Climate change: melting glaciers, diminishing water resources, trapped sunrays increase global warming

THE ENVIRONMENTAL ISSUE: CHALLENGES AND SOLUTIONS

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Introduction

Refrigeration is everywhere:

- Food industry and the cold chain
- Air conditioning (buildings, data centres…)
- Process cooling in other industries
- Cryogenics (petrochemical refining, steel industry, space industry, nuclear fusion…)
- Medicine and health products (cryosurgery, anesthesia, scanners, vaccines…)
- Energy sector (including heat pumps, LNG, hydrogen…)
- Environment (including carbon capture and storage), public works, leisure activities…

The use of refrigeration is expanding in all industrial, services and domestic sectors, since the most sophisticated systems you have, the most maintaining temperature at a determined level is important: temperature is a key factor in information technologies, biotechnologies, nanotechnologies … and refrigeration is necessary for life.

In addition, there are increasing needs in developing and emerging countries for the following reasons:

- 1,600 US deaths per year registered in the US are due to pathogens, at least partly associated with temperature control with many more in developing countries
- A growth in global population, particularly in Africa and South Asia
- 70% (vs 50% now) will be in urban areas (doubling in developing countries)
- 23% of food losses are caused by a lack of refrigeration (vs 9% in developed countries)
- The cold storage capacity is tenfold in developed countries
- Needs related to better health are global (reliable cold chain, air conditioning), due specifically to an ageing population
- A recent MIT study showed mortality during hot days (temperatures higher than 32°C) decreased by 80% between 1900-1959 and 1960-2004 in the US: « The adoption of residential air conditioning explains essentially the entire decline in the temperature-mortality relationship »
- The IPCC forecasts an increase in energy demand in air conditioning in the summer over 13 fold between 2000 and 2050 and 30 fold by 2100 under its reference scenarios.

Refrigeration can play a major role in reducing global warming, since reducing food losses reduces the carbon footprint of the food produced: saving energy used for food that will be lost encompasses the environmental impact of refrigerating equipment. However, increasing needs of refrigeration may increase the environmental impact. We thus need to face two challenges.

1. The Energy Issue

Refrigeration, including air conditioning, represents 17% of the overall electricity used worldwide (IIR estimation).

Chart 1: *Distribution of the global refrigeration sector's electricity consumption (%)*

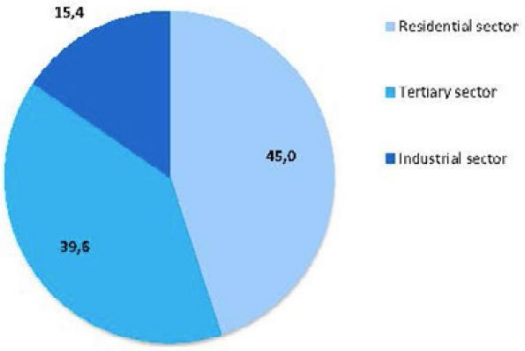
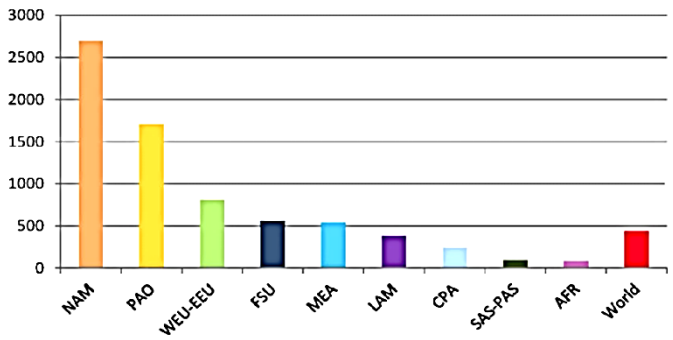


Chart 1 shows the distribution of the global refrigeration sector's electricity consumption between the residential, tertiary and industrial uses (as estimated by the IIR).

Chart 3: *Distribution of electricity consumption for refrigeration (kWh/year/capita) between world regions**



* *According to IPCC definition of SRES World Regions* [17]

Chart 3 demonstrates differences in the refrigeration-sector electricity consumption regions with different development levels and climatic conditions.

Globally, 440 kWh/year/capita are spent for refrigeration purposes; however, this figure varies from 76 in Sub-Saharan Africa to 2,697 in North America.

NAM: North America

PAO: Pacific OECD

WEU-EEU: Western, Central and Eastern Europe

FSU: Independent states of the former Soviet Union

MEA: Middle East and North Africa

LAM: Latin America and the Caribbean

CPA: Centrally planned Asia and China

SAS-PAS: South Asia – Other Pacific Asia

AFR: Sub-Saharan Africa

This 17% share is constantly progressing because of increasing refrigeration demand. Electricity is mainly produced thanks to fossil fuels and thus indirect CO2 emissions of refrigerating equipment are higher than direct greenhouse gas emissions due to the refrigerants use.

We can decarbonize the energy used thanks to renewables in energy production or in energy directly provided to the refrigerating system: solar cooling, evaporative cooling, use of waste energy (cogeneration, trigeneration…). We also can improve the energy efficiency of the system, in improving the coefficient of performance:

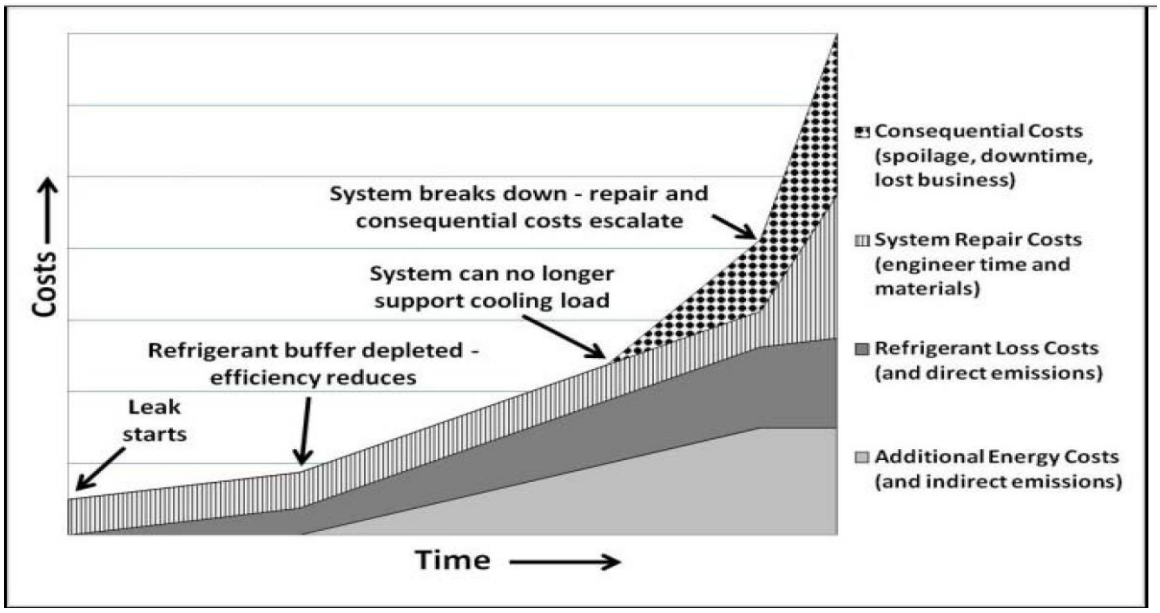
$$\mathrm{COP} = \frac{\text{Heat extraction rate}}{\text{Rate of energy used}}$$

1st solution:

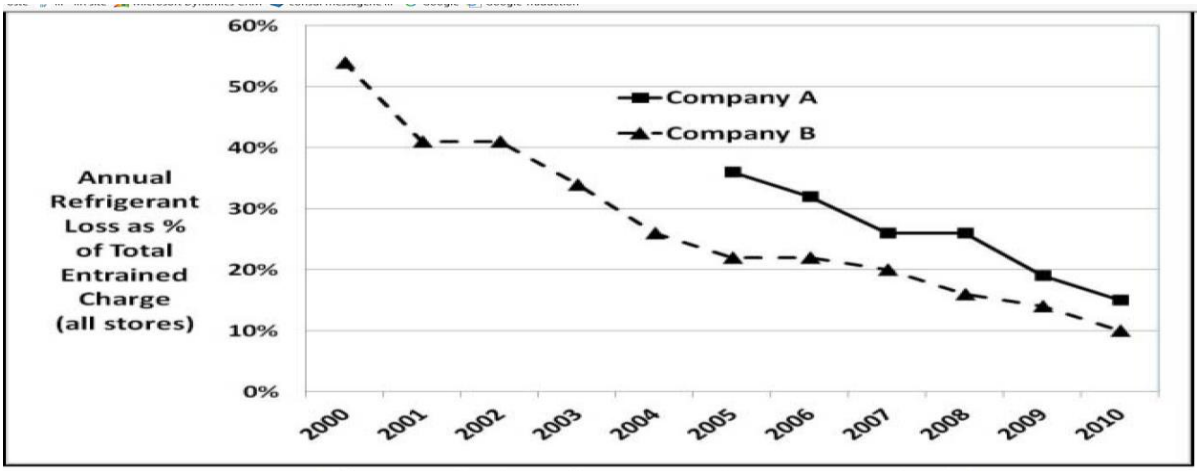
- to insulate the refrigerated room and low temperature parts of the system
- to minimize ambient air infiltration
- to reduce the energy used in refrigerated applications (fans…)

2nd solution:

- reducing the refrigerant leakage
- reducing the refrigerant charge



Escalating cost of an unchecked refrigeration system leak

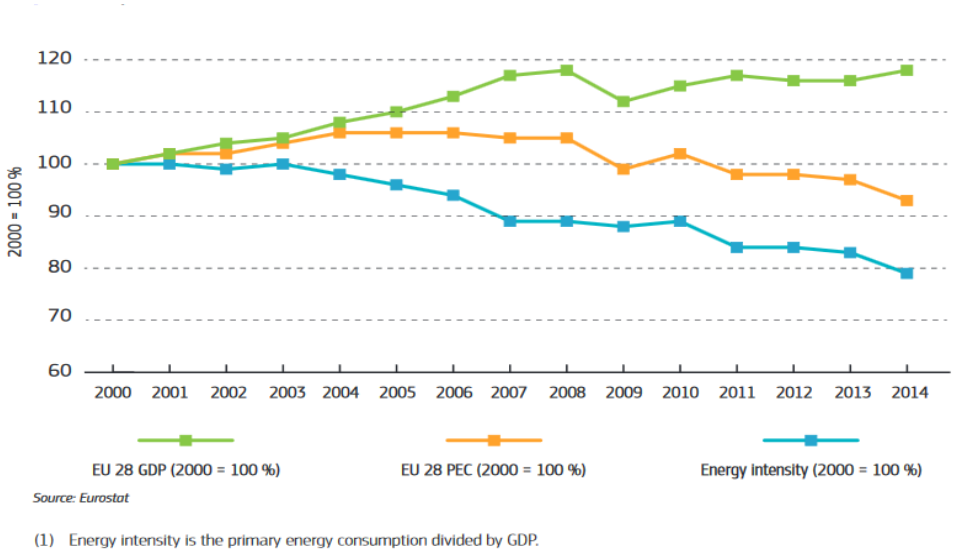


Leakage rates reported by two end users (supermarkets)

3rd solution: improving the efficiency of the system components

- properties of the refrigerant
- Lubricant
- Design of:
    - Compressor
    - Expansion devices
    - Evaporators
    - Interconnecting piping

Many measures can be taken at national or regional levels to incite people to improve the energy efficiency of the systems: regulations, standards, labialization (energy classes), financial incentives, research, training, information … And it can be efficient, as showed by the following figure of the European Union:



Source: Eurostat

(1) Energy intensity is the primary energy consumption divided by GDP.

Gross Domestic Product (GDP).Primary Energy Consumption (PEC) and energy intensity in the European Union from 2000 to 2014. This policy must be coordinated with the policy on refrigerants.

2. The Refrigerants Issue

- 2 secretariats within UNEP, 2 different issues:
    - Climate change + Ozone layer
    - Rio Convention/Kyoto Protocol + Montreal Protocol
      - CFCs, HCFCs ➔ Montreal Protocol
      - HFCs (+CO2, CH4…) ➔ Rio
- The ozone layer is recovering, thanks essentially to the phase out of CFCs
- The GWP of HFCs is (on average) similar to HCFCs
- HFCs are essentially used for refrigeration and air conditioning (+ foams) as well as HCFCs: they progressively replace them
- HFCs are short-lived climate pollutants
- The Montreal Protocol is a success. Montreal Protocol tools are efficient (ozone officers, MLF…)
    - Climate Change tools are still to be established

➔ the proposal: continuing to count HFC emissions within other greenhouse gas emissions (UNFCC) but using the Montreal Protocol tools to reduce these emissions

➔ Amendments to the Montreal Protocol since 2009, until the Kigali amendment, adopted in October 2016.

	A2 countries	**A5 countries (Group 1)****	**A5 countries (Group 2)*****
Baseline	2011-2013	2020-2022	2024-2026
Formula	Average HFC consumption	Average HFC consumption	Average HFC consumption
HCFC	15% or 25% baseline*	65% baseline	65% baseline
Freeze	-	2024	2028
1st step	2019 – 10%	2029 – 10%	2032 – 10%
2nd step	2024 – 40%	2035 – 30%	2037 – 20%
3rd step	2029 – 70%	2040 – 50%	2042 – 30%
4th step	2034 – 80%		
Plateau	2036 – 85%	2045 – 80%	2047 – 85%

* Belarus, Russia, Kazakhstan, Tajikistan, Uzbekistan
** Group 1: Article 5 parties not part of Group 2
*** Group 2: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, India, Iraq, Iran, Pakistan

It was an oral approval. The amendment must be signed and ratified by all parties
In addition, proposals were discussed in Kigali to be formally adopted and to be implemented:

- additional funds to the MLF
- new rules for the MLF: energy efficiency, priorities / sectors, country / country…
- stationary air conditioning and hot climates
- links between Montreal protocol secretariat and ISO
- new TEAP reports on alternatives
- how to follow and eventually modify national phase down plans

The challenges are:

➔ Financial and regulatory initiatives in the field of energy must accompany those regarding HFCs

➔ Combining HCFC phase out and HFC phase down, reducing leakage or the charge of refrigerants + replacing high GWP refrigerants

- old equipment vs new equipment
- solutions application by application

➔ Safety requirements: adopting safety regulations and standards, since low GWP refrigerants bring higher risks in matters of safety

Conclusion: we now have to work

Works at an international level:

- Adapting new standards: safety requirements for A3 and A2L refrigerants; works with ISO and IEC
- Links with UNFCC regarding energy consumption plans, actions and forecasts: energy efficiency in buildings, vehicles, factories; development of renewables
- Coalitions IIR-UNEP-UNIDO… and links with international and regional associations and companies

Works at national levels:

- Adopting new regulations and standards on safety issues, based on the state of the art of technical solutions and international evolutions
- Adopting new regulations and standards on energy efficiency, coherent with phase out and phase down schedules of refrigerants (not obvious!)
- Financial incentives for investors and **information** to companies (SMEs…)
- Training and certification of technicians

Works in universities, research organisations, research centers of international companies:

- Increasing R&D on HFOs and blends: a lot of new refrigerants will appear on the market: be careful (efficiency; short term or long term solution; neutrality of information)
- Increasing R&D on natural refrigerants, especially CO2 (the South way!)
- R&D on low charge, on containment

Scientific, objective, hands-on and updated information on the available or coming technologies, on their potential usages, their pros and cons, is crucial. The IIR is in position to provide it to you.