
ASIA
ATMO sphere
Business Case for
Natural Refrigerants
04/09/2018 – Singapore

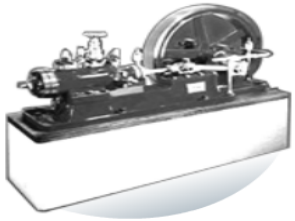
ATMO sphere ASIA

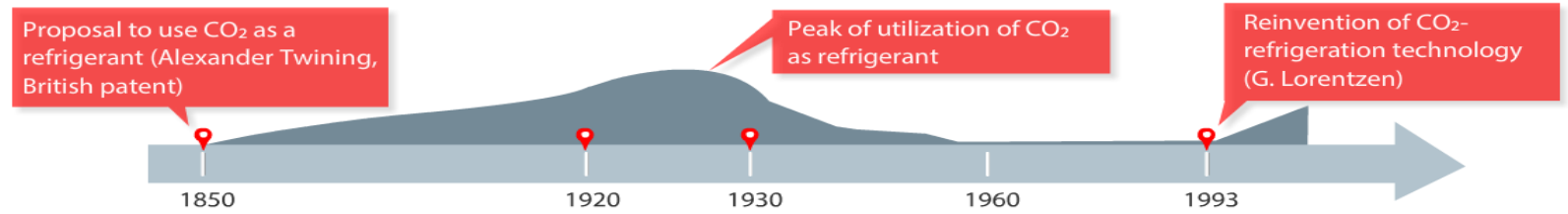
CO_2 Journey so Far....

Indy Saund Beijer Ref/SCM

History of CO_2

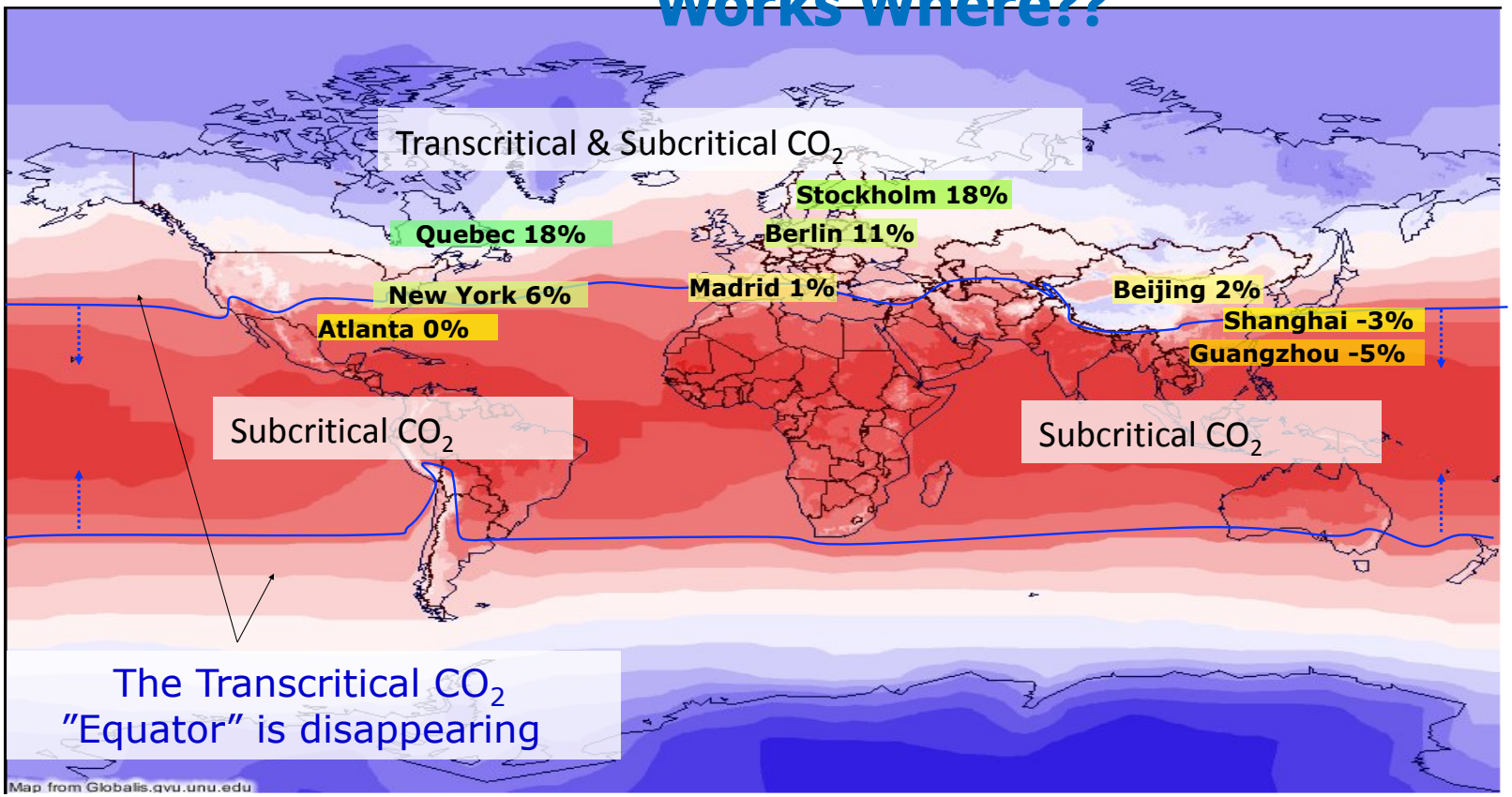
The first use of CO_2 as a refrigerant was in the nineteenth century.





The History of CO_2 Used as a Refrigerant	
1850	British Patent - A. Twining mention $C0_2$
1860	S. C. Lowe builds a CO_2 refrigeration system
1860 -	CO_2 becomes more widely used in follwing years
1920 - 1930	CO_2 refrigeration system peak
1950 - 1960	Last CO_2 systems installed in marine applications
1993	CO_2 refrigeration technology revives

What Type of CO_2 System Works Where??



Regulations and Restrictions in the different Countries

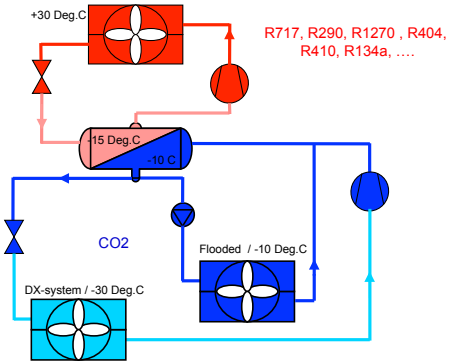
There are several national and international programs that regulate refrigerants, one of those being the European F-gas regulation, which was passed in 2006.

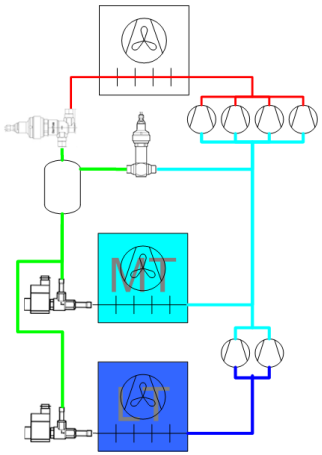
The F-gas rule significantly reduces the amount of fluorocarbons that are sold in the European Union (EU) by dramatically phasing them down.

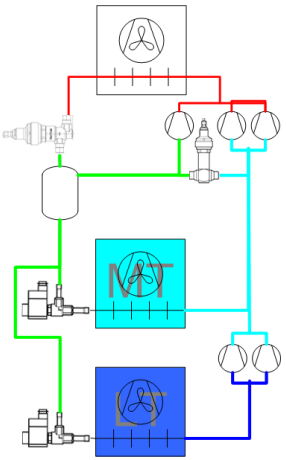
Facts:

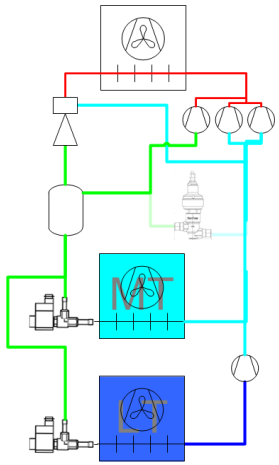
- **As a result of the Kigali amendment more and more countries are stepping up legislative efforts to limit the use of HFCs (China, India, and other developing country).**
- **Upcoming Montreal Protocol meetings will determine funding guidelines for developing countries;**
- **USA - how HFCs will be treated remains to be seen**
- **California will advance its legislation nevertheless - scientific assessment of possible measures currently ongoing**
- **Canada Implementing HFC phase down until 2030 and introduced national carbon tax.**
- **New F-gas law introduced in Japan**
- **New f-gas legislation introduced in Australia amending the Ozone Protection and Synthetic Greenhouse Gas Management (OPSGGM) Act by adding an HFC phase-down plan**

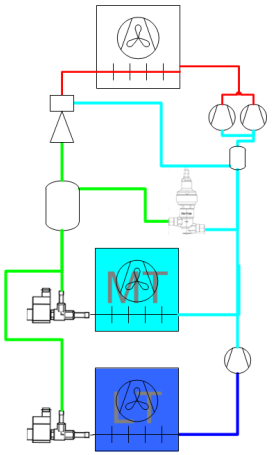
The Journey of CO_2 Systems









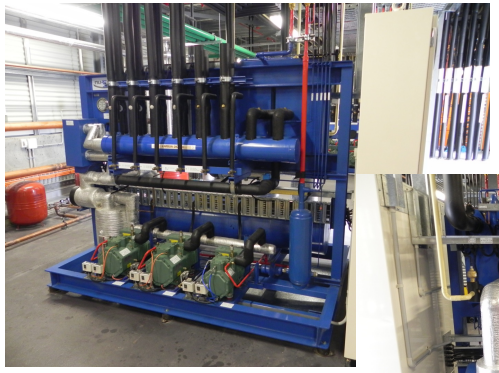


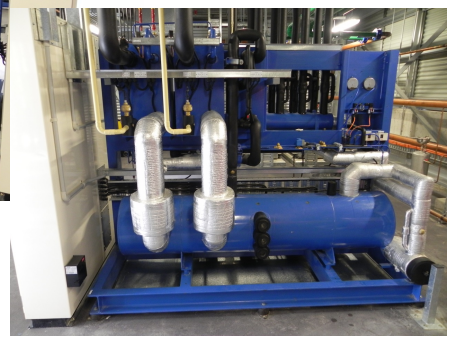
Cascade | Booster | Parallel | Gas Ejector | Liquid Ejector

1993 — 2018

Diagram Source: Danfoss

CO_2 Cascade Systems





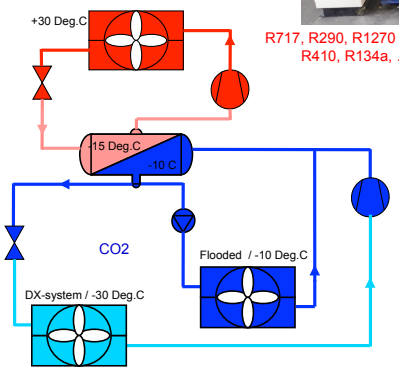


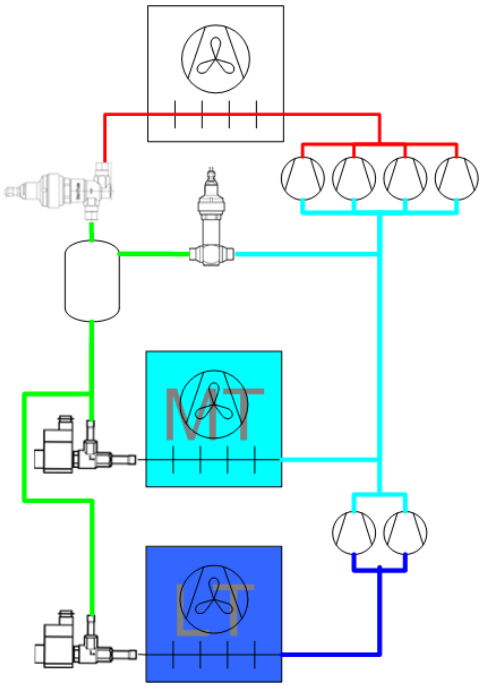
Diagram Source: Danfoss

When our journey started back in 1993 the first Systems to the market where Sub-Critical.
So CO2 used on MT & LT via a liquid pump and then Either a HFC or Ammonia used the High Side.

These systems then evolved into Co2 only on LT and MT was generally on R134a.

Within APAC a lot of these systems setup in Australia, New Zealand, China, Singapore and throughout ASEAN.

CO_2 Booster Systems



After the success of Sub-Critical CO2 systems And in the interest of making the systems more Efficient we saw the introduction of CO2 Booster systems.

Great performance and worked very well, but Limited to cold climates, which then saw the Introduction of the CO2 Equator.

At this point people started to look at ways to Make full CO2 system possible.

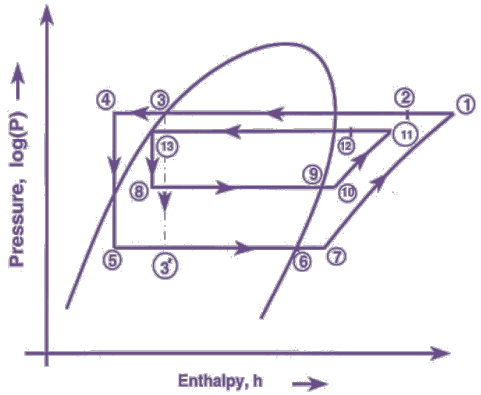
Diagram Source: Danfoss

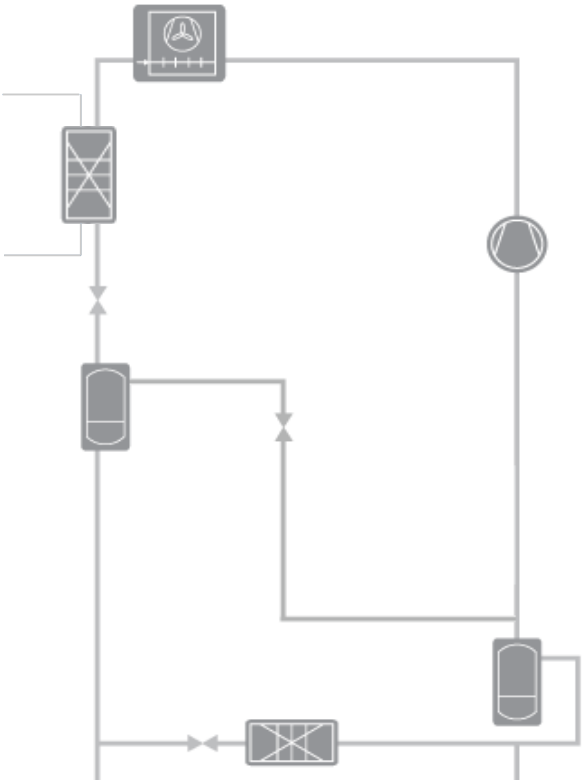
CO_2 Transcritical Cycle Efficiency Optimization: Mechanical Sub Cooler

Reducing throttling losses: Mechanical Subcooling

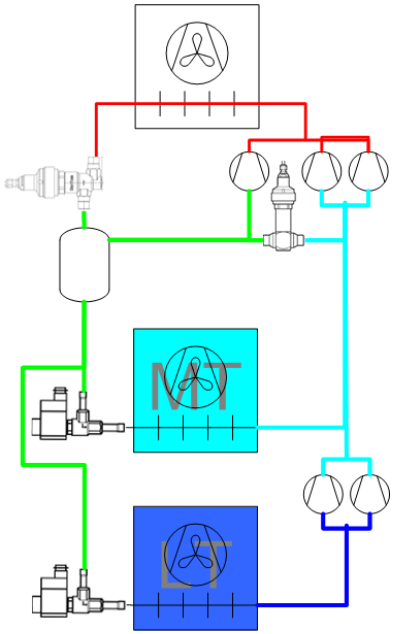
The mechanical subcooling solution strongly reduces exergy trottling losses thus increasing the overall system energy efficency.

Thermodinamically further cooling of refrigerant leaving the gas cooler or condenser can significatelly reduce power consumption and improve the system COP.





Parallel CO_2 Systems

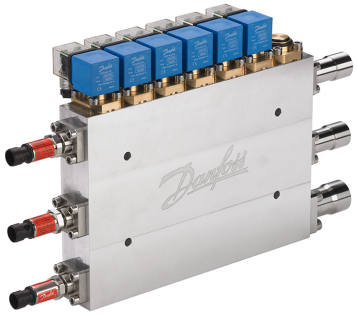


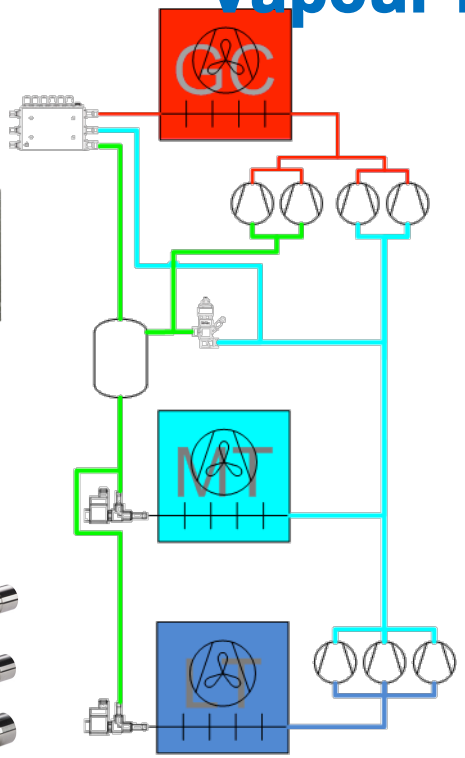
Another option that came to light was Parallel Compression systems, where by Adding a 3rd compression stage to Manage the flash gas it become possible To now have full CO2 systems in warm Climates.

However search to further improve efficiency was sit on.

Diagram Source: Danfoss

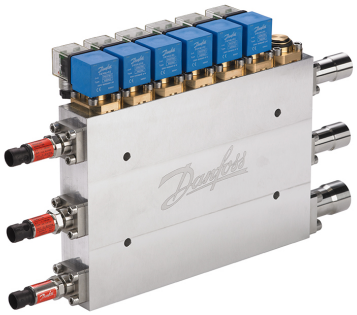
Parallel CO_2 System with Vapour Ejectors

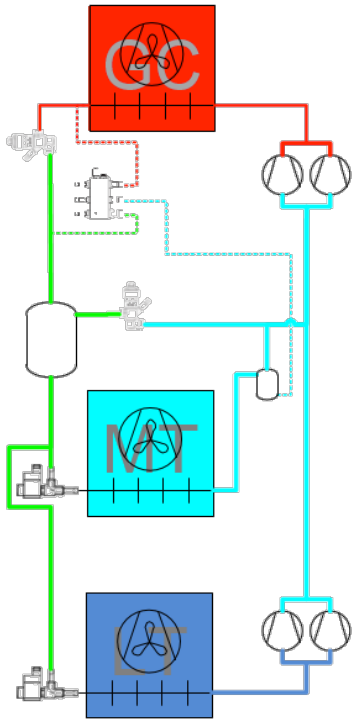




In the on-going search for better efficiencies trend uncovers the use of ejectors.
A simple mechanical device which takes Two pressure streams and makes them one, Within a single chamber.
This has now led to further improvements And greater reliability of CO2 systems in Warmer climates.

Parallel CO_2 System with Liquid Ejectors

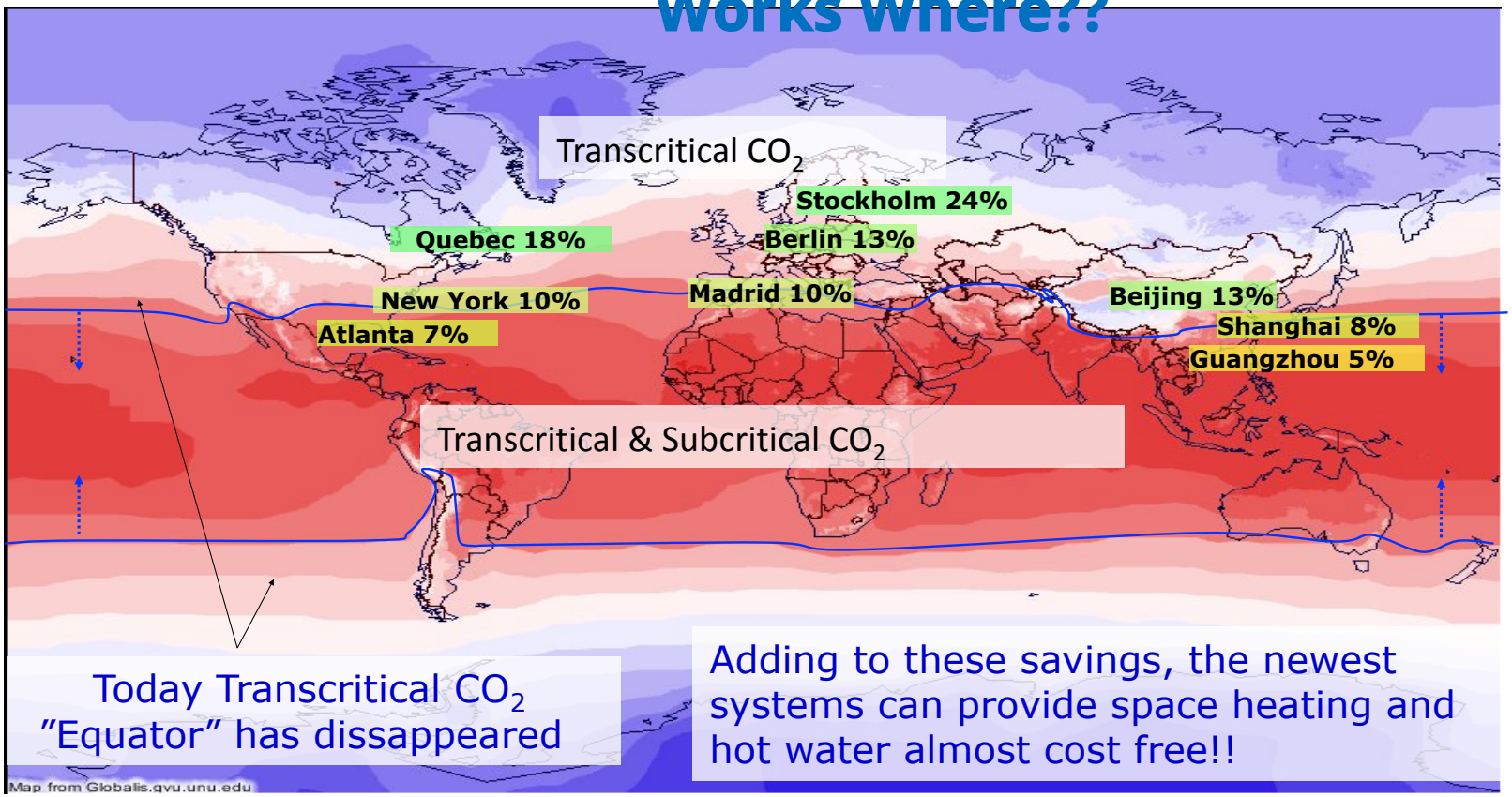




The next trend in motion is being trialled in
A few countries around the world and that
Is the use of Liquid Ejectors.
This technology now drives further system
Efficiencies and again makes Co2 possible
Anywhere in the world.

Diagram Source: Danfoss

What Type of CO_2 System Works Where??



2018

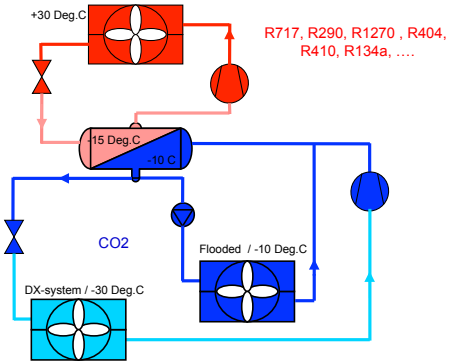
Introducing **parallel compression** and the **multi-ejector**

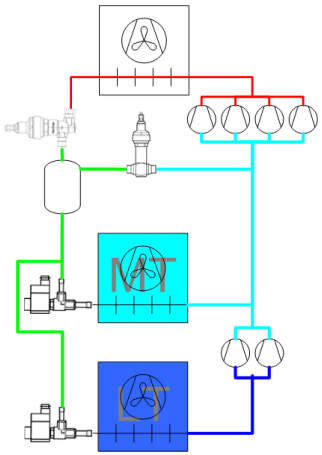
Legend:

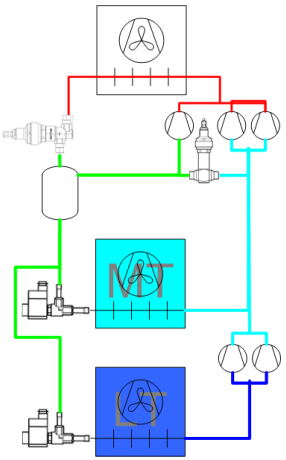
Centigrades of temperature

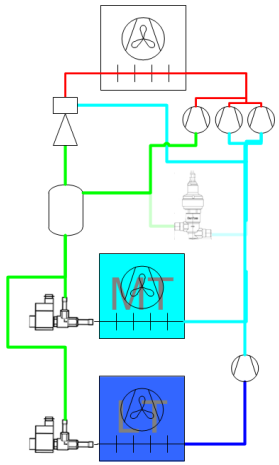
- -60 - -50
- -50 - -40
- -40 - -30
- -30 - -20
- -20 - -15
- -15 - -10
- -10 - -5
- -5 - 0
- 0 - 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30

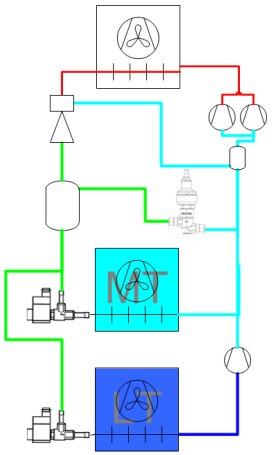
The Journey of CO_2 Systems











Cascade | Booster | Parallel | Gas Ejector | Liquid Ejector

1993 — 2018

Diagram Source: Danfoss

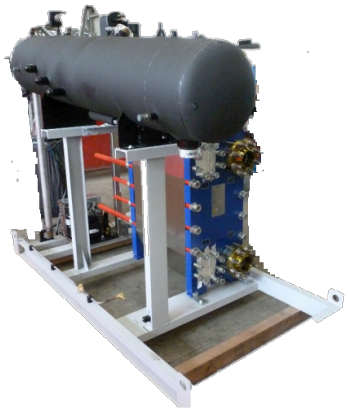
CO_2 System Options

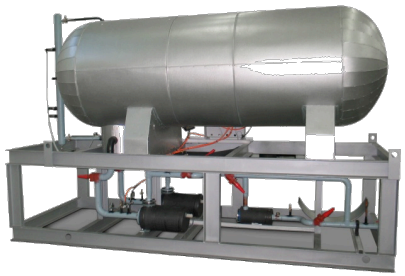
CUBO plus 2

SCM FRIGO
A BEIJER REF Company

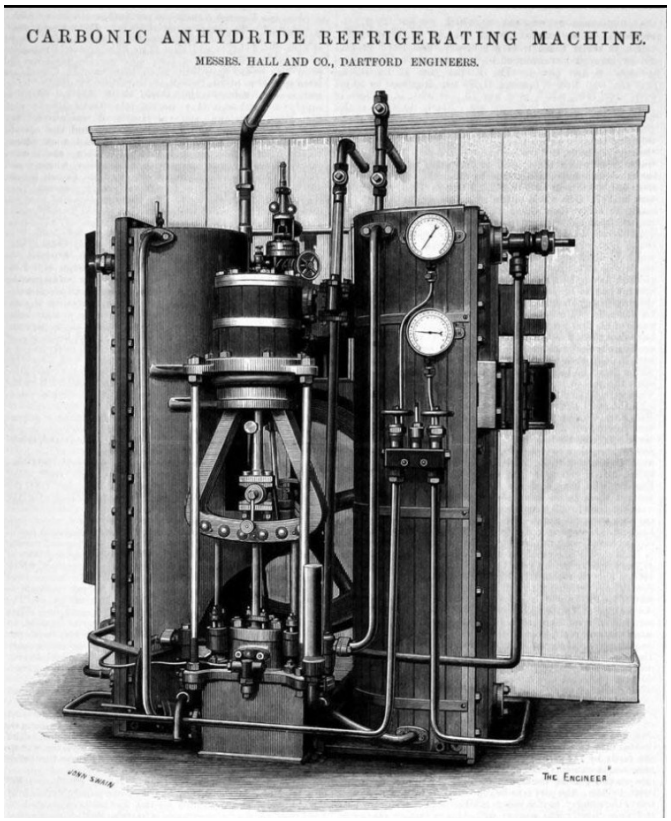
CUBO smart 2

WHICH ONE ARE YOU GOING TO CHOOSE!!!





Back to the Future CO_2 System



On A final note here is a picture of
The first CO2 machine marketed by
J & E Hall back in 1888.

If Co2 was right back then why not now !!


ATMO
ASIA
sphere
Thank you for listening!