

# NH<sub>3</sub> and CO<sub>2</sub> as natural working fluids

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# Refrigerants, what is important?

## Energy efficiency

Differences in thermophysical properties gives the refrigerants unique characteristics

However, all refrigerants can in principle obtain the theoretical maximum energy efficiency (COP) for a given application

System and component development, together with an optimum system integration is the key tasks

## Local safety

Proper engineering will reduce risk to acceptable levels, even for toxic and flammable refrigerants, but cost is an issue

## Environmental issues

CFCs and HCFCs has failed due to ozone depletion (Montreal protocol)

HFCs has failed due to high global warming impact (Kyoto agreement)

Are we ready for a new range of synthetic refrigerants?

CO<sub>2</sub> and NH<sub>3</sub> are known not to be harmful for the environment

## What to choose for the future?

# Ammonia, NH<sub>3</sub>, the old giant

## Application status

Industrial refrigeration: since 1872  
Preferred refrigerant in most of  
the world (80% in Europe, 90% in  
US est) Expected to become  
preferred option in developing  
world and Article 5

Marine refrigeration: increasing  
share

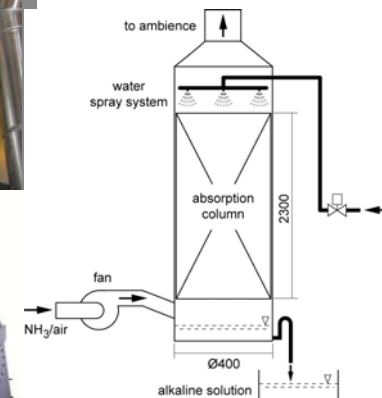
Heat pumps: medium to large,  
increasing

Lower capacity systems under  
development

## Local safety developments

Combination with CO<sub>2</sub> in cascade  
Charge minimisation  
Scrubber systems eliminate  
emissions to the atmosphere for  
medium sized systems

## Statement



# Carbon dioxide, CO<sub>2</sub>, coming back

## Application, technology available

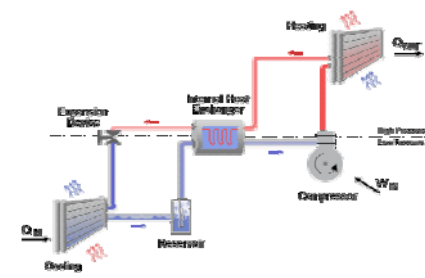
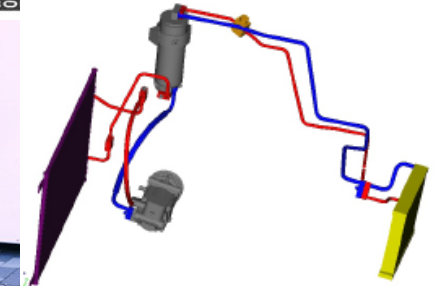
- Heat pump water heaters
- Mobile air conditioning systems
- Commercial refrigeration systems
- Beverage coolers

## Under development

- Mobile heat pumps
- Transport refrigeration systems (containers, truck, marine)
- Residential heat pumps and air cond.
- Vending machines, combined hot-cold
- Heat pump dryers
- Water chillers
- Industrial refrigeration

## Energy efficiency, an issue?

Superior energy efficiency is proven in many applications. Ongoing development will increase efficiency further and enable commercialisation in new



# Conclusion on $\text{CO}_2$ and $\text{NH}_3$



$\text{CO}_2$  and  $\text{NH}_3$  (and HCs) are complimentary refrigerants which may cover most applications, alone or together

$\text{NH}_3$  has a dominant role in industrial refrigeration and new applications are coming

Safety risk of  $\text{NH}_3$  can be reduced by combining with  $\text{CO}_2$  in cascade systems, charge minimisation and by using scrubbers

$\text{CO}_2$  systems has been commercialised in some applications and more are coming

$\text{CO}_2$  systems will contribute to reduction in GHG emissions both by eliminating direct emissions and through reduced indirect emissions due to better energy efficiency

$\text{CO}_2$  and  $\text{NH}_3$  are natural substances known not to be harmful to the environment, thus long term alternatives

Is there any reason to start using a new generation of artificial substances which have unknown and known negative effects to the local and global environment?