MAKING MODERN LIVING POSSIBLE

Global perspective on CO_2 & Danfoss strategy

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KVCA CO2 strategy seminar
Hedensted
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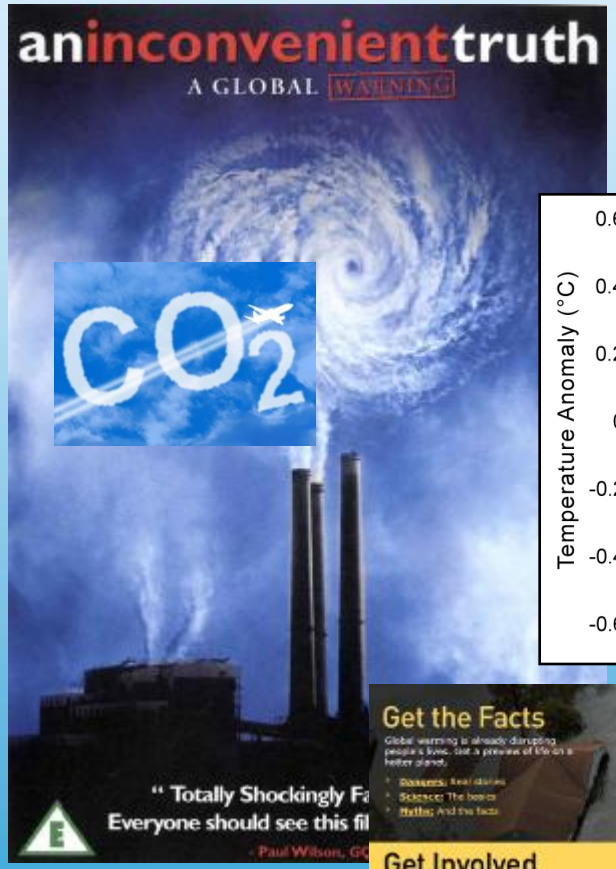
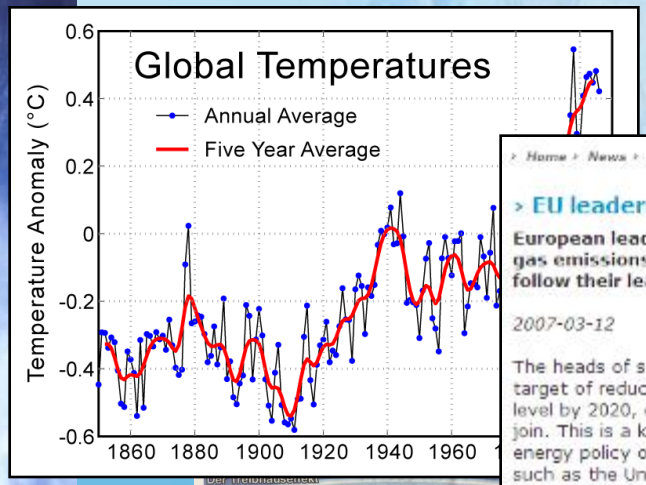
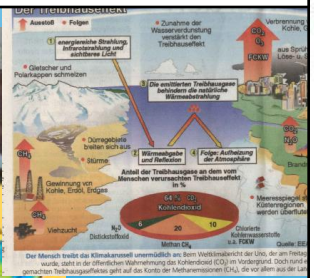
The Global Warming focus …







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› EU leaders support tough emissions cut

European leaders agreed last week on a mandatory target to cut greenhouse gas emissions by 20% from the 1990 level by 2020, challenging the world to follow their lead in fighting climate change.

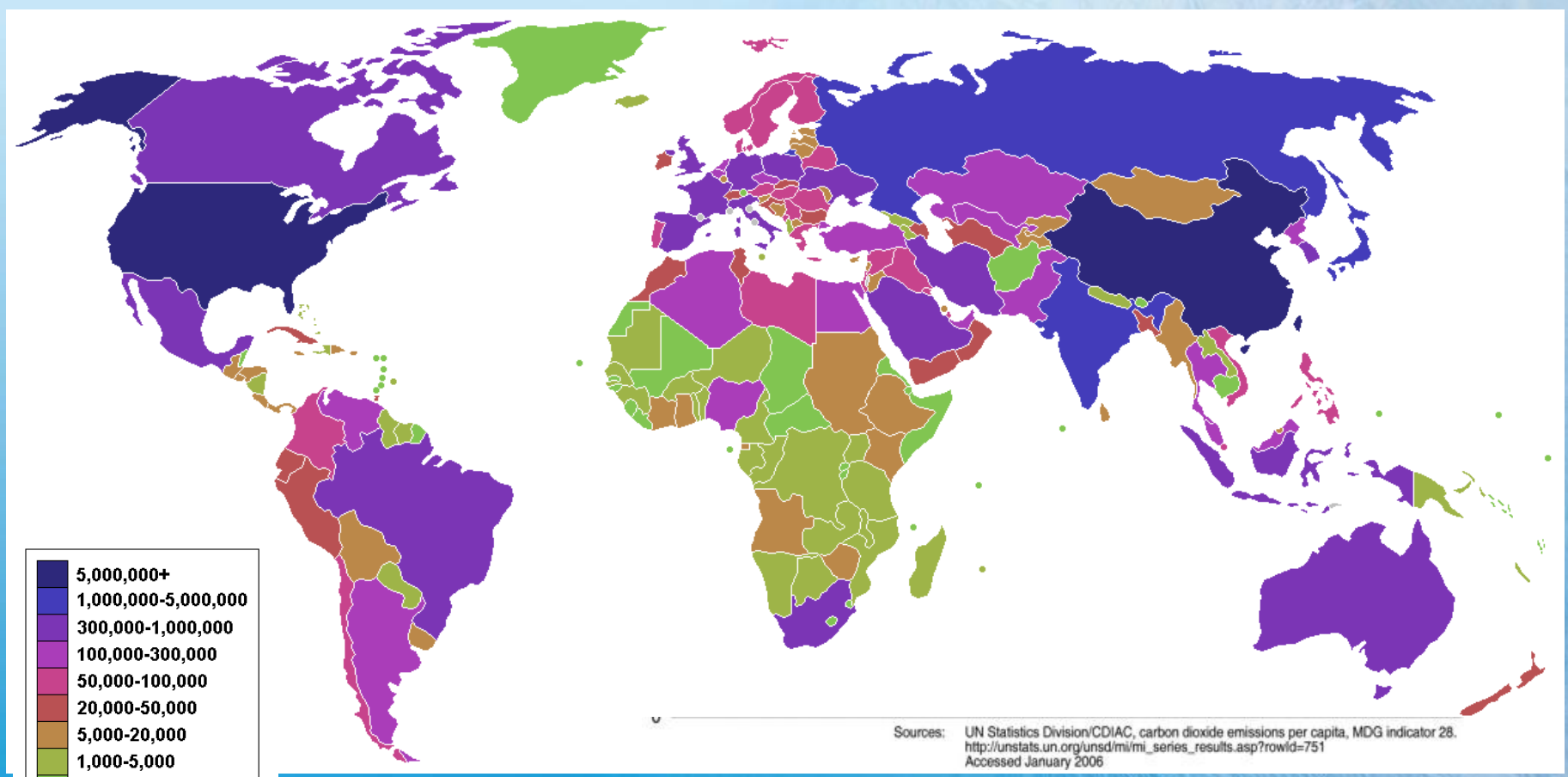
2007-03-12

The heads of state and government of the 27 EU Member States have committed to a target of reducing greenhouse gas (GHG) emissions by at least one fifth from the 1990 level by 2020, offering to endorse even a 30% reduction if other developed nations join. This is a key result from the two-day debate on climate change and European energy policy on 8-9 March in Brussels. EU leaders thus challenge other major polluter such as the United States, Russia, China and India to follow the European leadership and commit to deep cuts in GHG emissions.

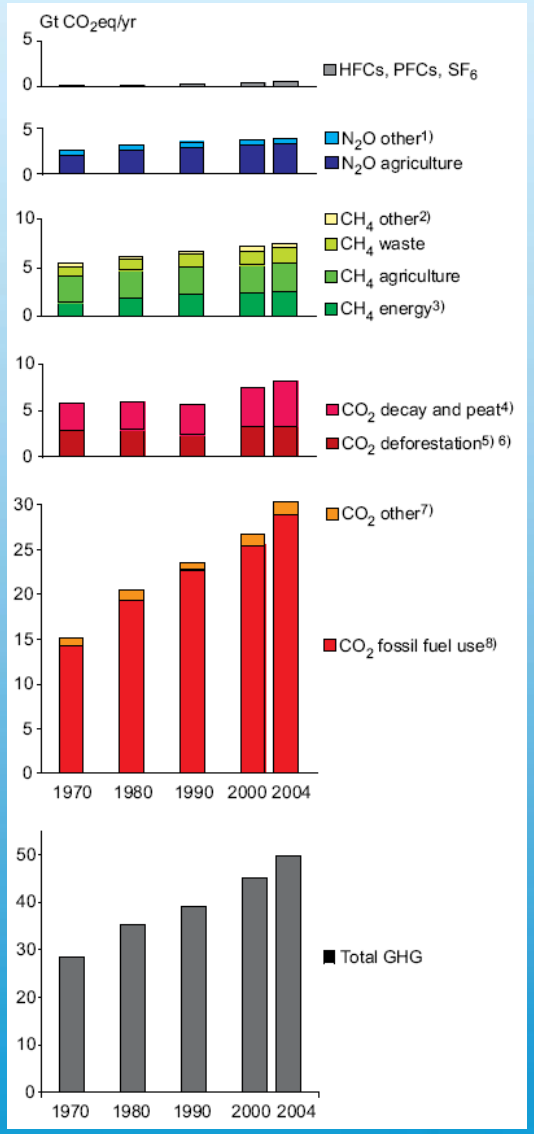
In addition, it emerged from the meeting a commitment to:

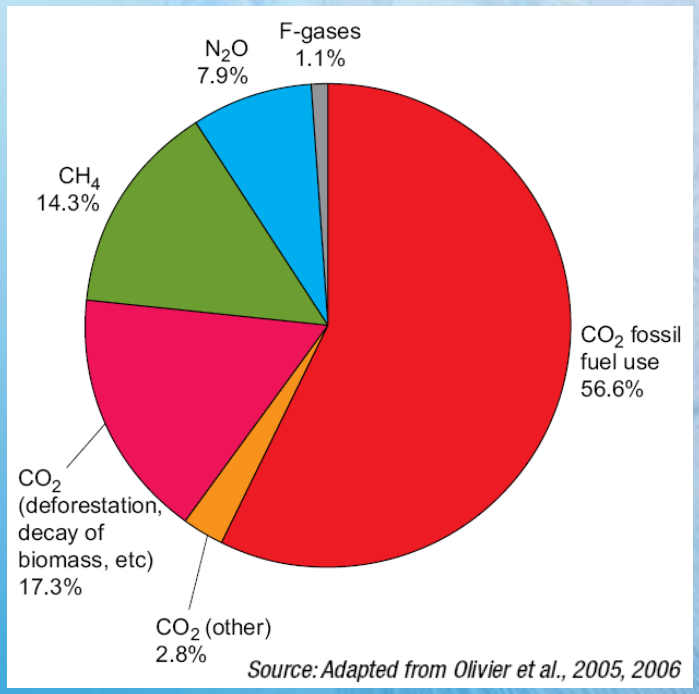
- reduce EU-wide energy consumption by 20% by 2020. However, this target is indicative and non binding.
- implement rapidly the Energy Efficiency Action Plan the European Commission had proposed in October 2006. This will most likely also include minimum efficiency requirements for Mobile Air Conditioning.

Total Carbon dioxide emissions by country



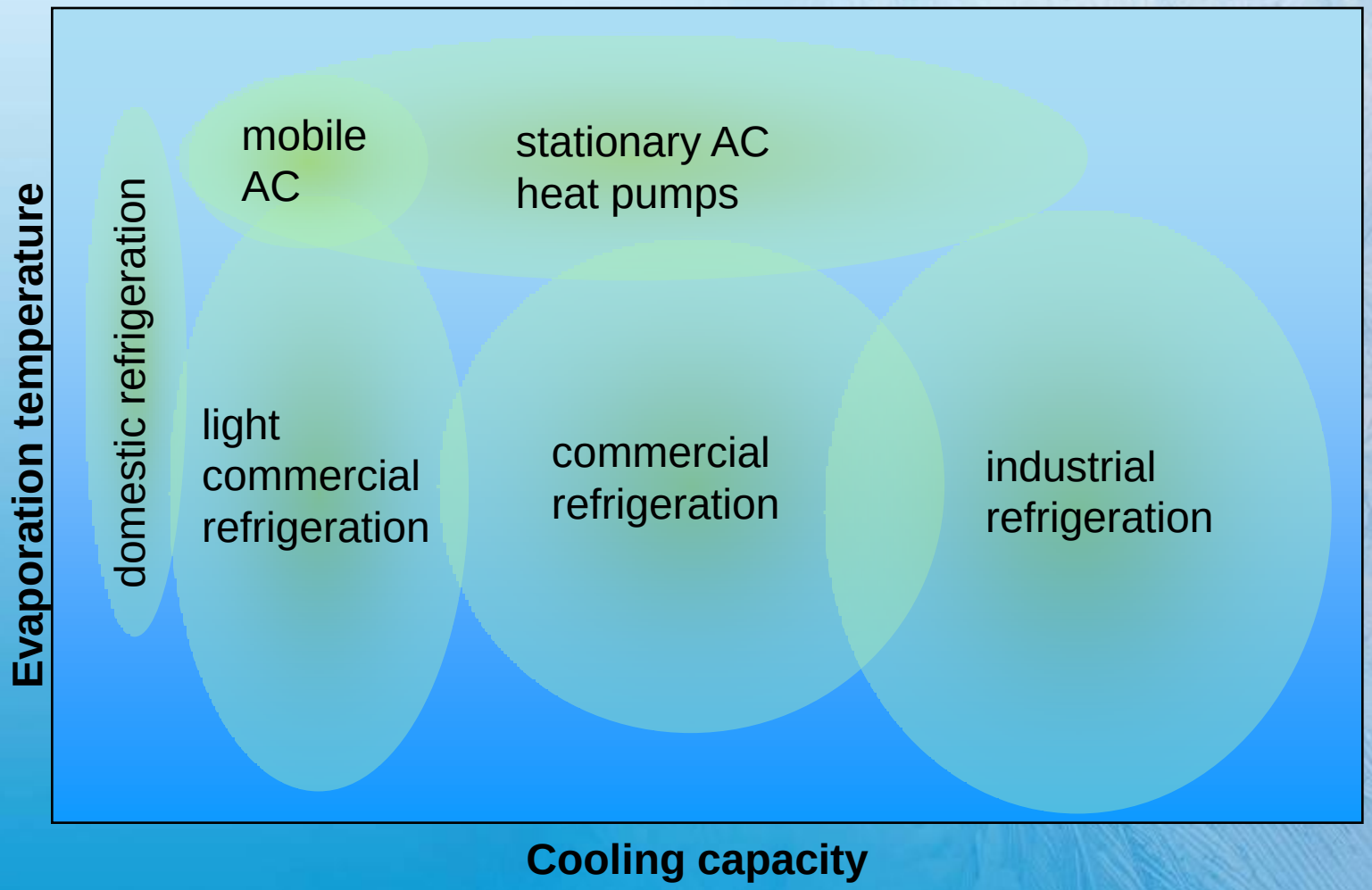
Global anthropogenic GHG emissions by segment



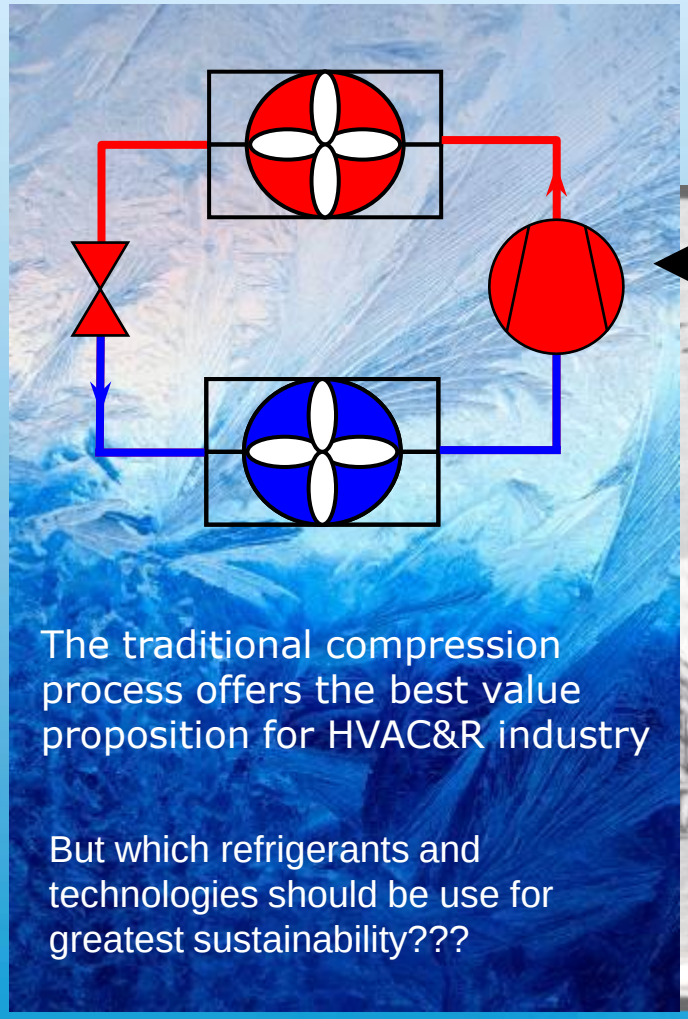


Refrigeration technologies are very energy-consuming, thus directly contributing to the emission of large amounts of CO_2. When including air conditioning, they account for about 15% of worldwide electricity use. Energy efficiency, which varies according to units and refrigerants used, is therefore an essential element to take into consideration.

The refrigeration application map



Different ways of cooling

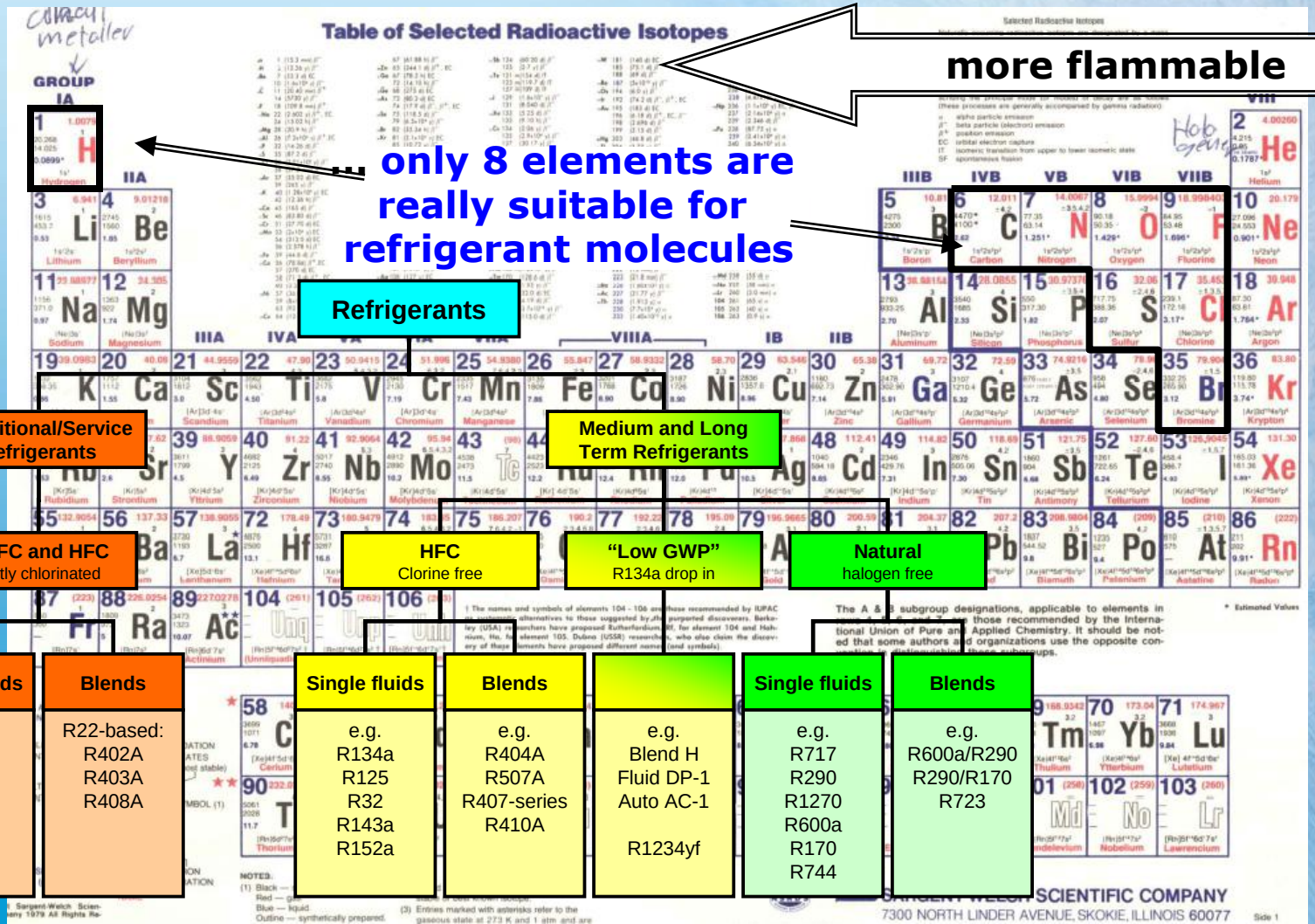


The traditional compression process offers the best value proposition for HVAC&R industry

But which refrigerants and technologies should be use for greatest sustainability???

- Reverse Rankine
- Stirling
- Magneto caloric refrigeration
- Vortex tube
- Joule process
- Peltier
- Steam ejector
- Absorption
- Adsorption
- .....

Refrigerants options



GHG emissions of HVAC&R systems

- ~~Mobile Air Conditioning (HFC)~~

  MAC DIRECTIVE 2006/40/EC

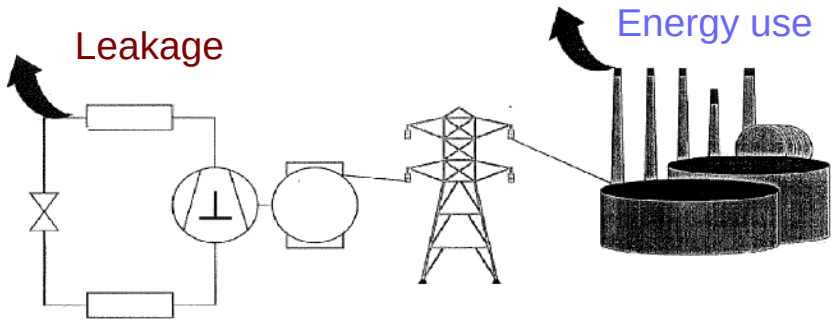
- Commercial Refrigeration (Supermarket DX HFC)
- Unitary Air Condition/Heat Pump (HFC)
- Commercial Air Condition (HFC)
- Light Commercial Appliance SME (HFC)
- Water Chiller (HFC)
- Domestic Refrigerator (HFC)
- Domestic Refrigerator (HC)

Energy use for system operation

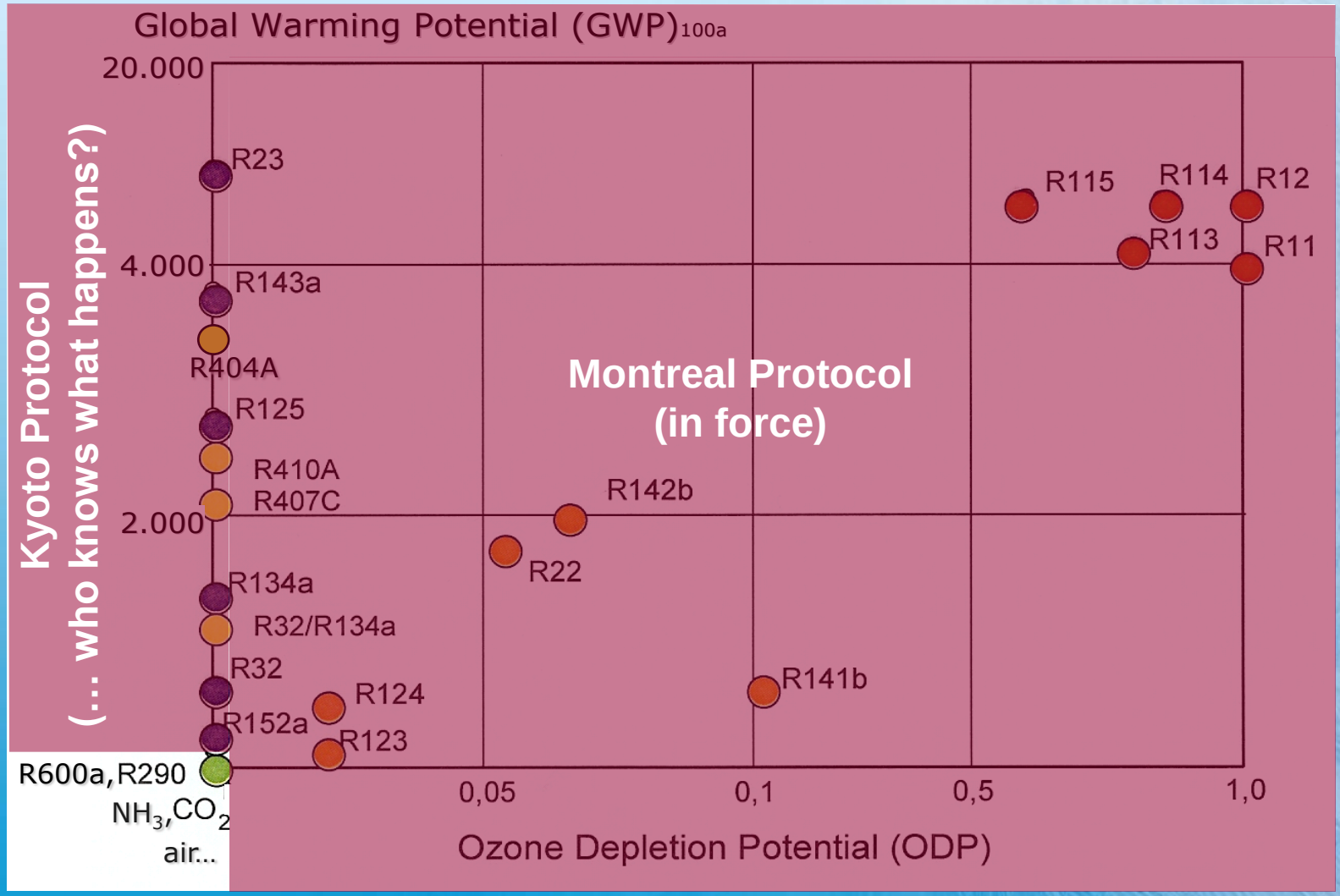
"Indirect Emissions"

Refrigerant leakage/release

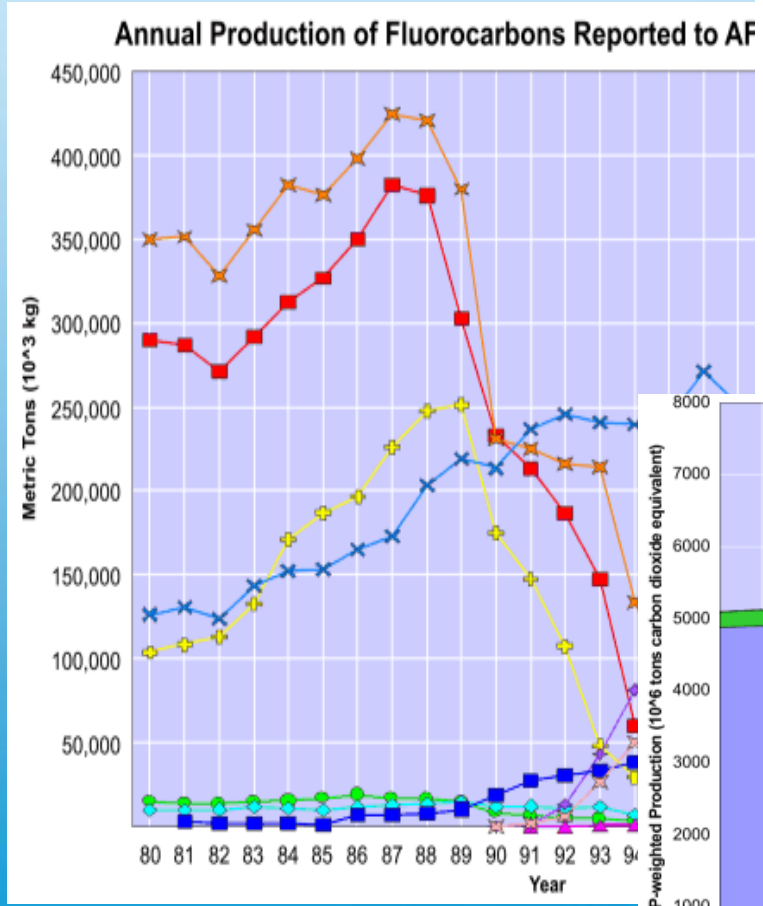
"Direct Emissions"

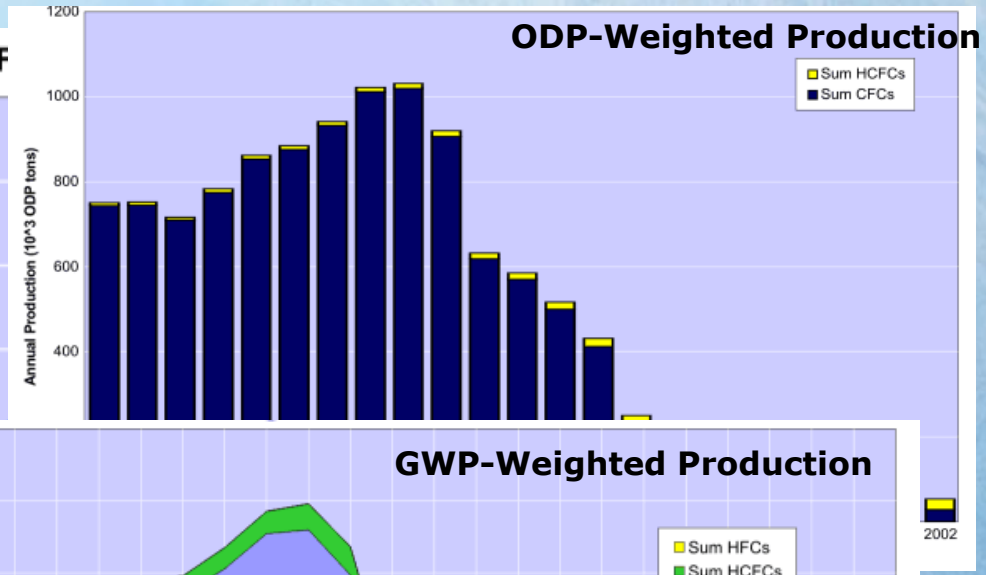


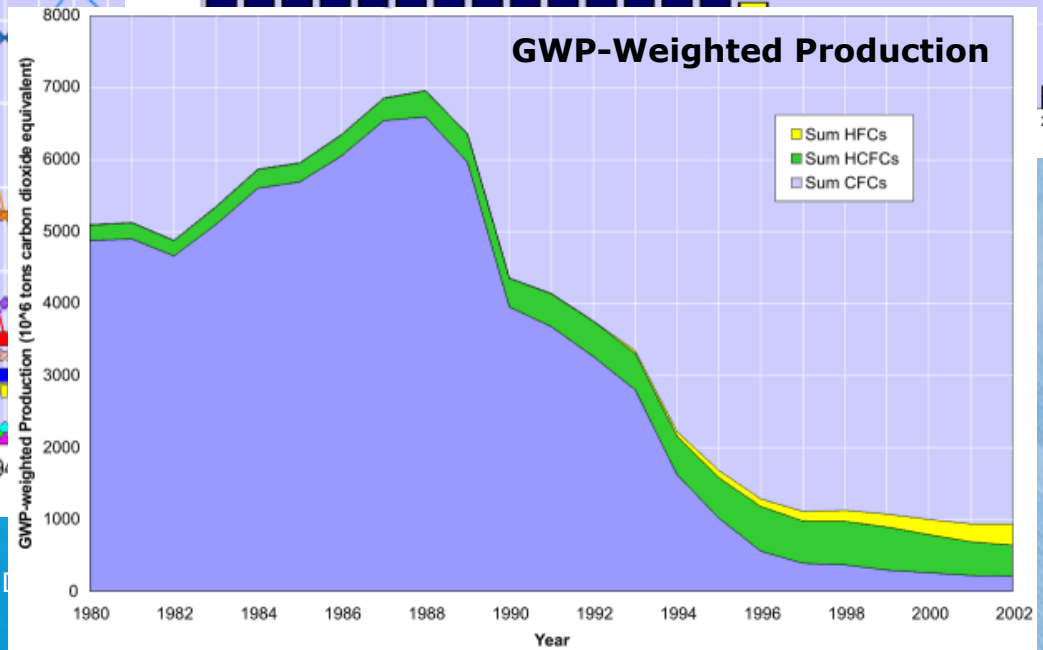
Ozone Depletion and Global Warming



CFC and HCFC phase-out achievements







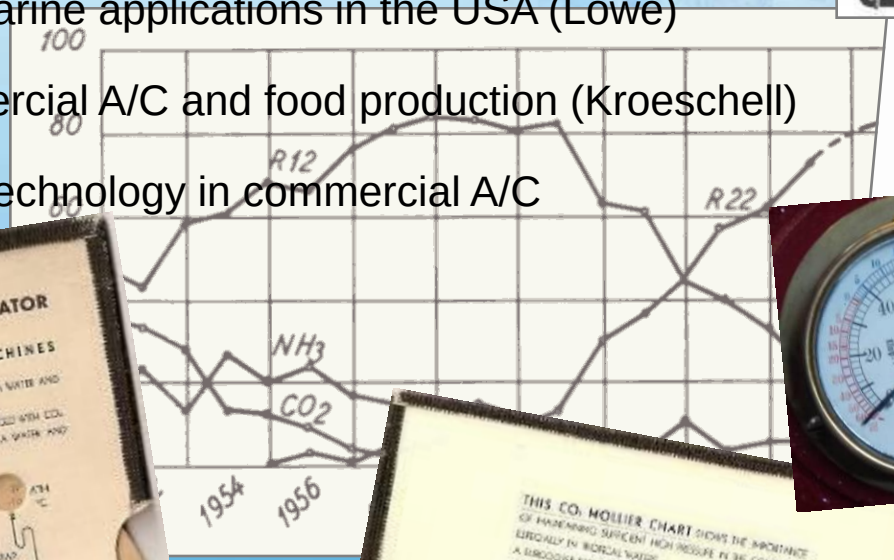
CO_2 as refrigerant in the past

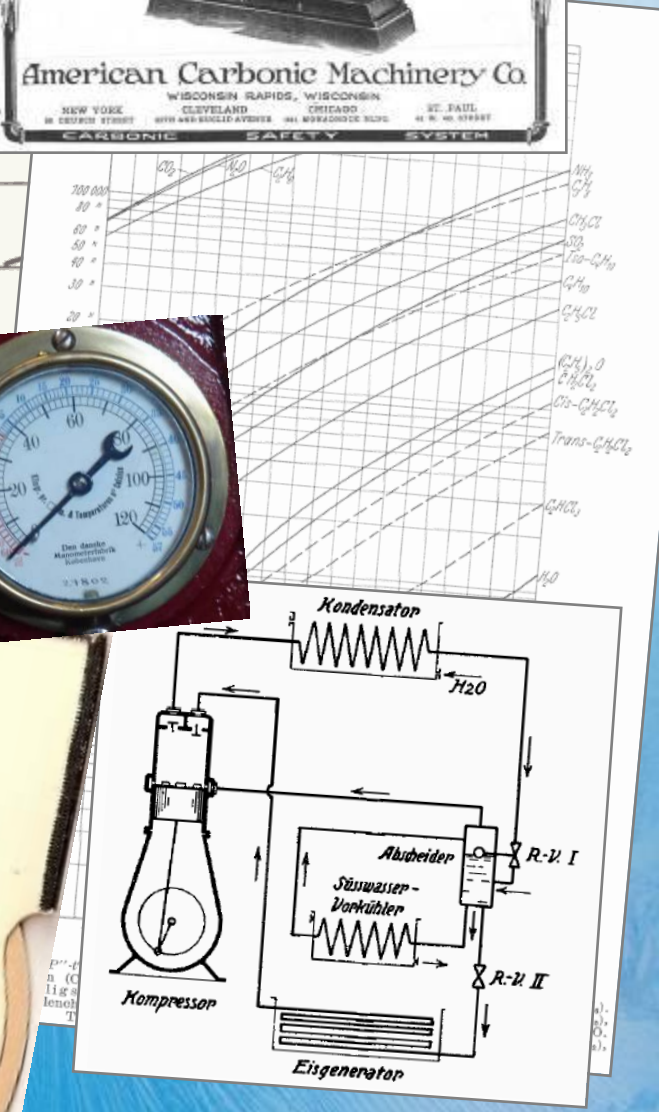
1850 Proposal to use CO_2 as a refrigerant (Twinning)

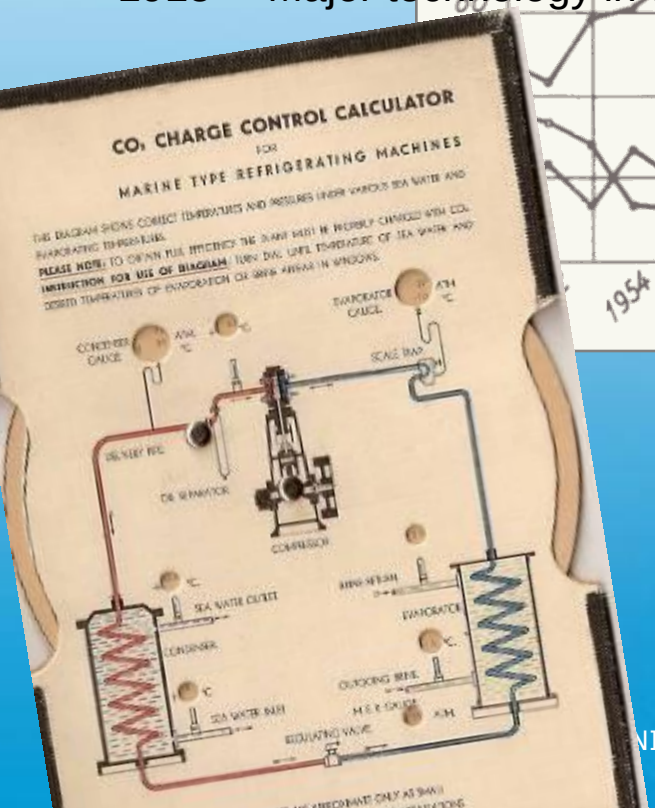
1868 First marine applications in the USA (Lowe)

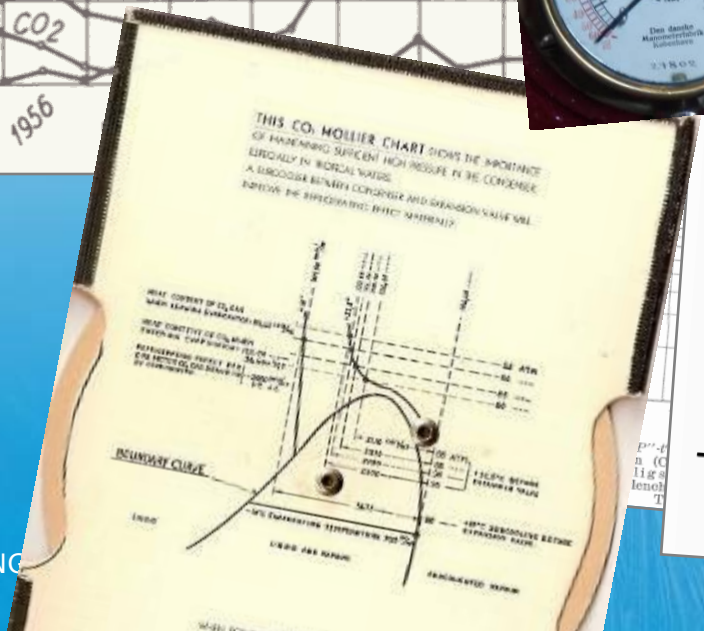
1890 Commercial A/C and food production (Kroeschell)

1915 Major technology in commercial A/C





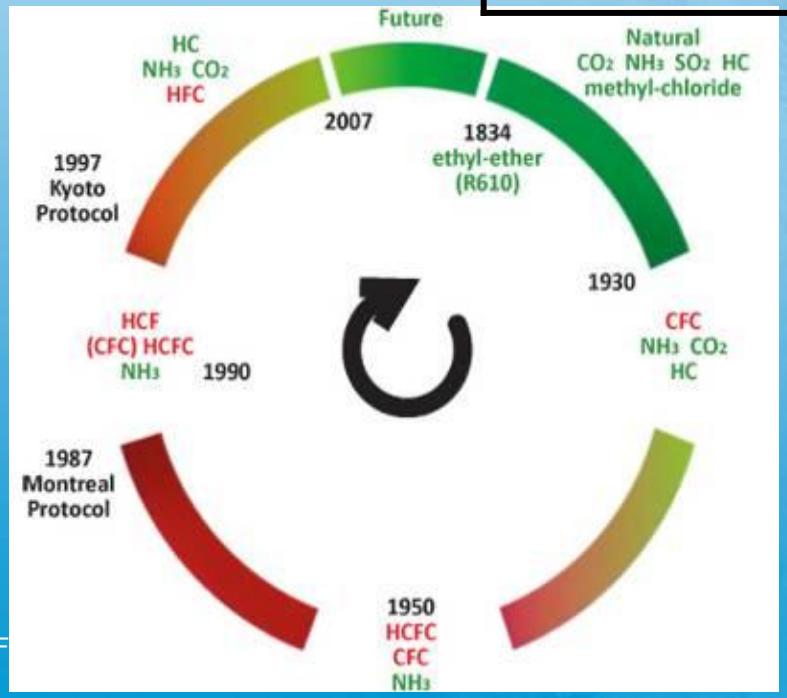


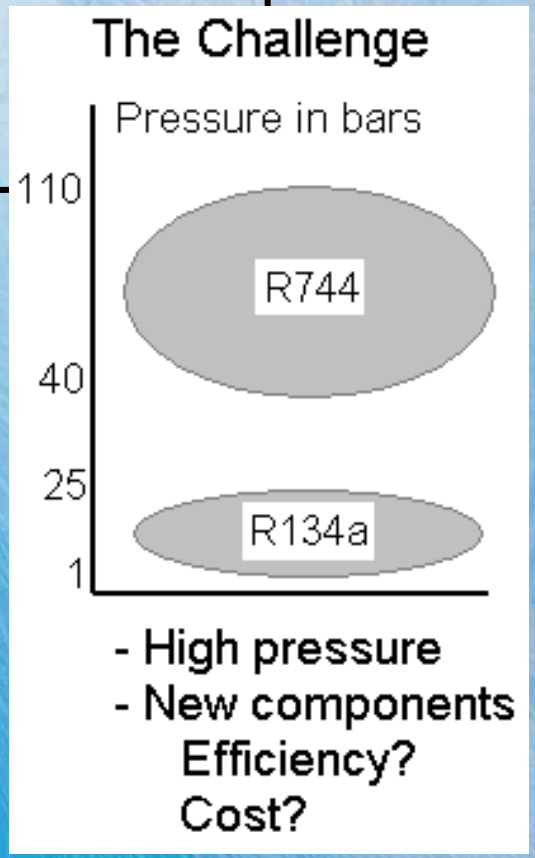


R744 - CO2 revival

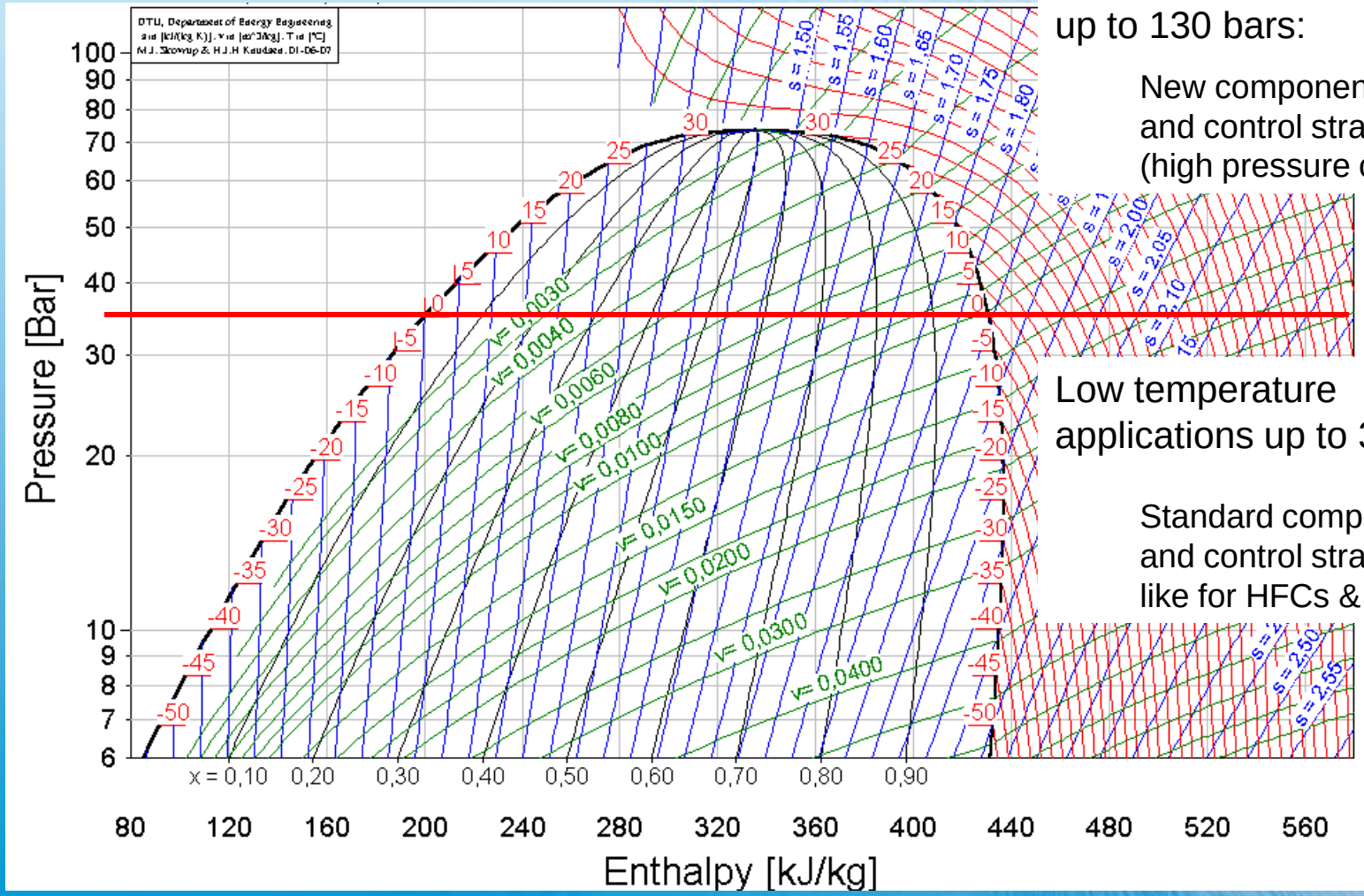
Environment - OK
- Refrigerant phase outs
- Companies policy
- Natural substance ✓

Safety - (OK)
- High concentrations ?
- High pressure ?
- Non flammable or toxic ✓





p,h-Diagram of CO_2



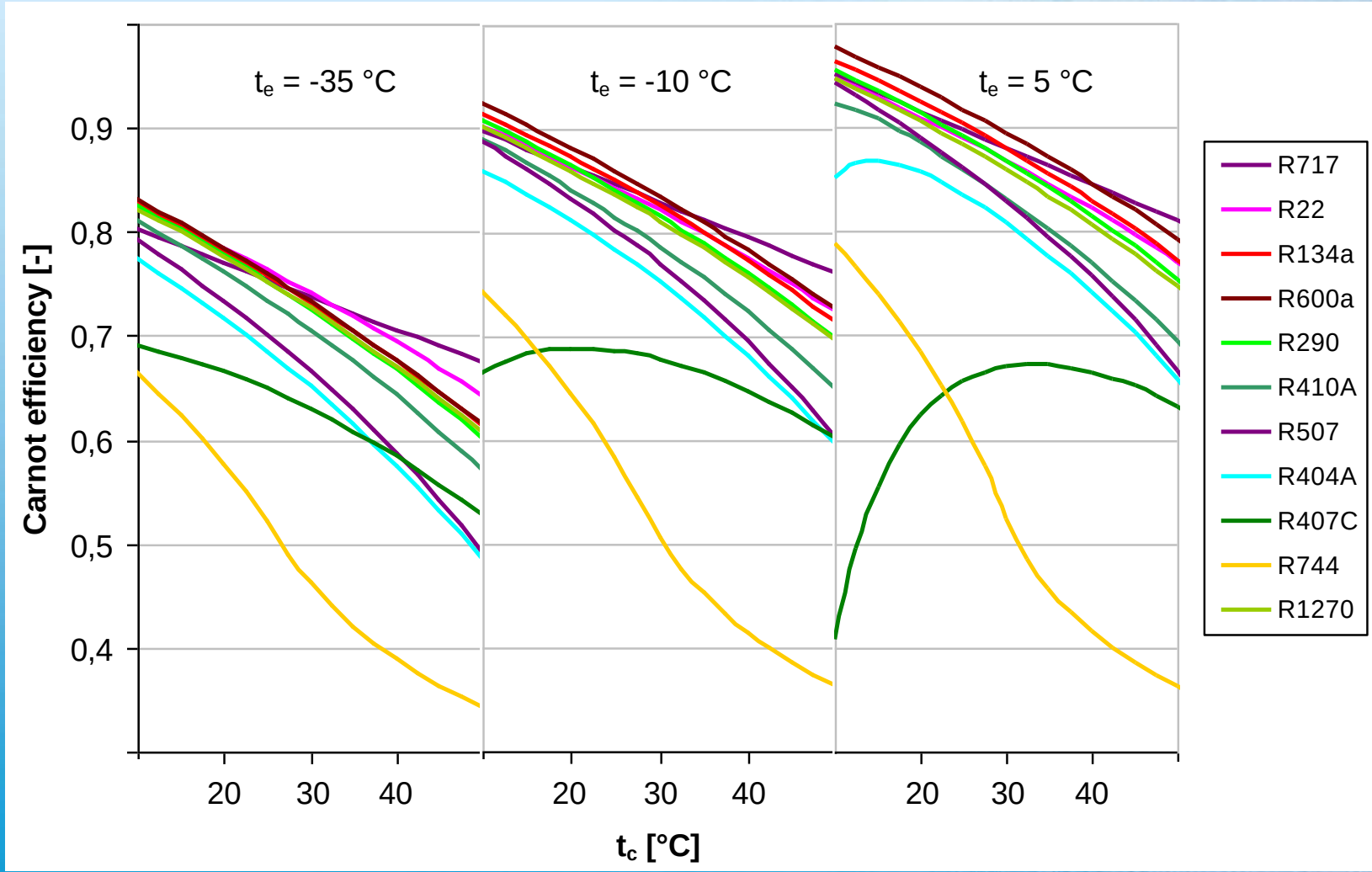
Transcritical applications up to 130 bars:

New components and control strategies (high pressure control)

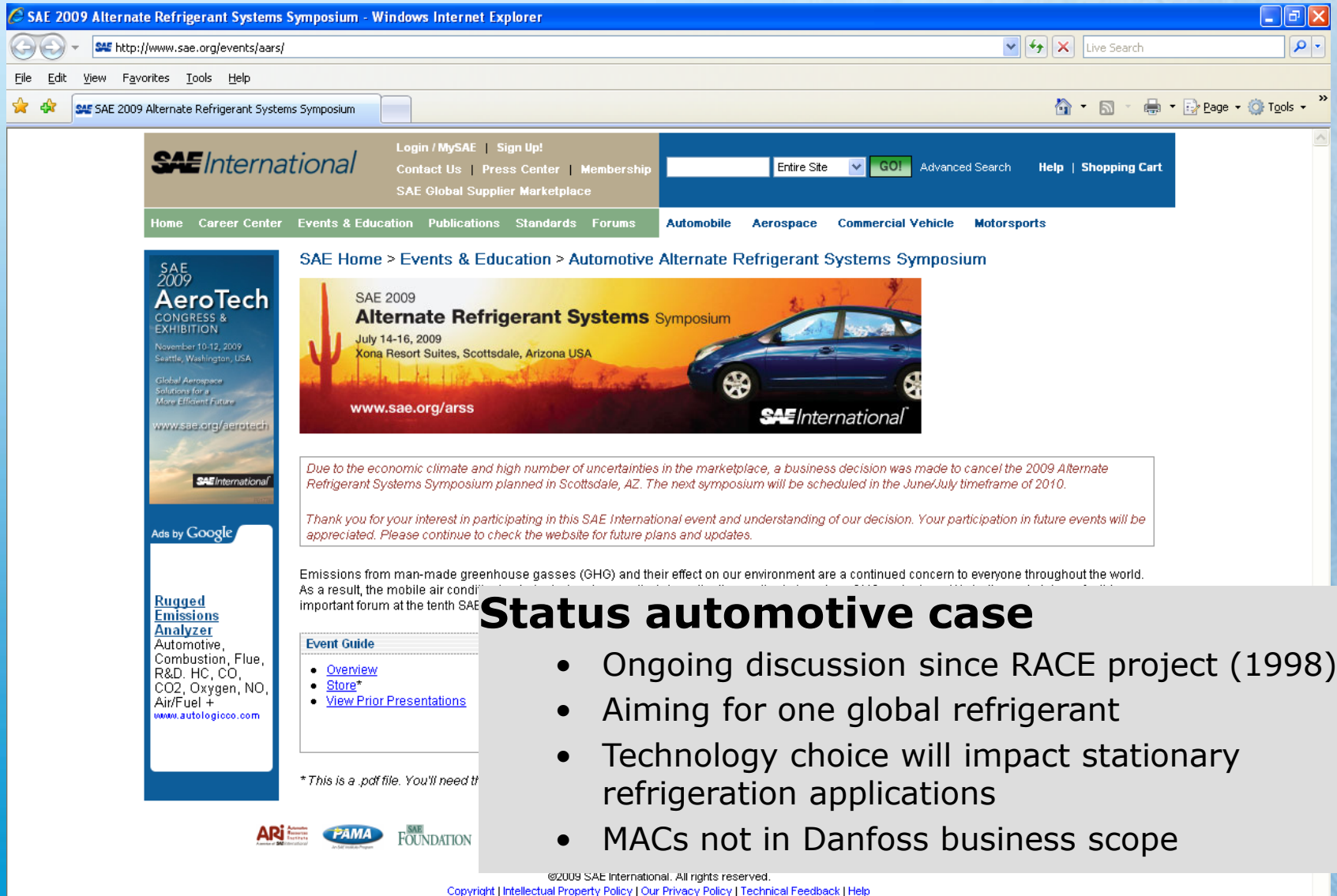
Low temperature applications up to 35 bars:

Standard components and control strategies like for HFCs & HCs

Efficiency of ideal reversed Rankine Cycle



The Automotive case (MAC)



Status automotive case

- Ongoing discussion since RACE project (1998)
- Aiming for one global refrigerant
- Technology choice will impact stationary refrigeration applications
- MACs not in Danfoss business scope

The Bottle Cooling case (SME)

1) “By the 2004 Olympic Games in Athens, we will **no longer** purchase new cold drink equipment using **hydrofluorocarbons** wherever cost-efficient alternatives are commercially available.”

2) “We will require suppliers to significantly improve the energy efficiency of the cold-drink equipment they sell to our system, making it **40-50 percent more energy-efficient** by the end of this decade.”

Environmental policy for cold drink equipment, June 27, 2000

The way into the future: higher efficiency at lower cost …

Status Bottle Cooling (SME)

- Depending on the component selection, the system layout and the actual cooling requirement CO2 systems can be better, equal or worse than HFCs ones.
- But with increasing ambient temperature the COP of CO2 systems generally drop faster…

Cascade system
(Two temperature levels)

ambient

Cooling

Freezing

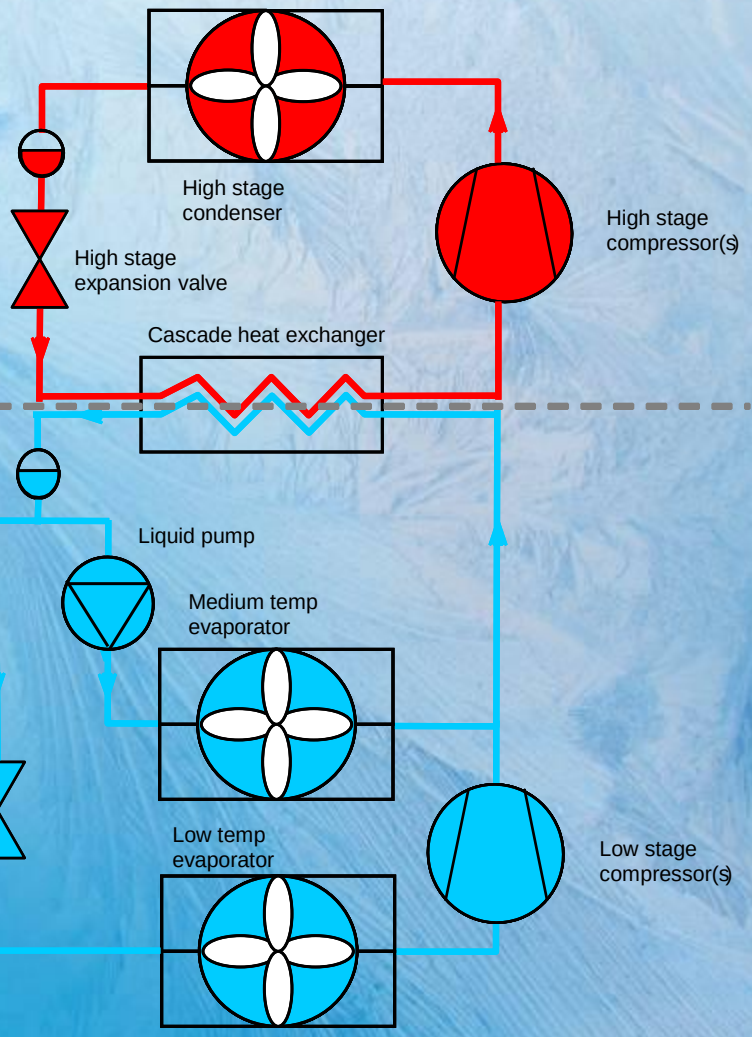
temperature stages

R717 (NH_3)

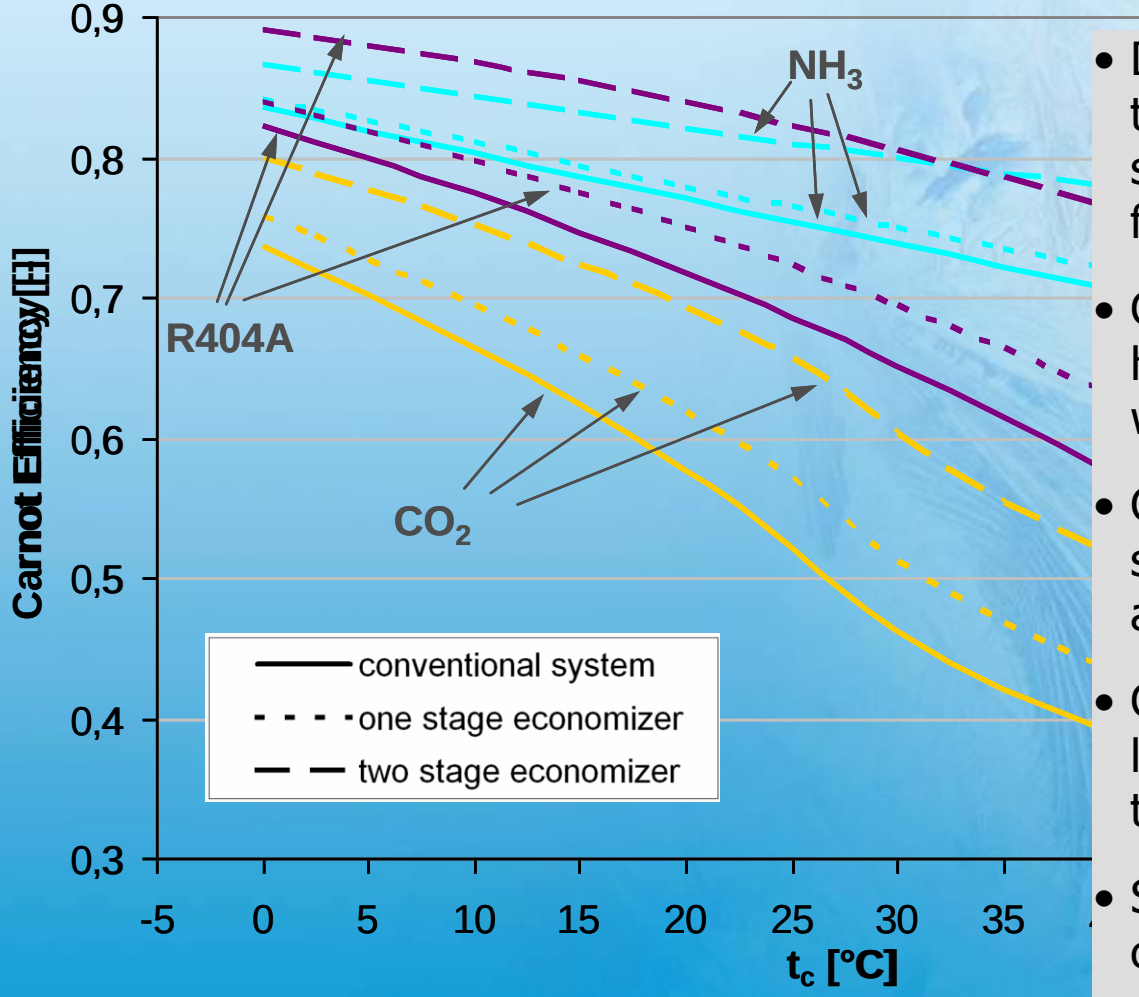
R134a, R404A,…

R290, R1270,…

CO_2



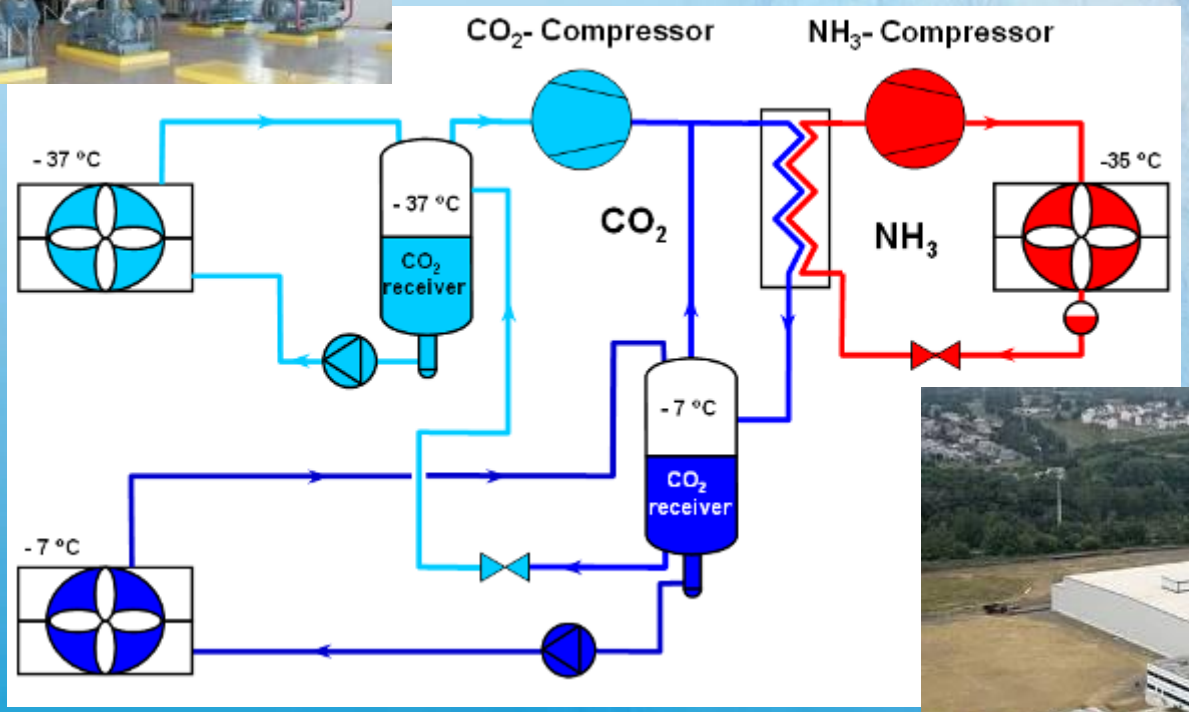
Status Supermarket Refrigeration (FR)



- Direct GHG emission from the cooling distribution system of FR systems calls for an alternative solution
- Cooling generation with CO2 has energetic drawbacks in warm climates
- Cascade systems build on state of the art technology and are globally applicable
- CO_2 Booster systems have a low temperature stage close to one of cascade systems
- System technology consolidation is pending

t_e = -35 °C, ΔT_{sup} = 10 K

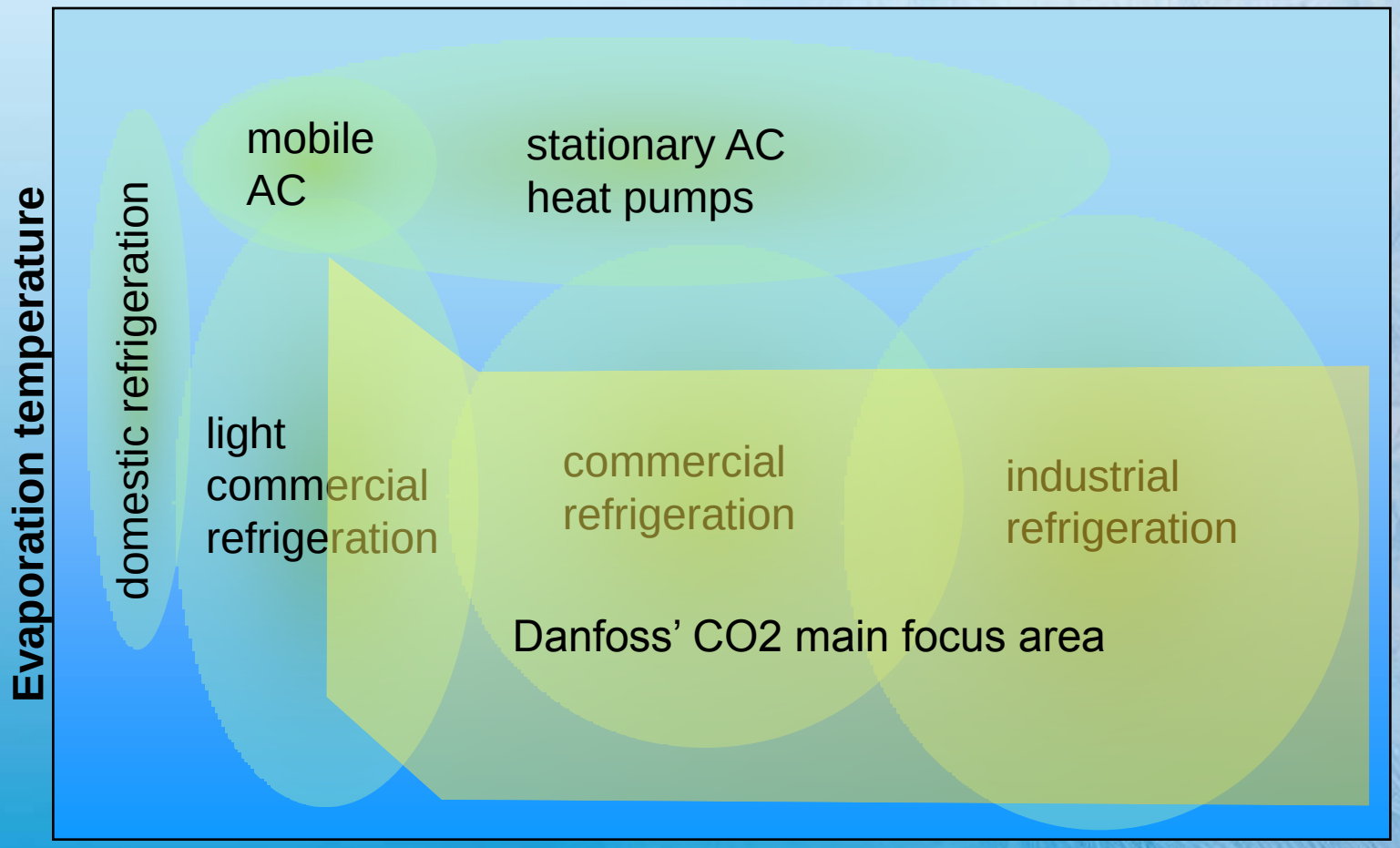
The Industrial Refrigeration case (IR)



Status Industrial Refrigeration (IR)

- State of the art technology
- Globally applicable
- Higher efficiency at lower installation cost than ammonia only systems
- Component and system knowhow available
- Ammonia charge reduction

The refrigeration application map (again)



Our "hit list" to minimize GHG emissions from the HVAC&R industry

1. Apply latest appropriate technologies and components
2. Service the systems to ensure optimal operation
3. Enhance and ensure energy efficient system operation by adding intelligence/electronics
4. Minimize refrigerant emissions (system layout, tightness & handling practices)
5. Minimize refrigerant charge
6. Enhance system configuration (layout)
7. Enhance component efficiency
8. Apply refrigerants with low GWP

Nobody wants to save energy,
but everybody wants to save/make money

The Danfoss' way to reduce GHG emissions

- Develop low charge and low leakage solutions
- Enhance significantly the system's energy efficiency e.g. by applying variable speed and enhancing component intelligence as well as Ease of Use concepts etc.
- Support the application of low GWP (natural) refrigerants where commercially viable and technical feasible

3x25

**25% less CO_2 and
25% more sustainable energy in 2025**

Danfoss climate strategy
- goals and ambitions

In 2025:

- **the CO_2 emissions from factories and transport of products must be reduced by 25% compared to the level in 2007**
- **the share of renewable energy must be increased by 25% compared to the level in 2007**