated from Cowan D, Gartshore J, Chaer I, Francis C, Maidment G. (2010), REAL Zero – reducing refrigerant emissions & leakage - feedback from the IOR project, Proceedings of the Institute of Refrigeration, Proc. Inst. R. 2009-10. 7-1
Source fig.2: Cowan D, Beermann K, Chaer I, Gontarz G, Kaar K, Koronaki I, Maidment G, Reulens W. (2011), Improving F-Gas containment in the EU – results from the REAL SKILLS EUROPE project.

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Importance of regular maintenance of buildings (credit IRI Ireland)

- **Benefits of Deep Cleaning and Maintenance**

➢Improved IAQ. A/C units act as filters of dust, filters must be cleaned.

➢Minimized odors and micro-organisms. By cleaning an A/C unit, we kill odor causing bacteria and prevent growth of micro-organisms.

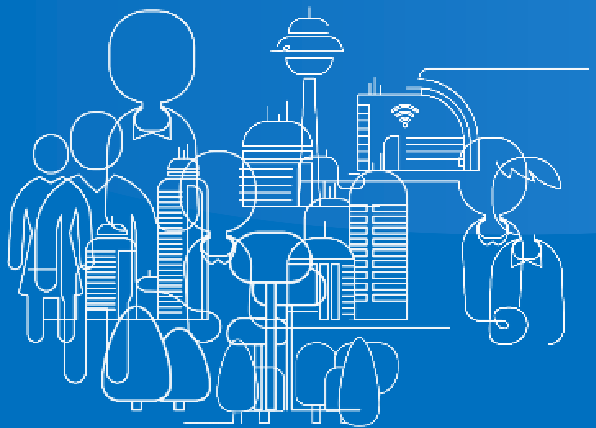
➢Lower energy use. HVAC uses significant % of energy. Cleaning and maintenance of indoor and outdoor HVAC equipment greatly reduces the amount of energy consumed. 3% per every °C of increasing of condensing temperature.

➢Longer equipment life expectancy.

- **Health and IAQ**

➢Low IAQ can lead to negative health effects: Short term and long term.

➢Studies show People perform better in better work environments.



Cooling for a better life

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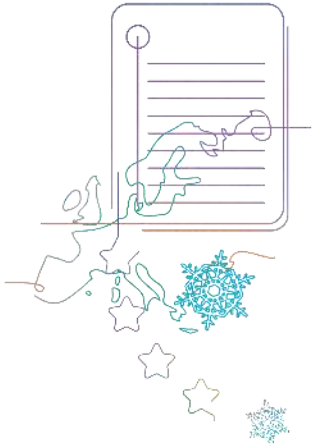
Stronger together

Thank you

Marco Buoni

Email: buoni@centrogalileo.it



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