

ENGINEERING
TOMORROW

Danfoss

Global Trends - Industrial Ref. system perspective

Maniam



Agenda

- Global Trends within IRF
- What could be relevance of CO₂ to India specific applications
- Conclusions

Industrial refrigeration systems

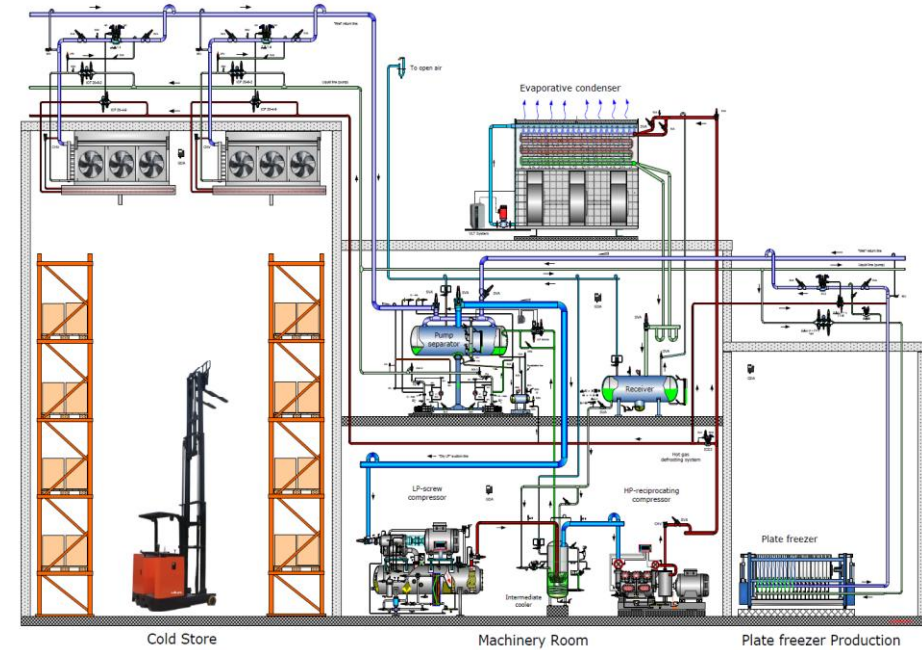
How do we define industrial refrigeration?

Large complex installations

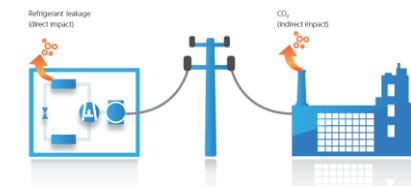
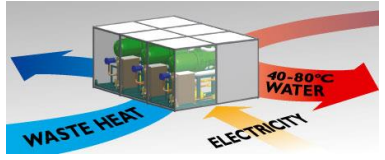
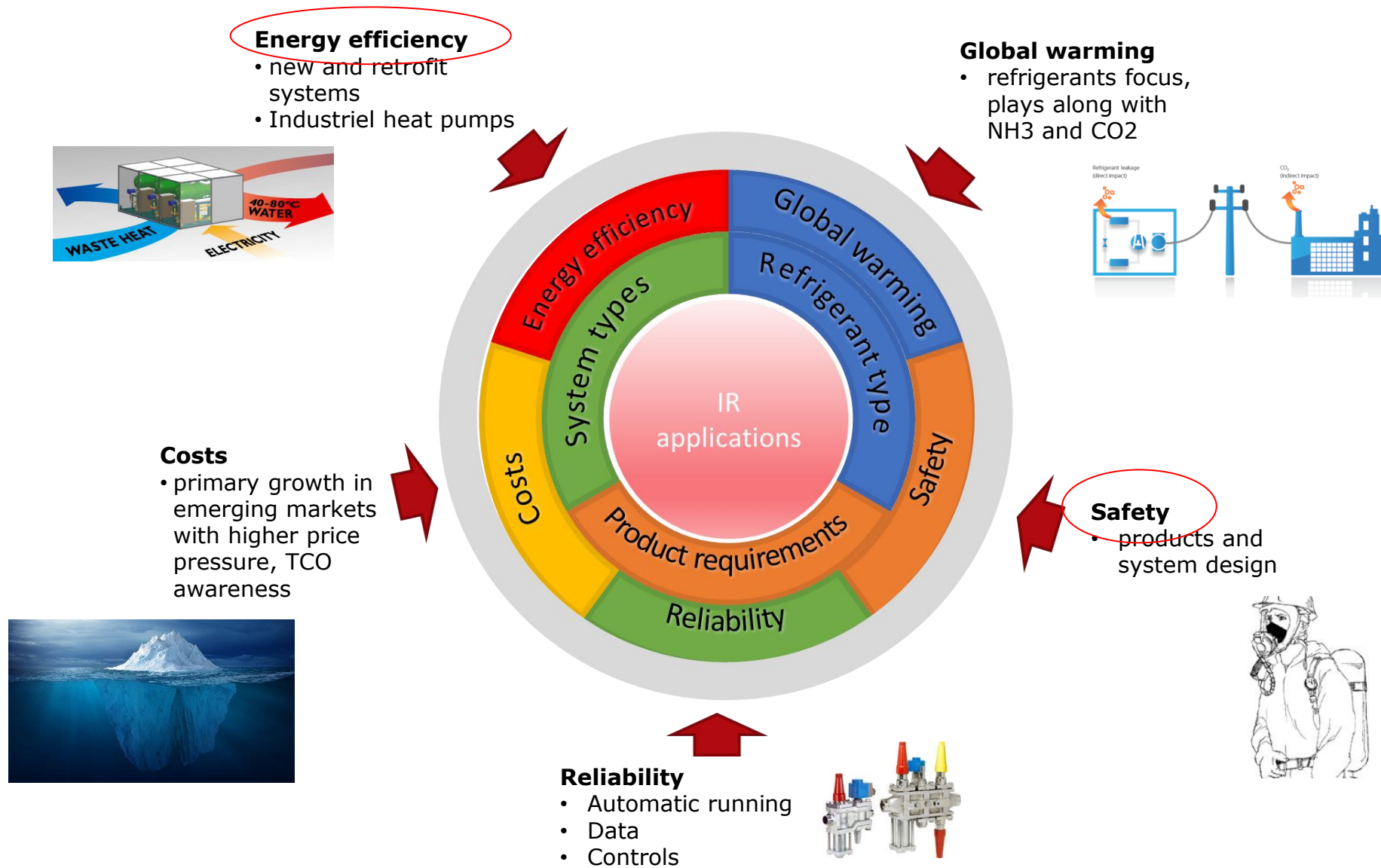
- Project business
- Wide variety of refrigerants, system designs etc.

Variety of applications

- Food processing and storage
- Marine / fishery
- Industrial heat pumps
- Chemical/petrochemical



Drivers and reactions for Industrial Refrigeration



Refrigerants: Ammonia , NH₃, R717



Ammonia Facts

- ▶ Natural refrigerant
- ▶ GWP=0
- ▶ ODP=0
- ▶ Environmentally friendly
- ▶ High efficiency
- ▶ Low Cost
- ▶ Widely available
- ▶ Self-alarming – by odour
- ▶ Ammonia is the dominant refrigerant in industrial systems.
- ▶ Specific design requirements needed, to do ammonia's classification as **toxic and flammable fluid**.



***Ammonia is
the natural
choice***

Refrigerants: Carbon Dioxide, CO₂, R 744



Carbon dioxide Facts

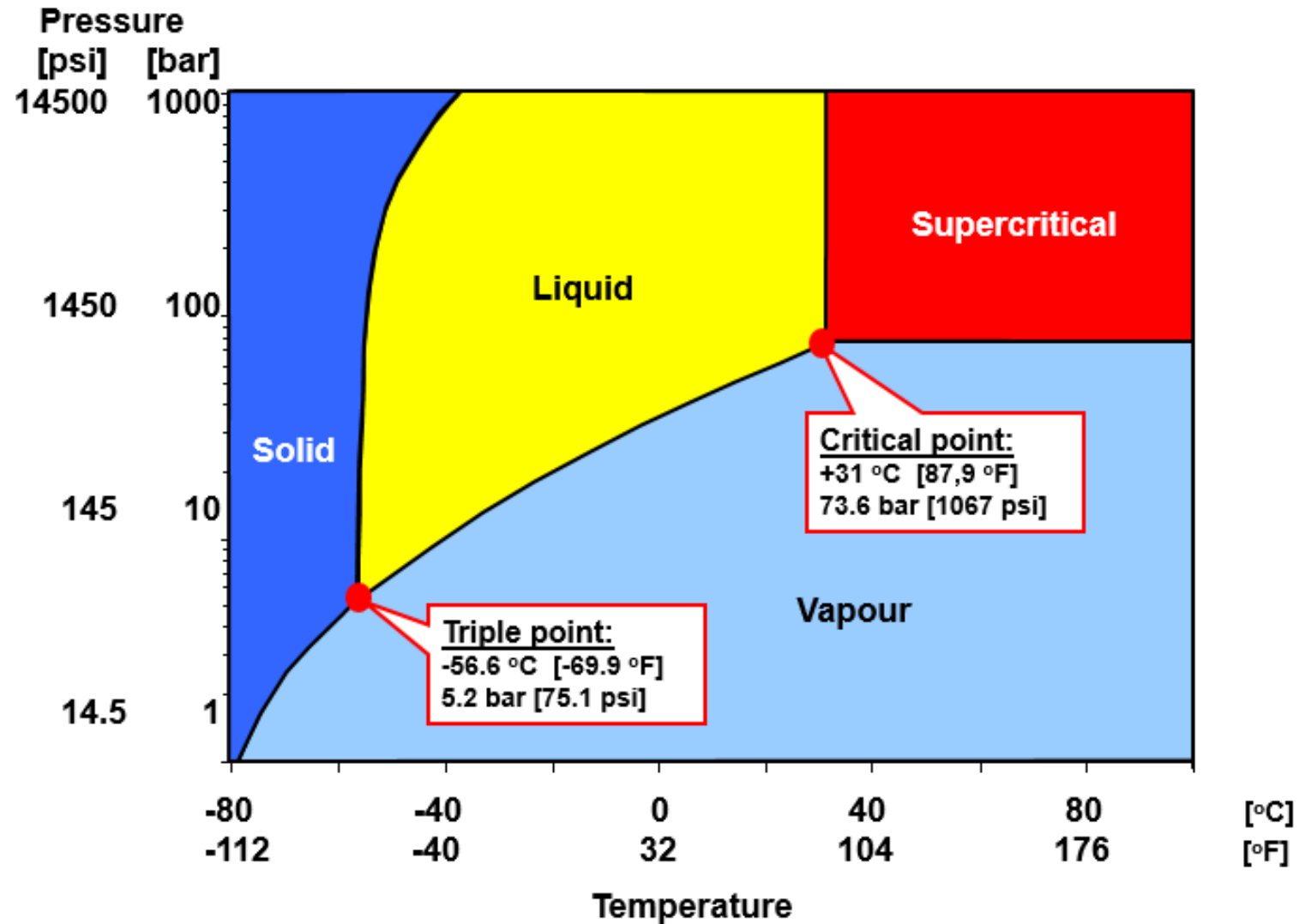
- ▶ Natural refrigerant
- ▶ GWP=1
- ▶ ODP=0
- ▶ Environmentally friendly
- ▶ High efficiency
- ▶ Low Cost
- ▶ Widely available
- ▶ Odorless
- ▶ Naturally present in atmosphere
- ▶ Classified as non toxic, non flammable, however is directly involved in the respiratory process and too high levels can be fatal



***Carbon dioxide
is a natural
refrigerant***

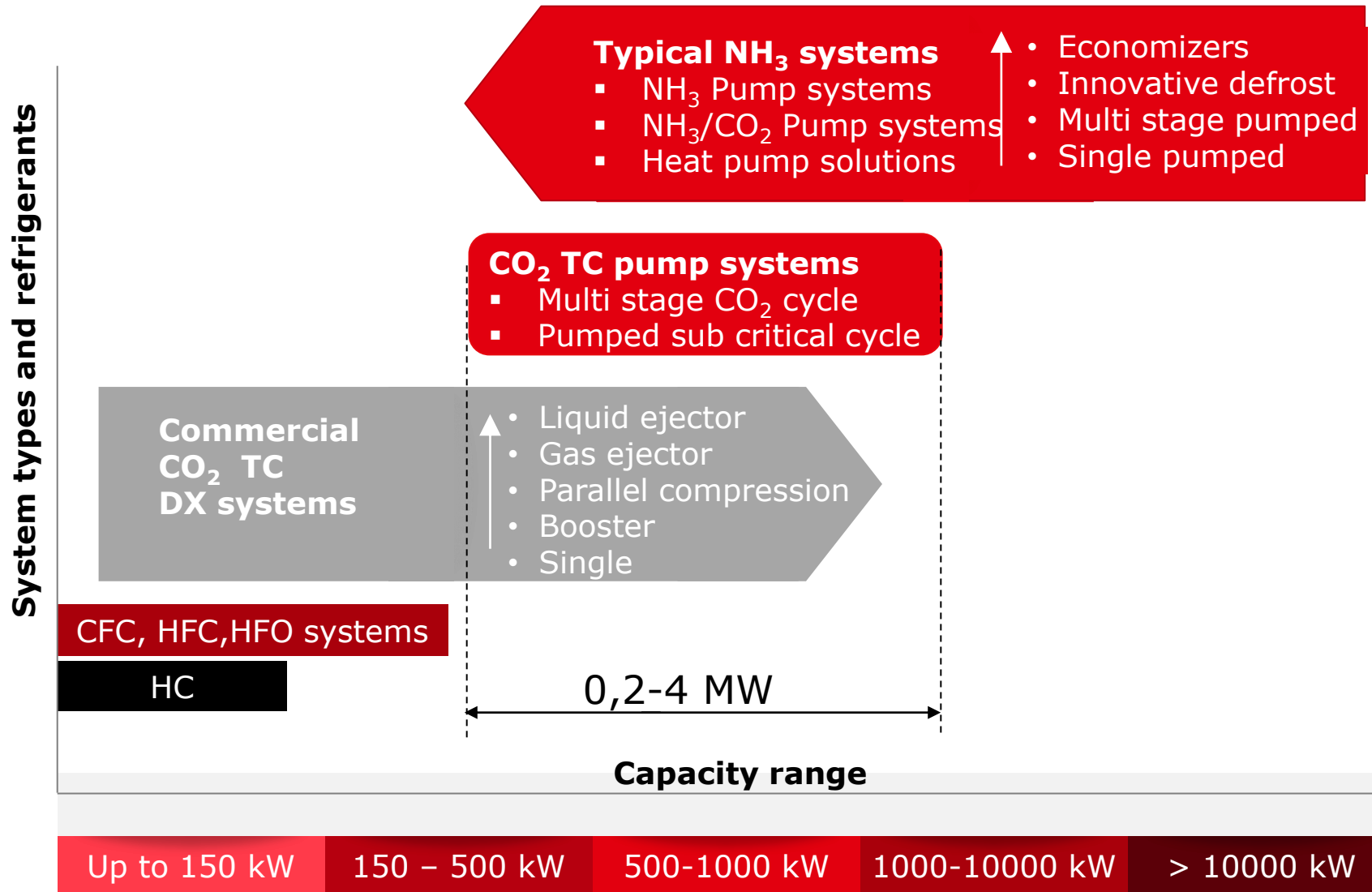
CO₂ basic properties

CO₂ phase diagram depending on pressure and temperature



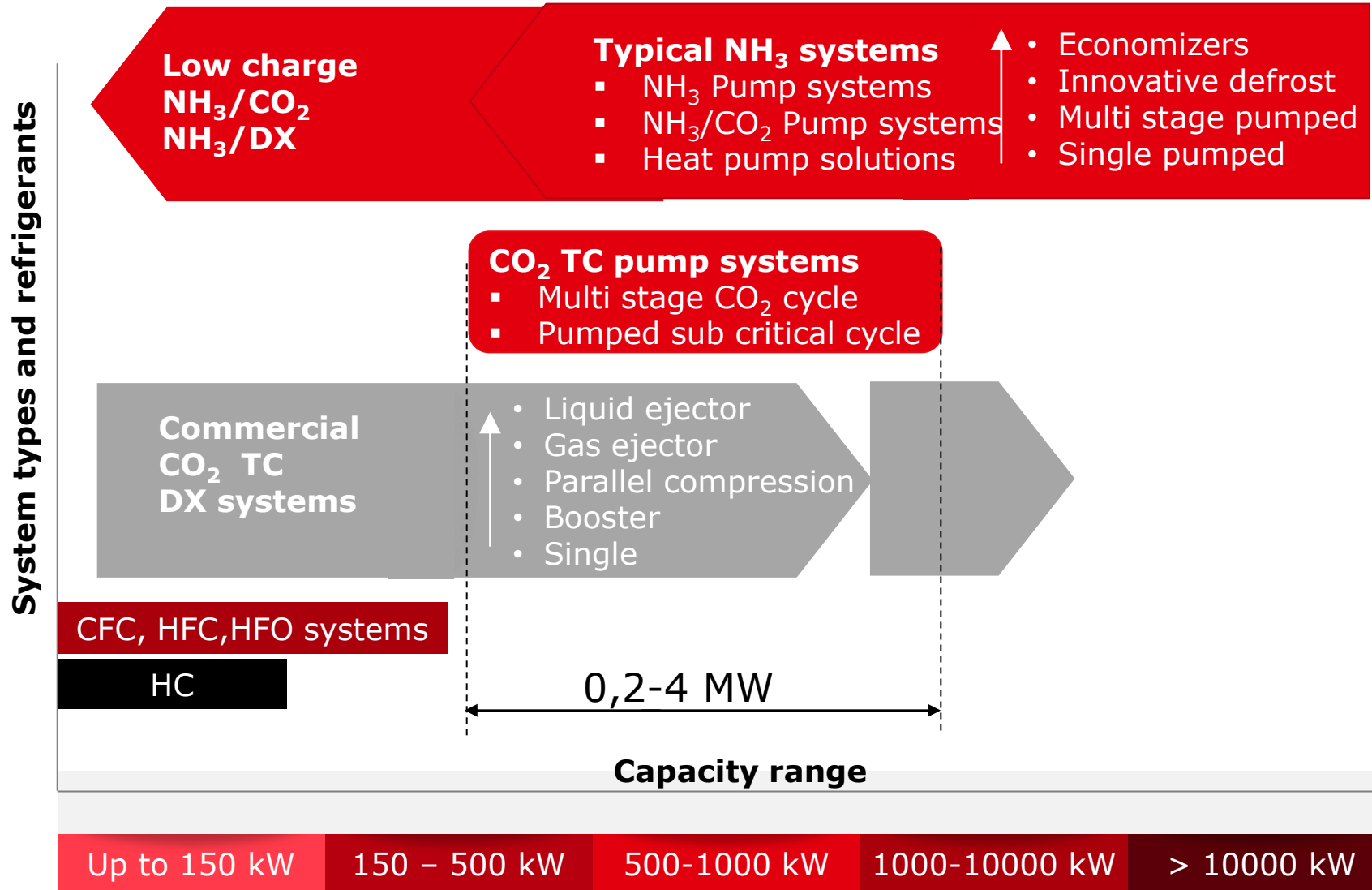
Refrigeration system developments

Dynamic developments

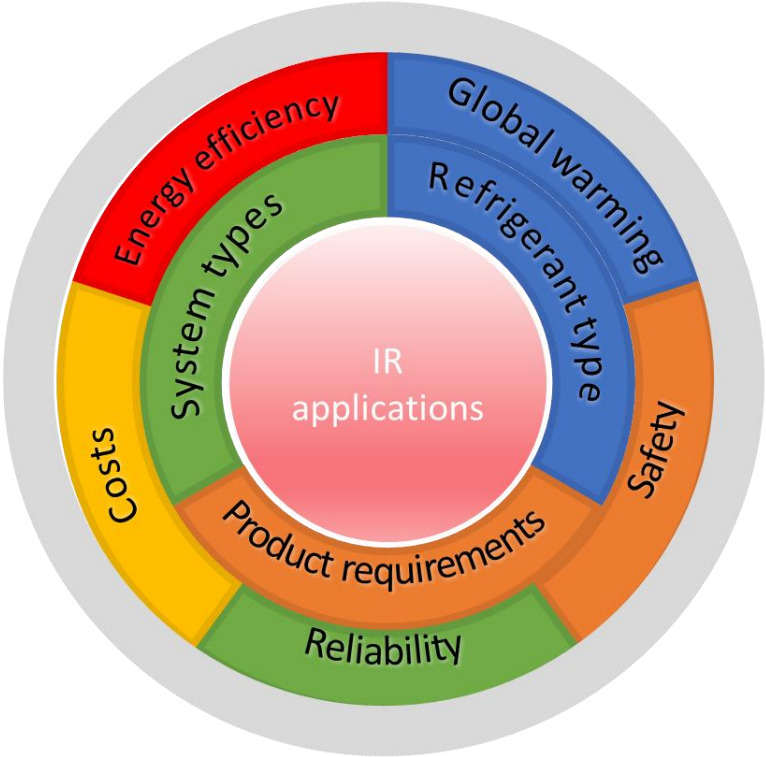


Refrigeration system developments

Dynamic developments



Drivers and reactions for Industrial Refrigeration



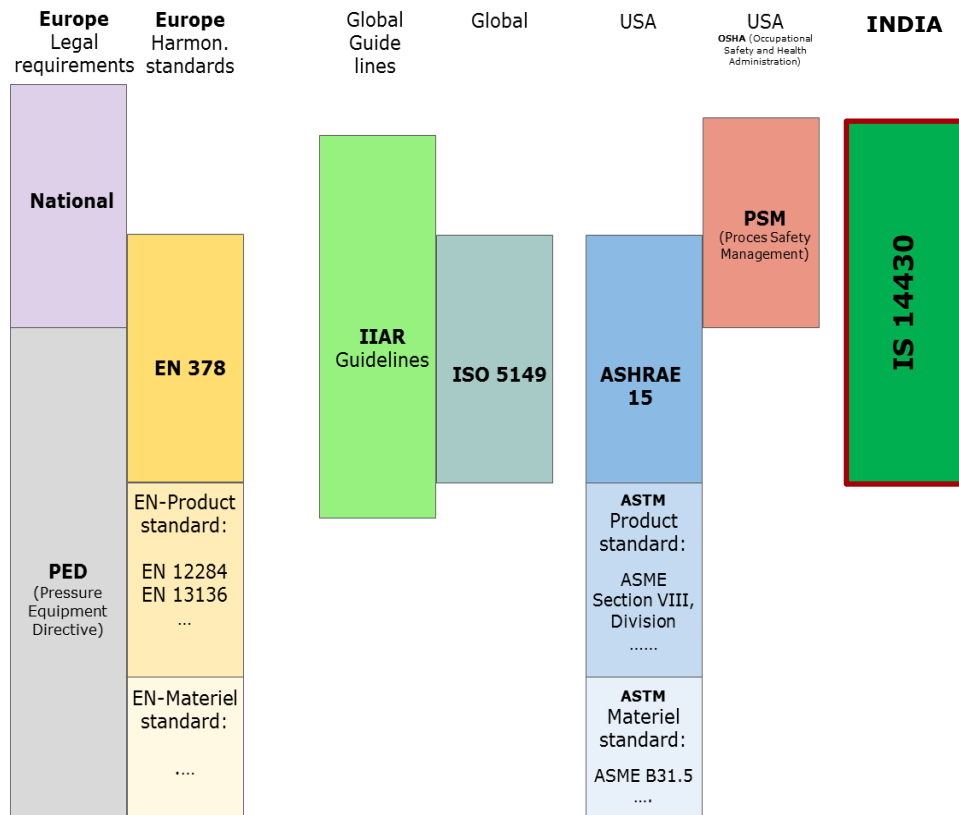
Safety
• products and system design



Ammonia safety concerns

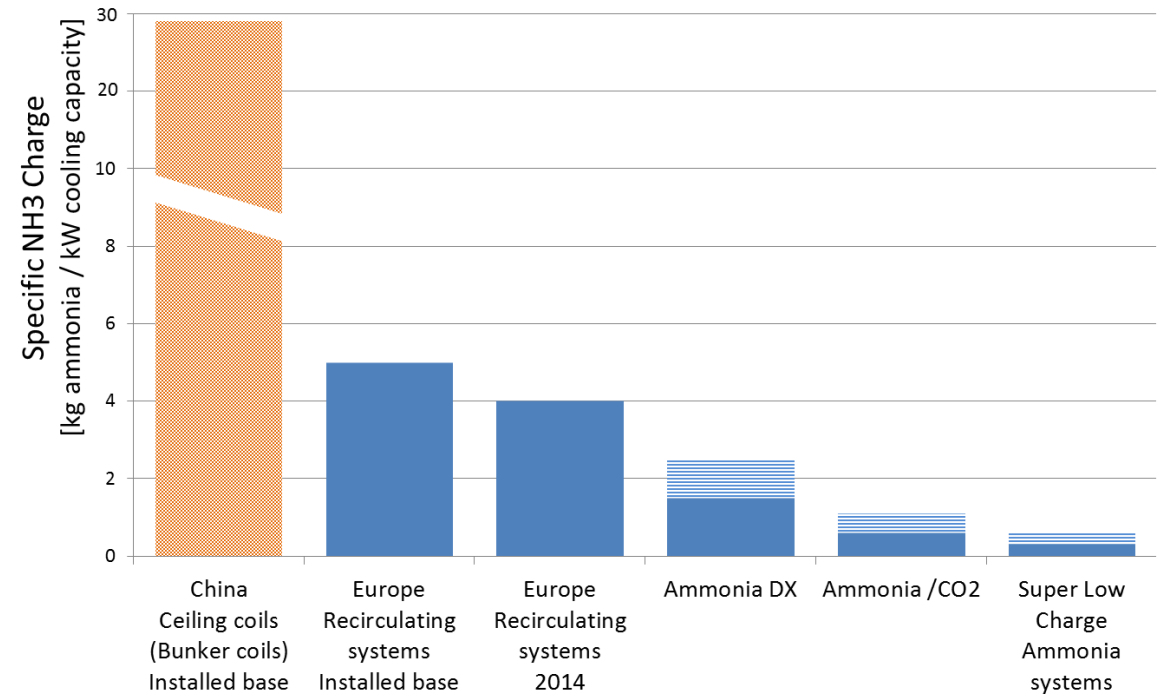
Many solutions are available, but no one fits all

Legislation and standards



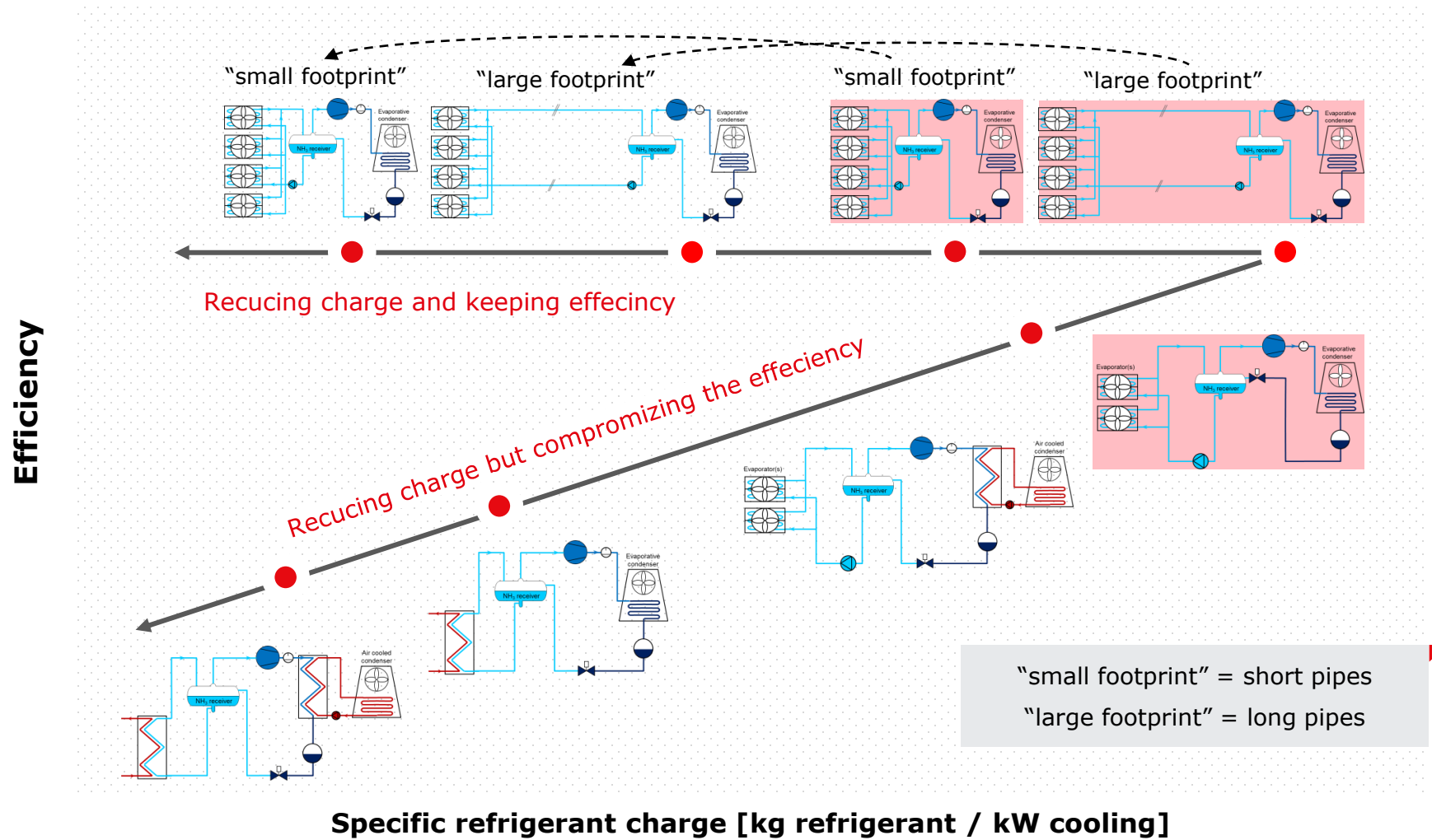
Reduction of ammonia charge

Specific NH3 charge in large industrial refrigeration systems



Charge reduction without compromising efficiency

Impact on efficiency by concepts



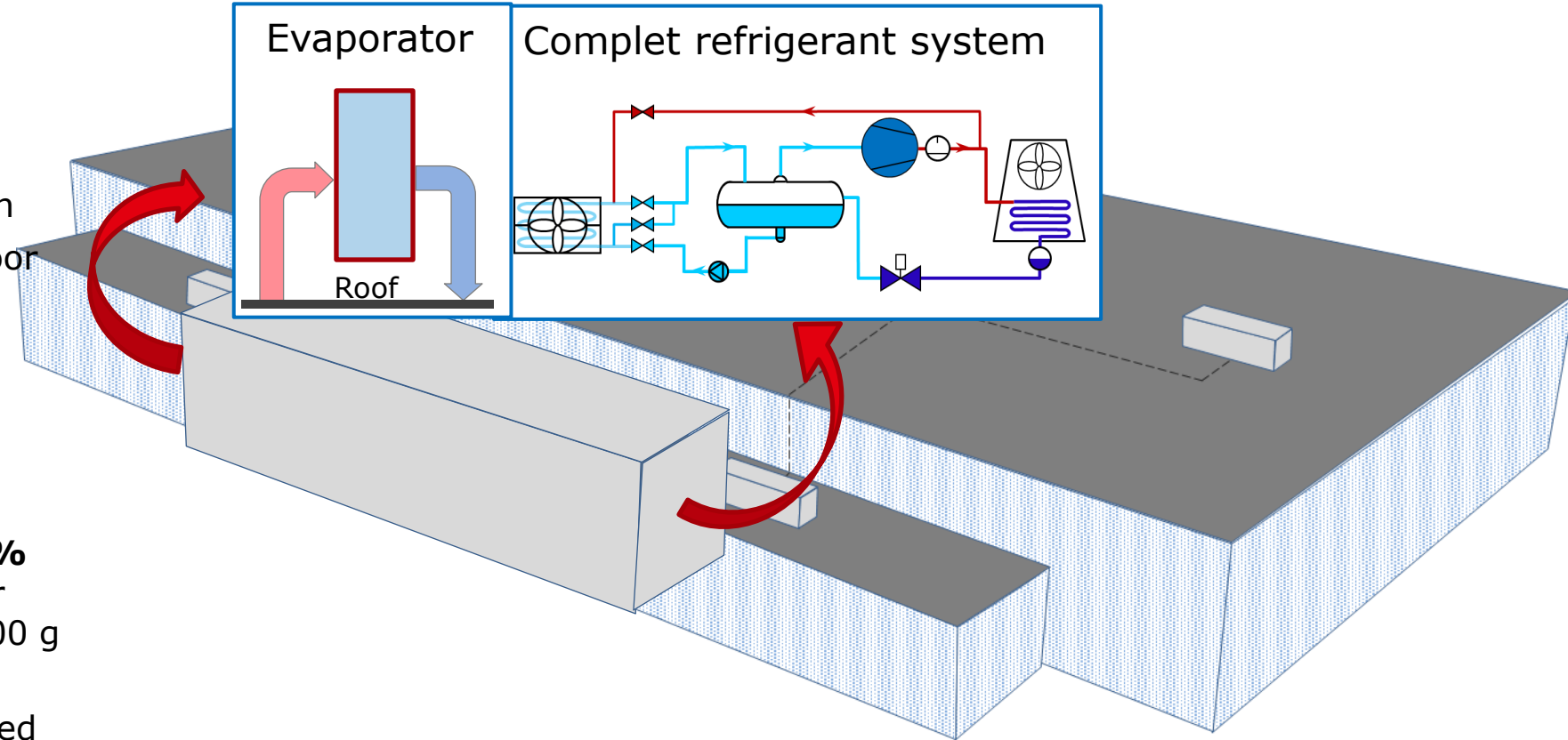
Super low charged ammonia system for cold storages

Upcoming trend

Mitigating risks

Though not entirely new, advancements in evaporator design and liquid feed control open the door to NH₃ systems offering

- No need for an engine room
- Roof-top based design
- "VLC" very low NH₃ charge
- **Claimed to have up to 98% less ammonia** than regular systems (lowest charge < 100 g / kW)
- Fully automated self-contained NH₃ system
- Very fast installation



Example:

Cold storages with 6 self-contained NH₃ "penthouse units"

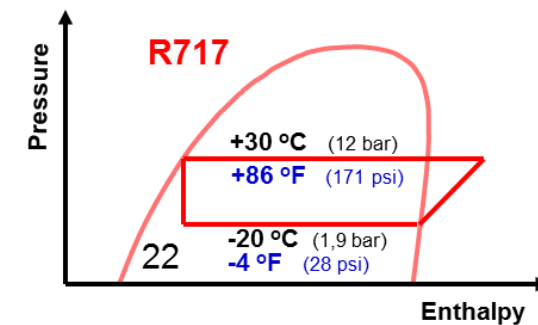
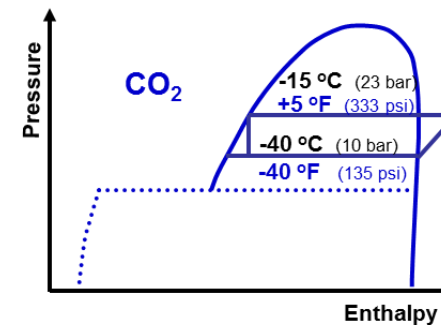
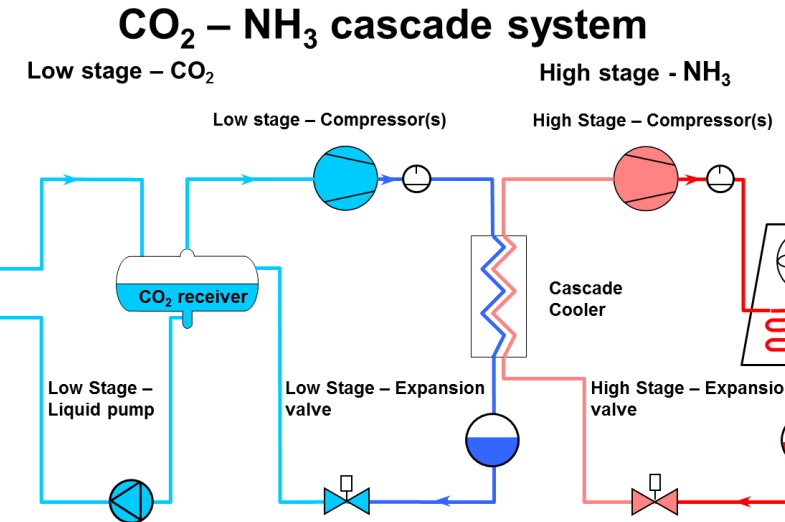
6 x 100 kg ammonia

6 x 250 kW cooling capacity

Ammonia & CO₂ cascade systems

NH₃/CO₂ cascade system

- Ammonia is limited to engine room
- **Reduce charge by 70-90%**
- Reduce potential risk of food pollution
- Reduce potential risk of food pollution
- Better performance / energy saving at low temperature-

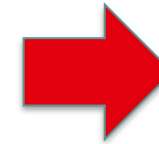


Safety – it is possible to make existing systems safer By using the right modern equipment

Example: Gas detection and safety valve



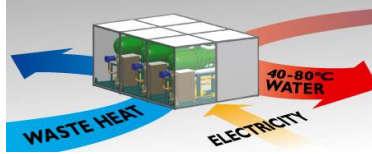
Example: Charge reduction in a coil



Drivers and reactions for Industrial Refrigeration

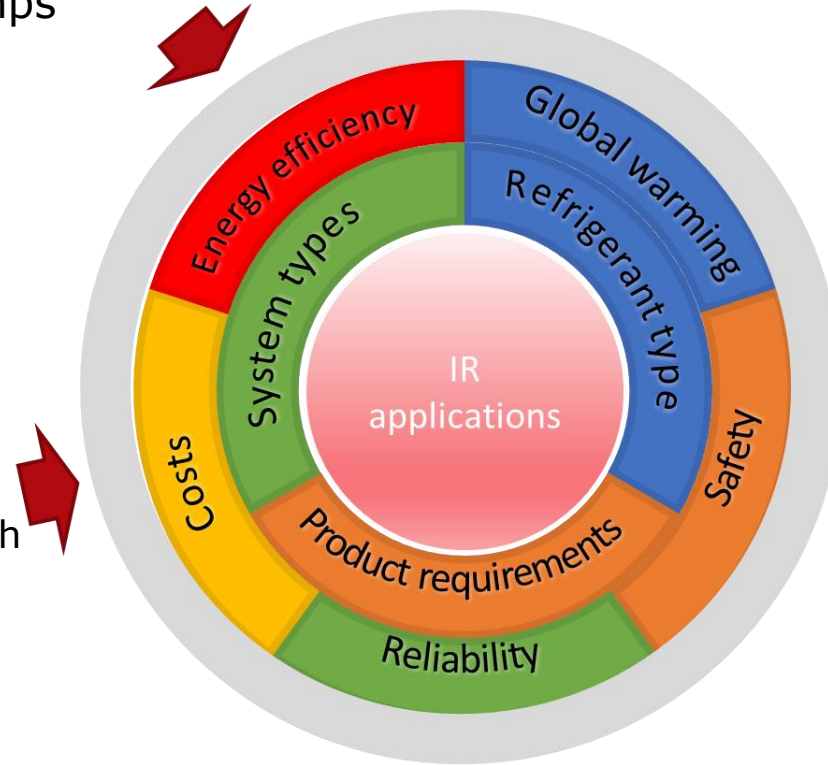
Energy efficiency

- new and retrofit systems
- Industrial heat pumps



Cost

- primary growth in emerging markets with higher price pressure, TCO awareness

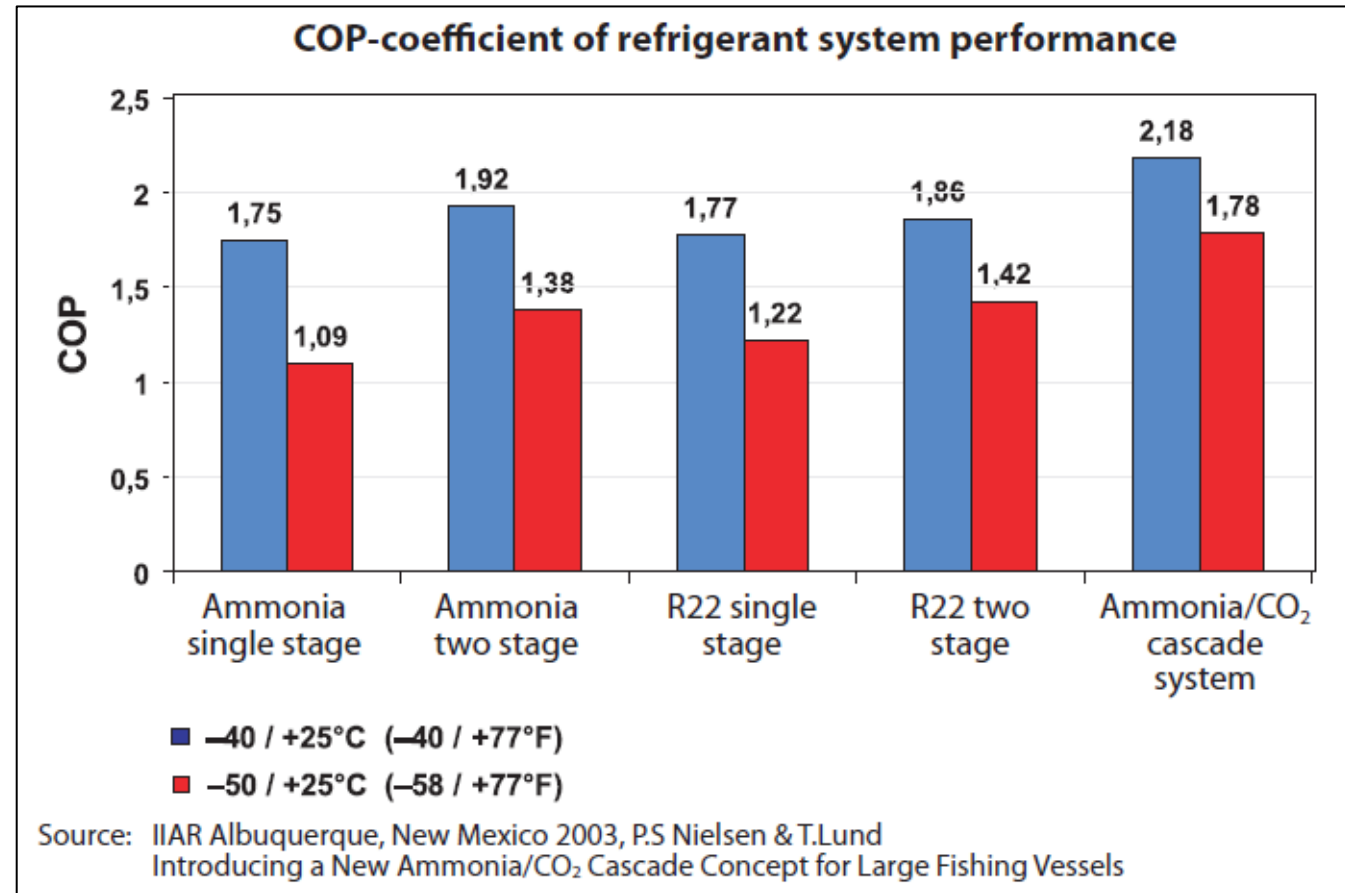


Efficiency indication cascade systems

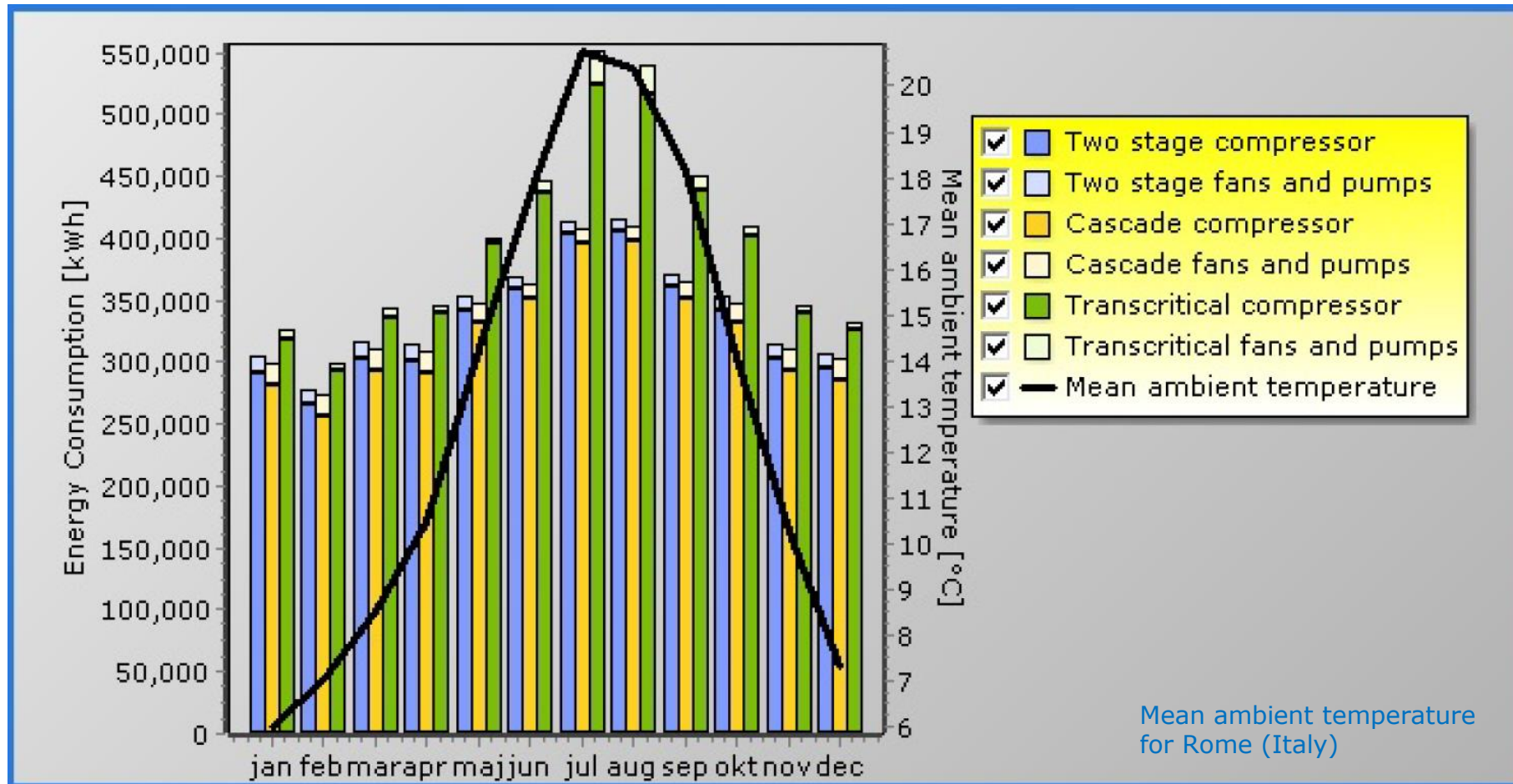
CO₂ cascade system compared with other systems

A heat exchanger decreases the system efficiency (dT), however:

- Compressors running with CO₂ have a better efficiency on low temp.
- CO₂ has a better heat transfer at low temp.



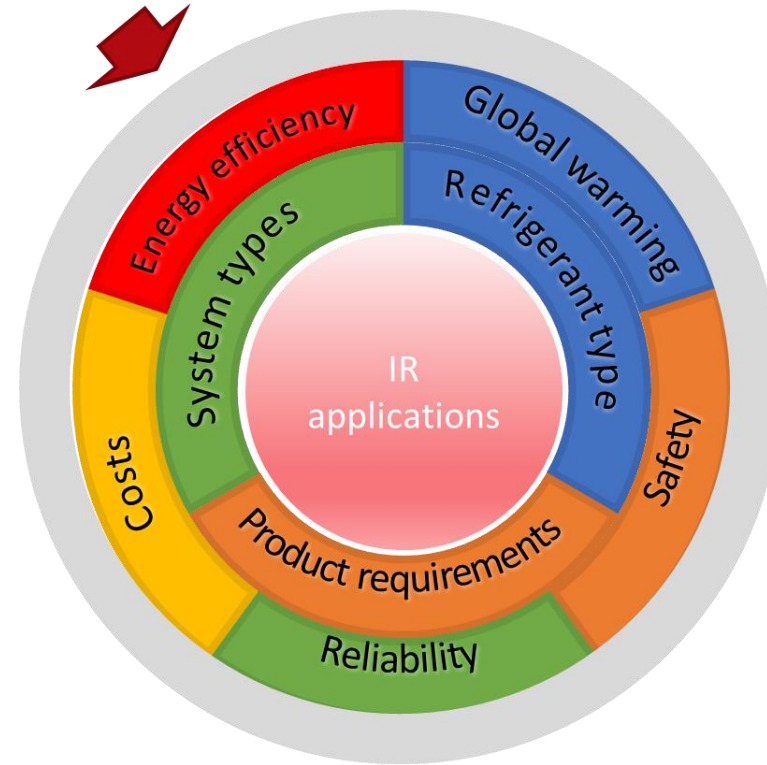
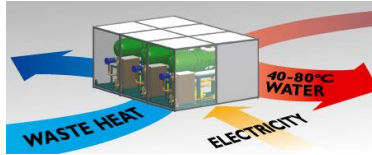
Comparison of ammonia vs. CO₂ systems



Drivers and reactions for Industrial Refrigeration

Energy efficiency

- new and retrofit systems
- Industrial heat pumps



Utilize waste heat with Ammonia Heat pumps



Dairies



Ice Rinks



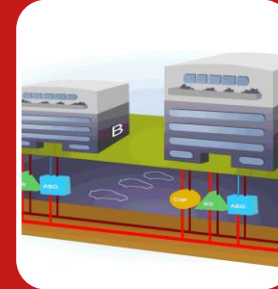
Slaughterhouses



Breweries



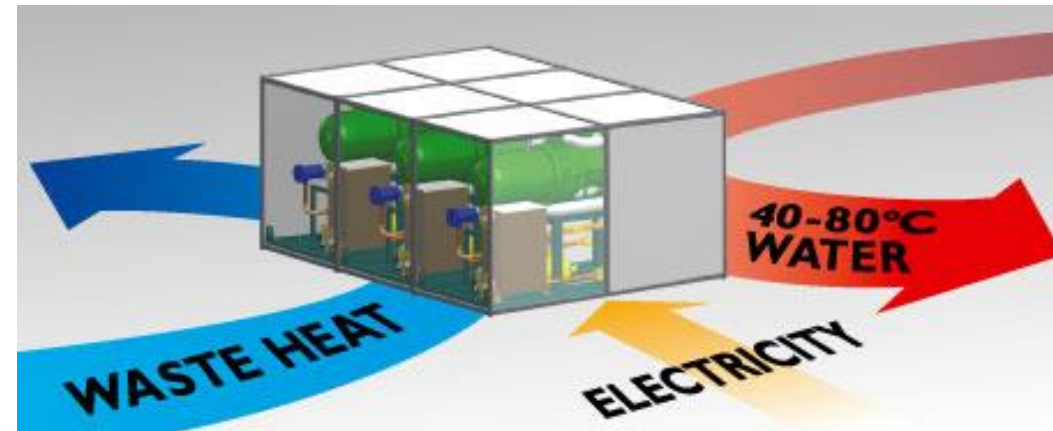
Poultry



District Heating

Ammonia – high temperature

- Pressure: up to 65 bar
- COP: up to 5 or higher as add-on
- Temperature range: water up to **95°C**
- Applications: **food processing, process technologies** and **district heating**
- Capacity range: ~200 kW → 30+ MW



Danfoss Air purgers & ICFD

Energy efficiency solutions

Why remove air?

- Non-condensable gasses (often referenced "air") can enter into refrigeration systems during operation or when servicing the system.
- This leads to increased condensing temperature and decreased refrigeration capacity and less system efficiency.
- Automatic Purging for maximizing system performance and reducing plant power consumption

Smart & Safe

Automatic purging maximizing system performance and operational safety



Why ICFD ?

- Reduction of blow-by gas by up to 90%
- Less loading of compressors
- Reduce hot gas consumption
- Reduce downtime of evaporator when defrosting
- Optimal system design

Our formula for efficiency



What could be relevance to India from CO₂ systems

- Food processing and Cold storage (Frozen applications)
 - Fishery production and storage
 - Slaughter house (Meat/Chicken production and storage)
 - Large cold storage (Target ≥ 500 Kw capacity within city or outskirts)
- Combining Cooling & Heating needs of Applications
 - Process industry (Dairy/Poultry/Beverage etc.)/Hotels/Large kitchens



Benefits of Sea food industry moving to Ammonia/CO₂ cascade systems

- Reduced ammonia charge of typical plant by 1/10th or less brings more safety
- Fast freezing resulting into higher product quality
- CO₂ being very energy efficient @ -50°C



Danfoss India & IISC Engagements on Natural Refrigerants

- ✓ To develop skills & knowledge system to promote the use of CO₂ based applications specific to India
- ✓ Demonstrate the benefits of such systems and build strong eco system in order to attain the sustainability

Danfoss takes CO₂ refrigeration to India

15 FEB 2021



Signing the deal (left to right): Anurag Chandra (head India sales – climate solutions), Ravichandran Punushokhaman (president – Danfoss India region) along with assistant Prof Phaniendra, Prof Pradip and Prof Prasad of IISc.

Conclusions

- **The ammonia and CO₂ industry has a long history with more than +100 years of experience, where ammonia's properties has shown that it has been, and still is, one of the most effective refrigerants during all the years.**

Today's challenges:

- Ammonia is still the preferred refrigerant for industrial applications, **however safety is a topic**, that has to be treated professional.
- Low charge ammonia systems is a solution for mitigating the risk, and "low charge" is the name of the game for new ammonia systems, in particular in US and Europe are starting to look into Low charge ammonia to find the best solution for the customer needs.
- **In India**
 - Recognize Ammonia with CO₂ is an option for Frozen applications (Seafood/Slaughtering/Ice cream etc.) where Safety, Efficiency & Product quality is a concern
 - Safety Standards – Up Skill, Voluntary Vs Mandatory