



Ultra-Low-Temperature cooling with air as refrigerant

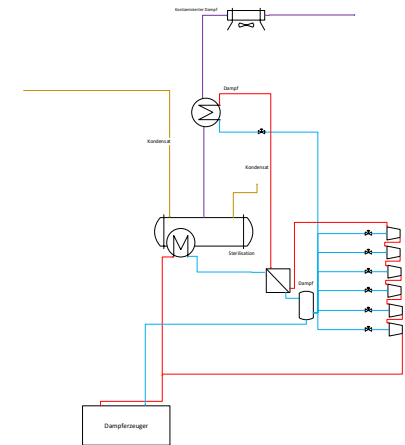
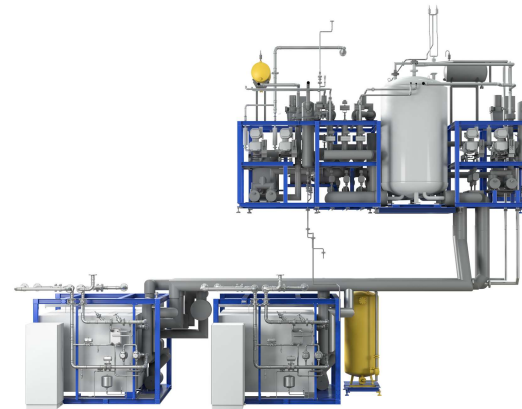
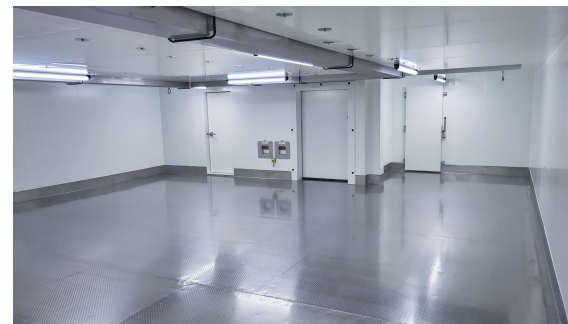
Thomas Frank

euramm^{on} Symposium, 28.06.2023

Refolution Industriekälte GmbH

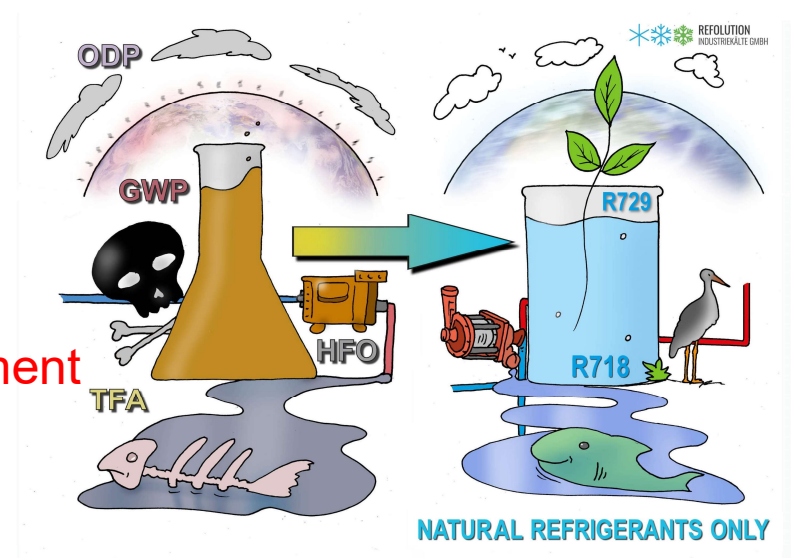
The engineering office for sustainable refrigeration

- Consulting
- Planning
- Special plant construction
- Product development



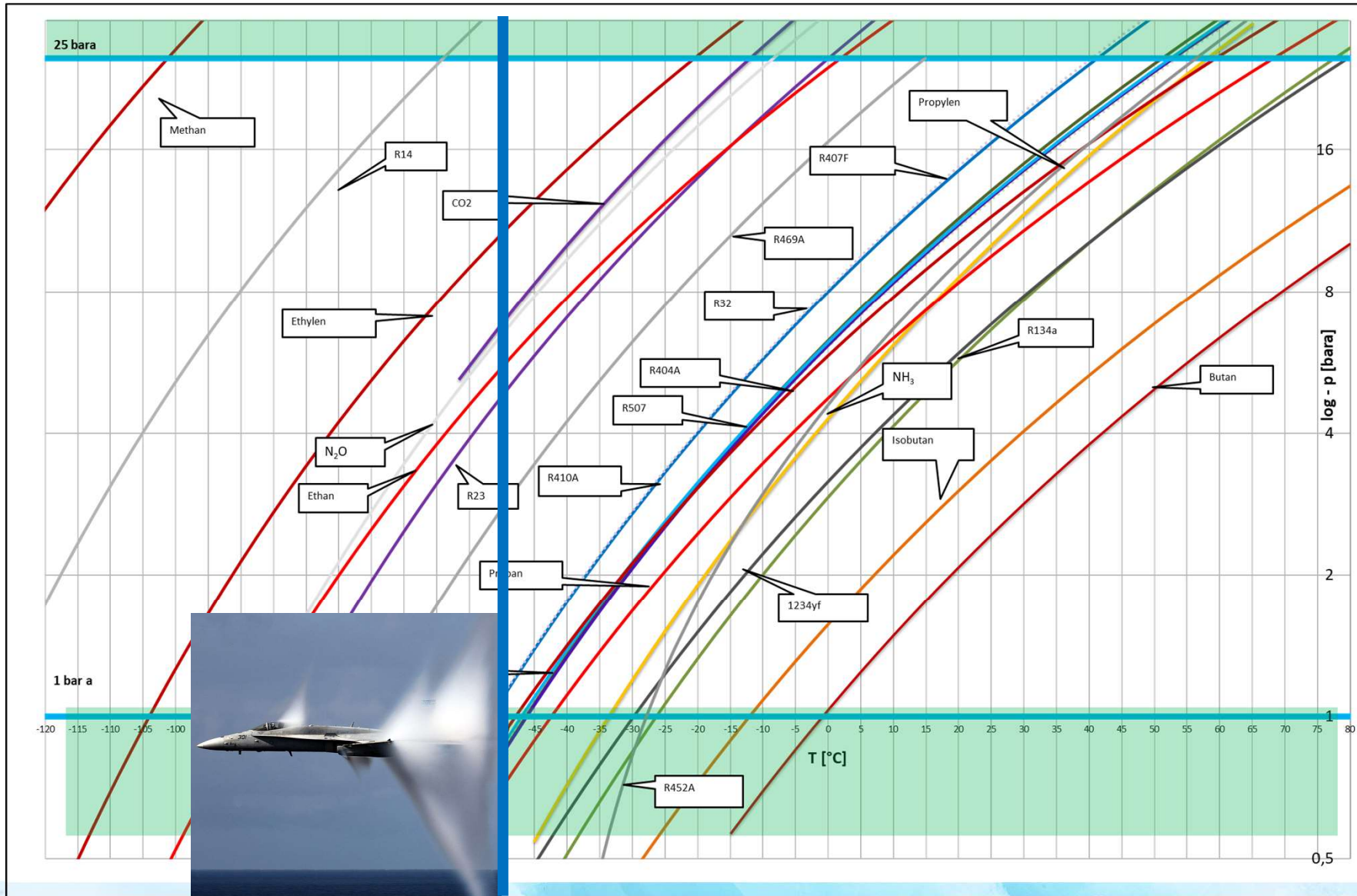
Impact of refrigeration

- Indirect CO2 emissions:
- In Germany about 14% to 19% of total electrical power is used in a refrigeration process
- Average life cycle is 15 years and life cycle cost is rarely counted
 - Need for efficient and long-lasting solutions
- Direct emissions of refrigerants:
 - ODP – Ozone Depletion Potential
 - GWP – Global Warming Potential
 - HFO/TFA/PFAS – persistent pollution of the environment
 - Use of natural refrigerants



Refrigerants Overview

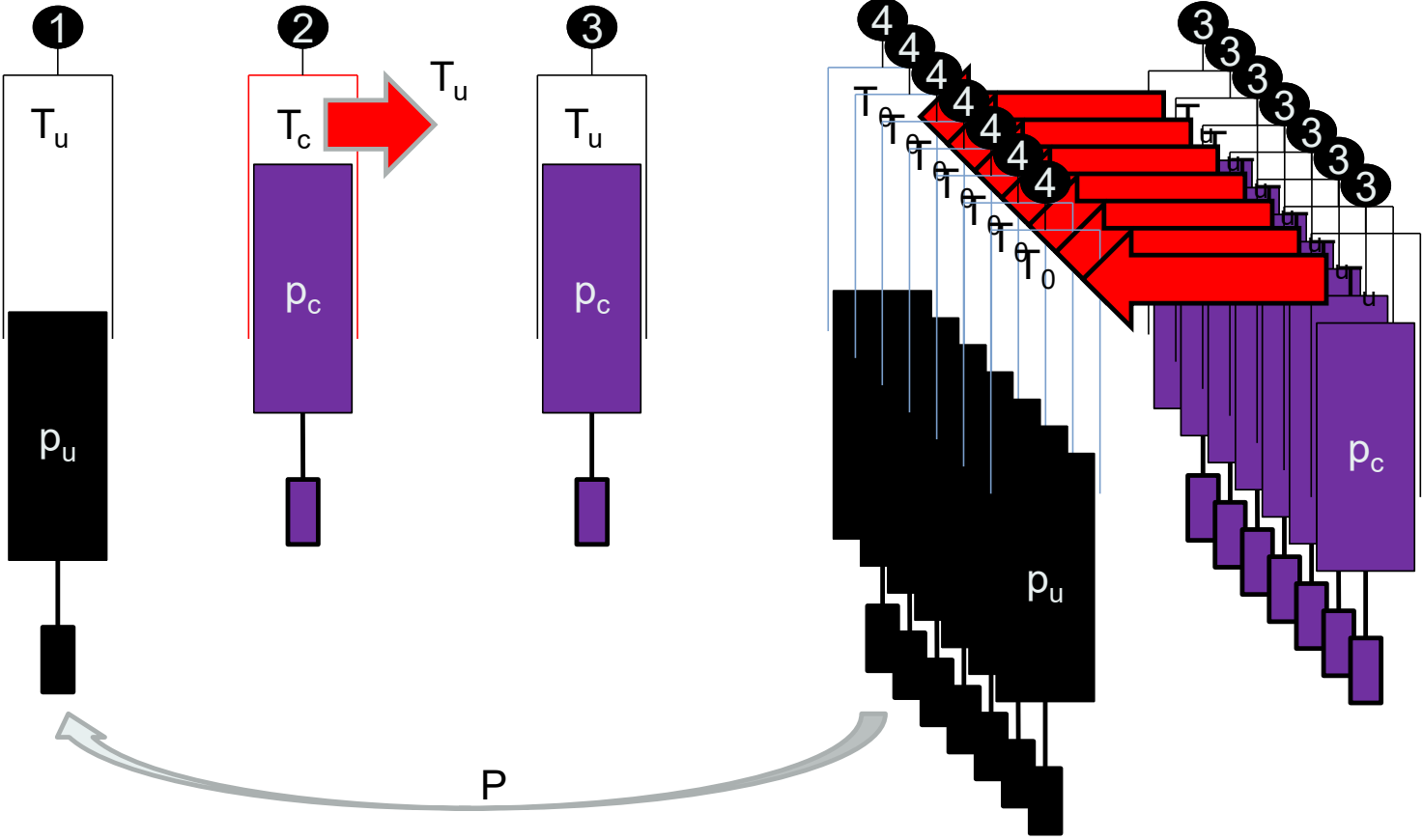
- NH3 R717 (GWP 0)
- CO2 R744 (GWP 1)
- R23 (GWP 14.800)
- R134a (GWP 1.430)
- R404A (GWP 3.922)
- R407F (GWP 1.825)
- R410A (GWP 2.088)
- R449A (GWP 1.397)
- R507A (GWP 3.985)
- 1234yf (GWP 4)
- R32 (GWP 675)
- Butan R-600 (GWP 4)
- Isobutan R-600a (GWP 3)
- Propylen R-1270 (GWP 2)
- Propan R-290 (GWP 3)
- Ethan R-170 (GWP 6)
- Ethylen R-1150 (GWP 4)
- Methan R-50 (GWP 25)
- WT69 R469A (GWP 1.357)
- R452A (GWP 2140)
- R14 (GWP 7390)
- N2O R744A (GWP 265)



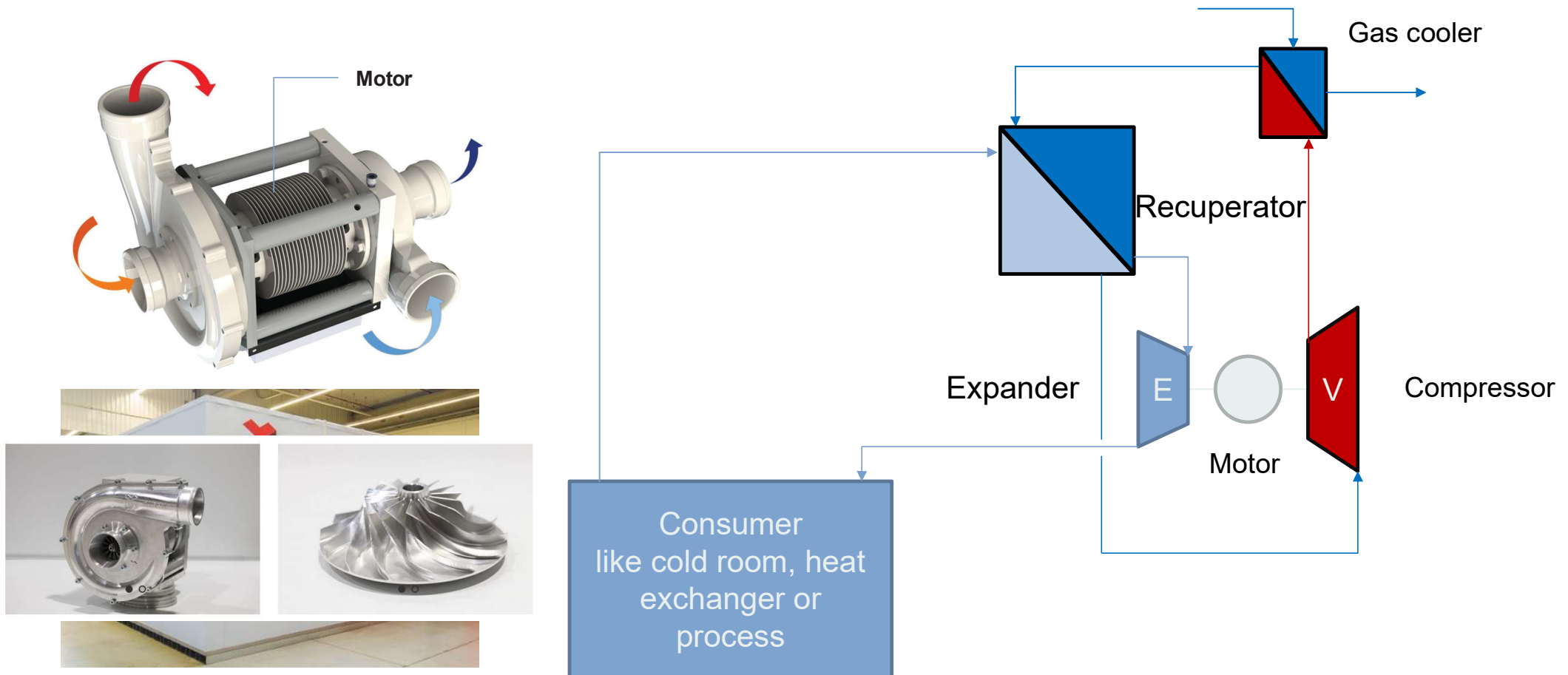
„Sound barrier“ below
-50°C use
temperature

Thought Experiment – air refrigeration

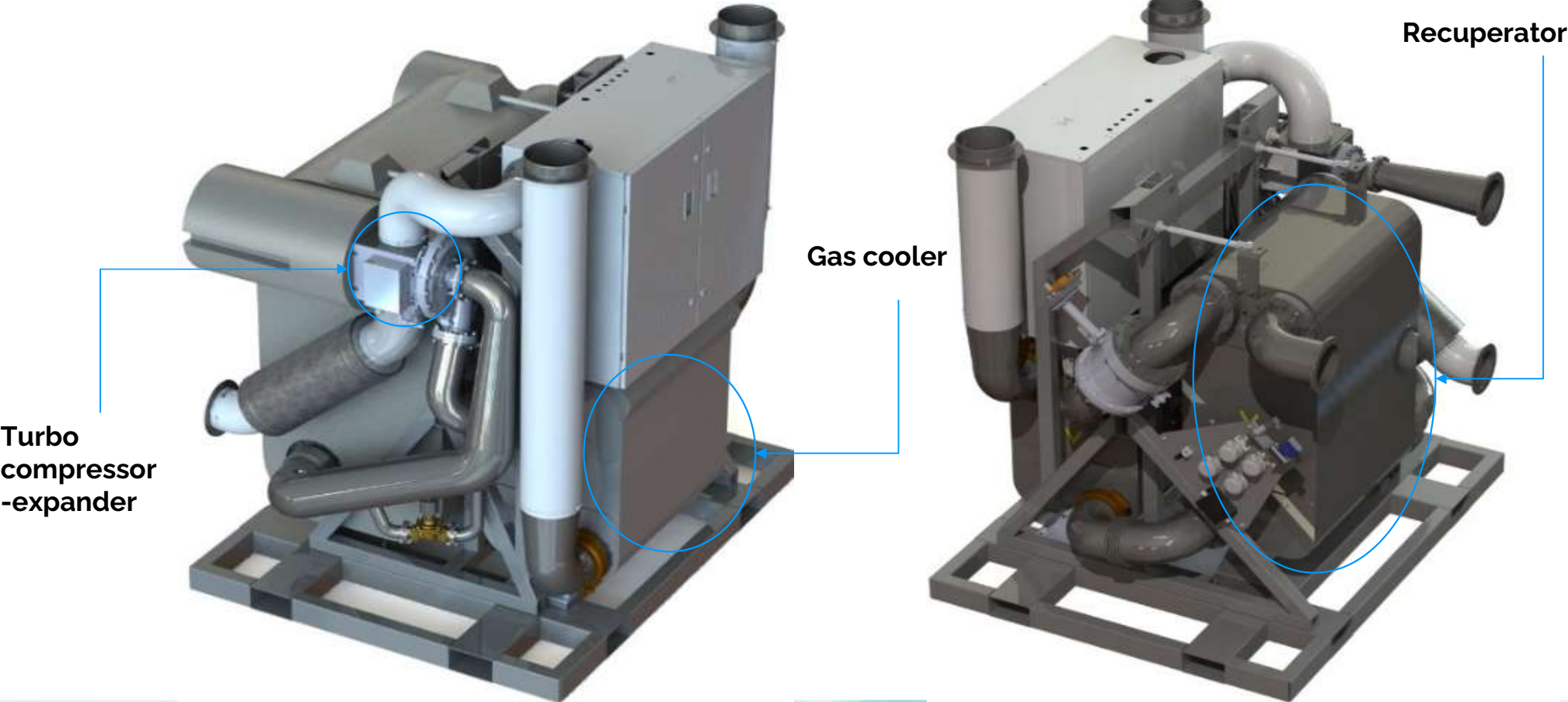
Air pump



Air refrigeration – Mirai Intex machine



Inside the Mirai Intex refrigeration machine



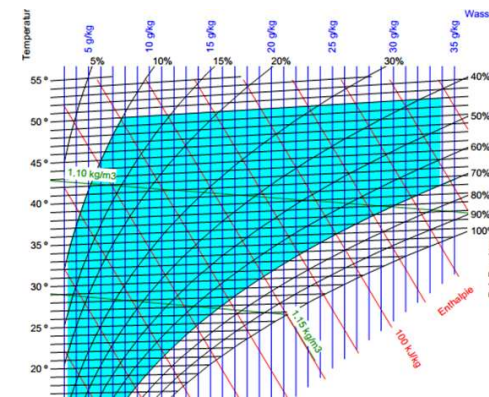
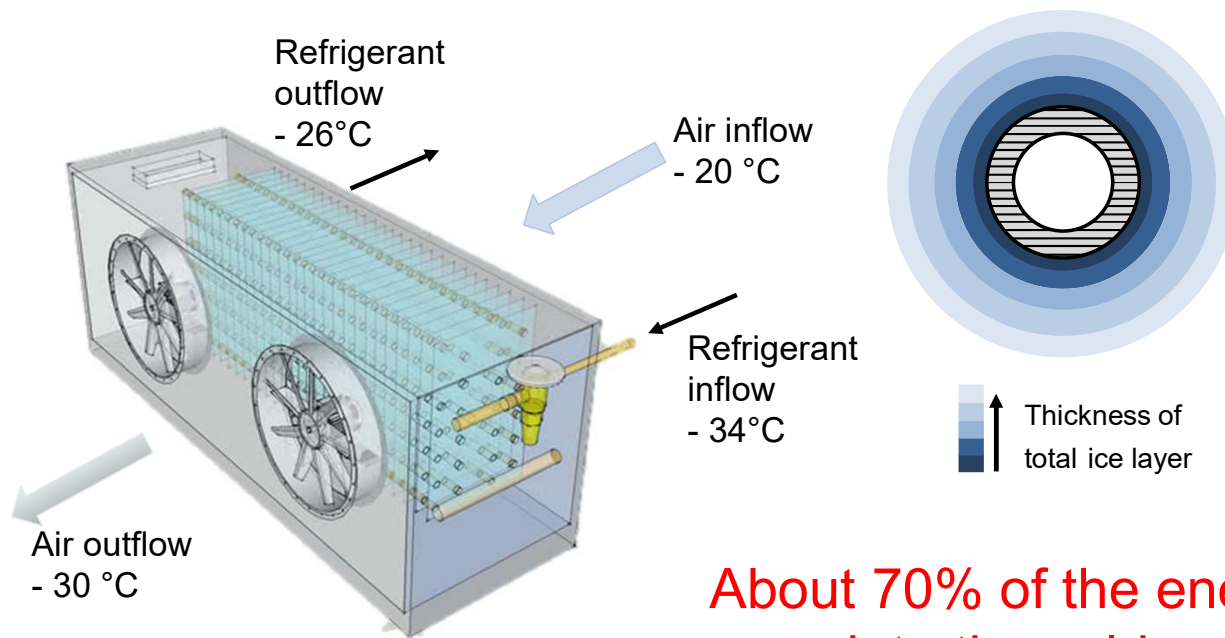
Open cycle

➤ Applications

- Storage
 - Medical – plasma – enzymes
 - Food – sushi fish
- Liquid N₂ replacement
 - Production - enzymes
- Environmental simulation
- Cold deburring
- Cold sauna



Evaporator in common refrigeration



About 70% of the energy for defrosting goes into the cold room

Humidity extraction device - No Evaporator



- ✓ Constant temperature (no defrost)
- ✓ No heat from ventilators and heaters
- ✓ Automated efficient de-icing
- ✓ Low Dewpoint

Signals	
Temperature in the chamber, °C	-70,1
Temperature of the motor, °C	65,8
Inlet temperature, °C	-70,9
Outlet temperature, °C	-88,3
The pressure of the compressor, kPa	83,4
Drop on heat exchangers, kPa	2,99
Power, kW	8,50
Rotation speed, rpm	77914
Drop on the grid, kPa	1,11
Pressure in the cleaner tank, bar	0,97

Recuperator drop

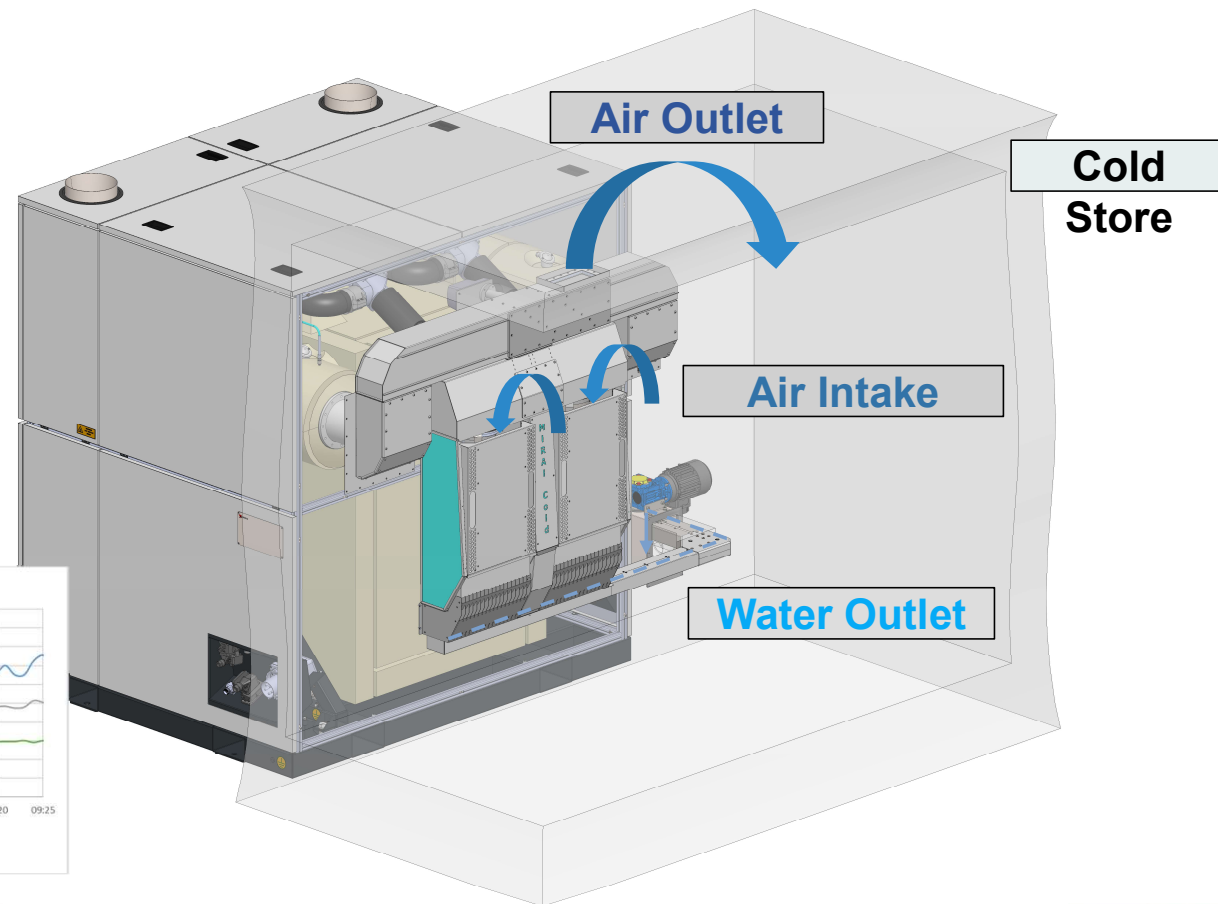
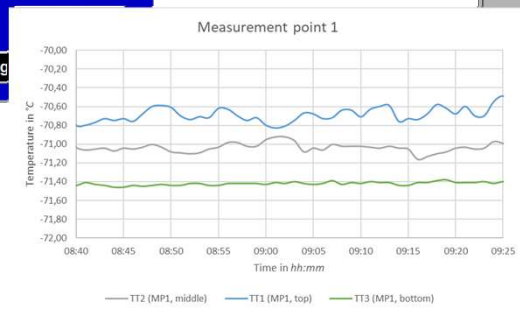
Water flow

Inverter

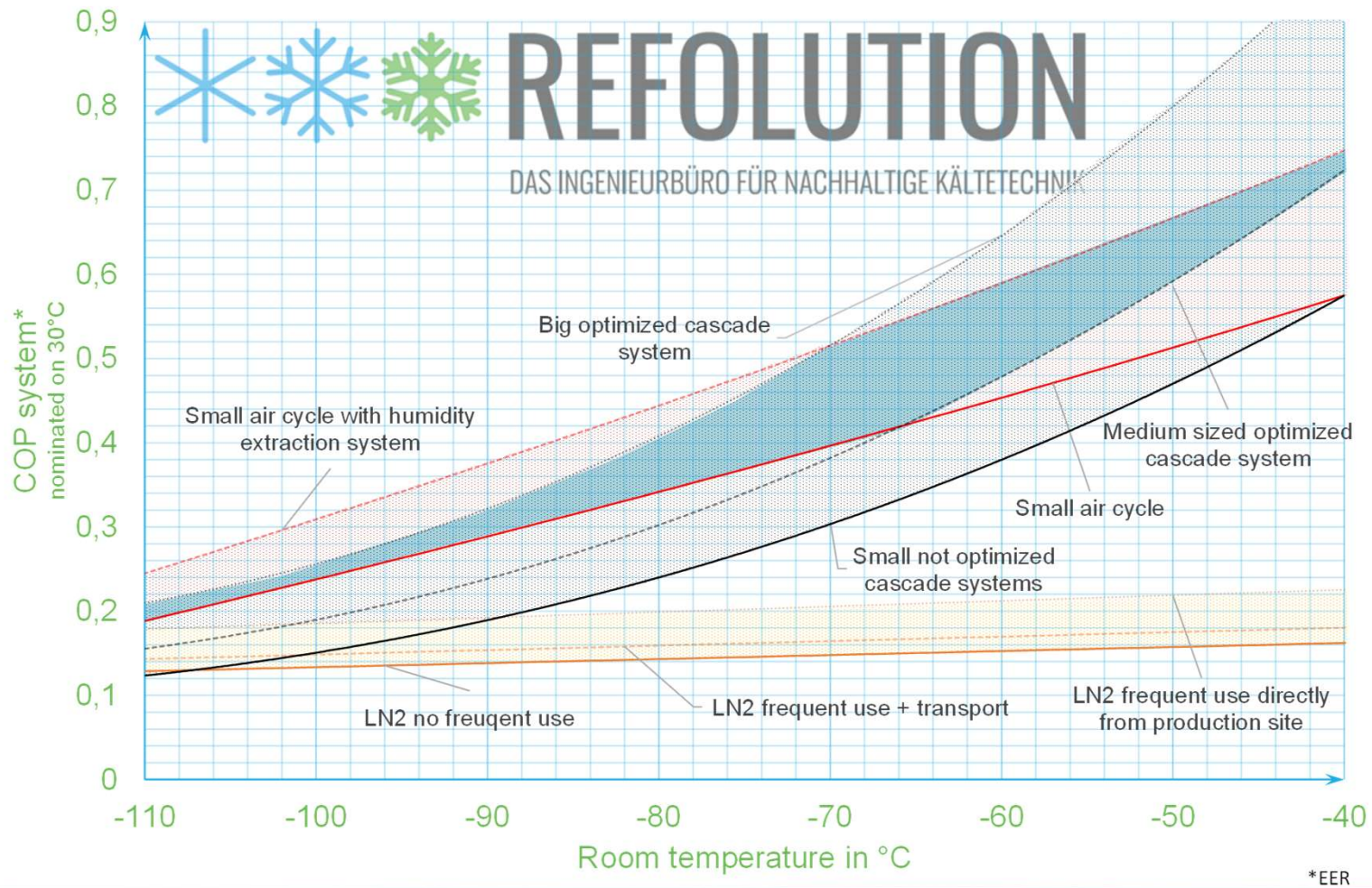
Ver. 3.21
SN 20/101

Drying mode
 OFF

<< Back Graph Alarms Logs Time and lang



Energy Comparison Full load– open cycle

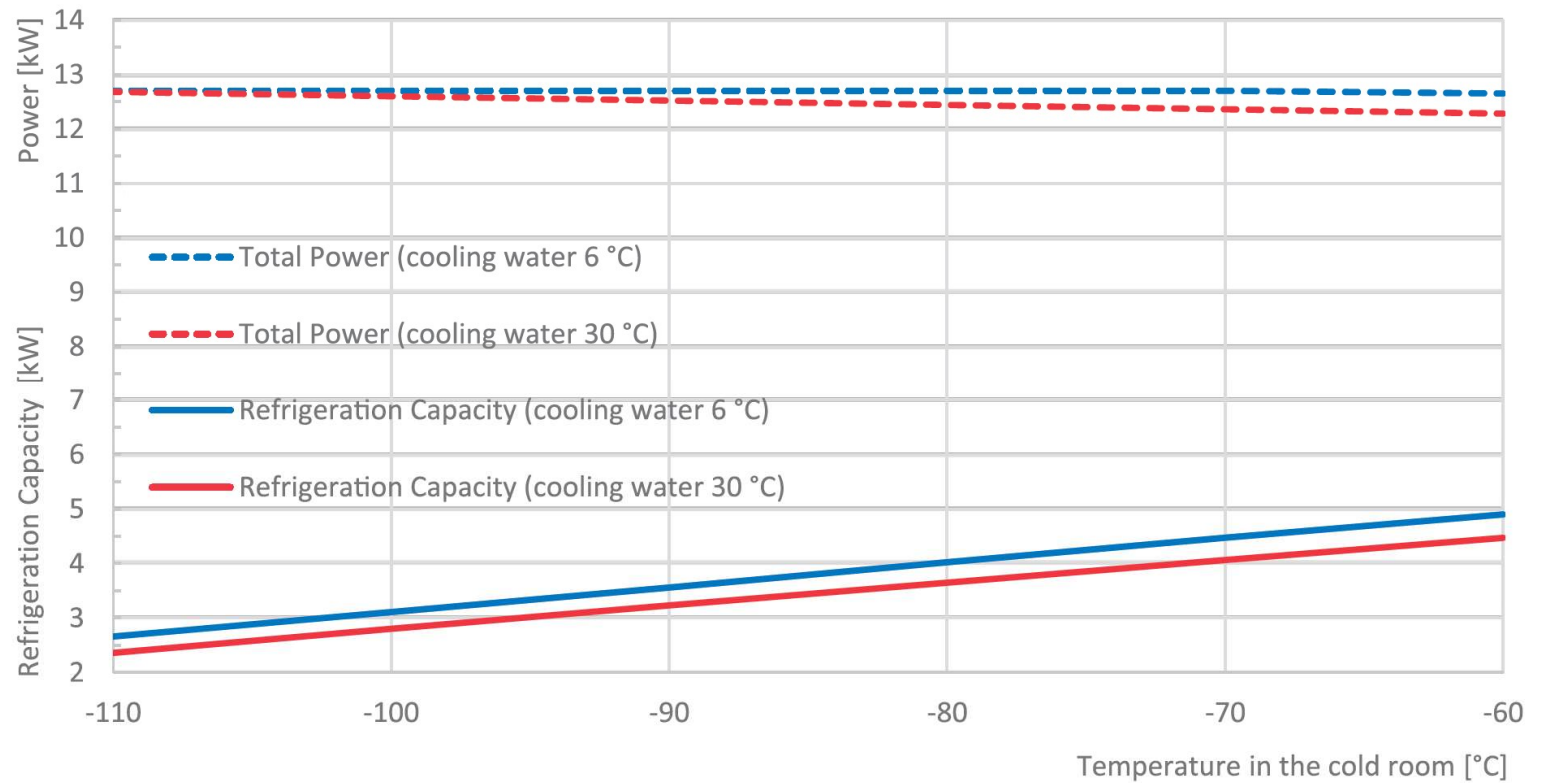


MC10-O/W



- Open cycle
- Water cooled

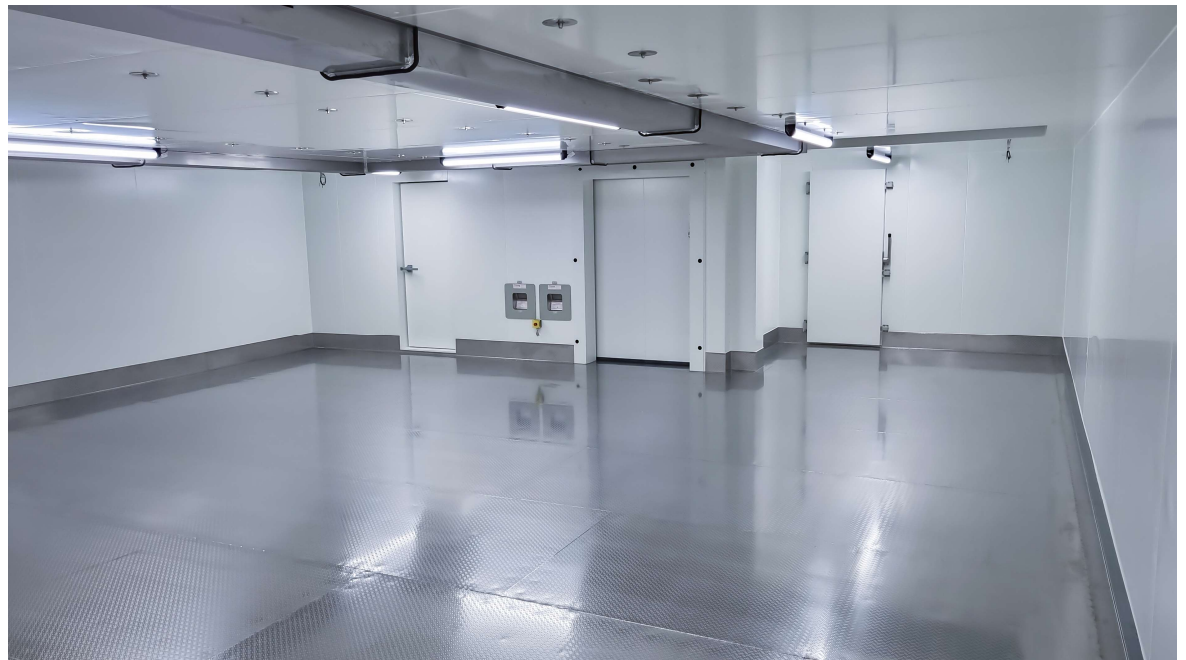
MIRAI Cold 10 (MC 10 O/W) - Refrigeration Capacity & Power



Referenz Recipharm / Wasserburg



Flexible -90°C to -20°C storage rooms
2 * 185 m^3 / 85 m^2 storage space
Teledoor insulation chambers



Mirai Intex air refrigeration machines (R729)
2+1 MC10 O/W for each room
Redundant cold water supply by Secon
propane chiller (R290)



<https://youtu.be/hWRI9LStHVo>

28.06.2023

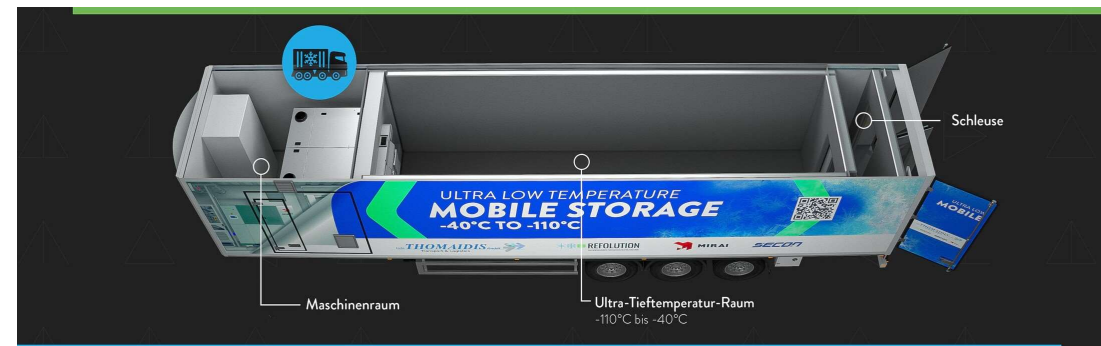
ULT Container with air refrigeration



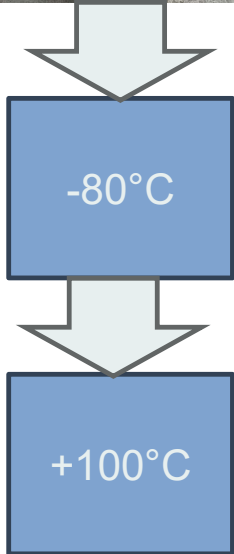
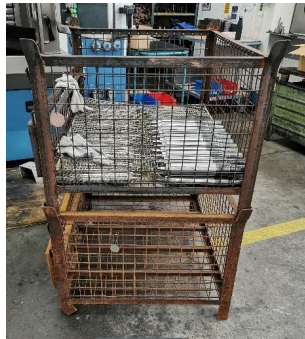
Cryocargo-110



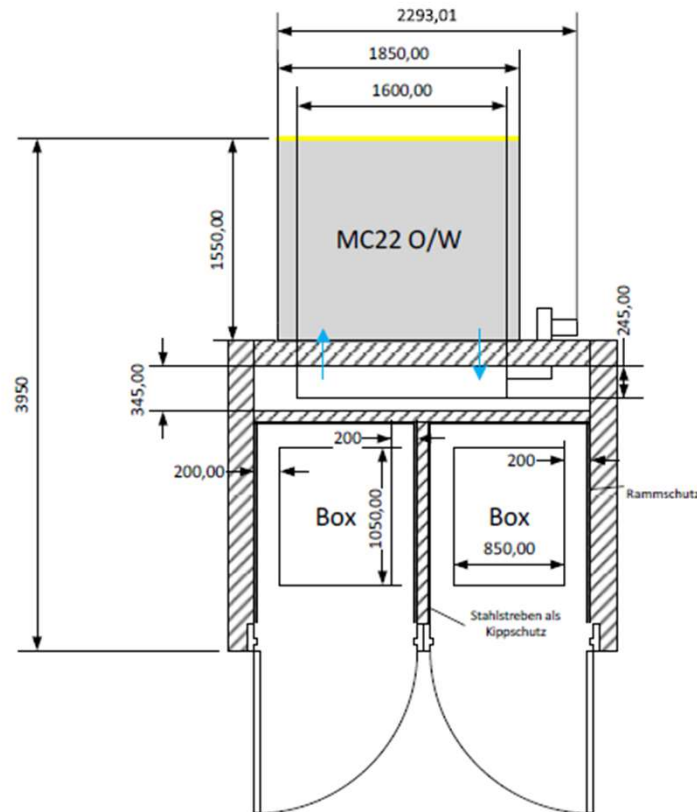
Gebr. **THOMaidis** GmbH
Transport & Logistic



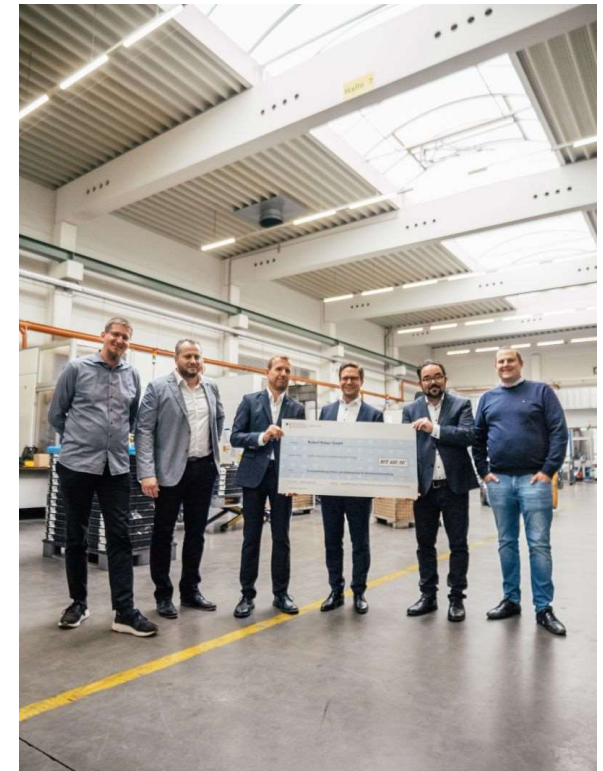
Steel hardening



Freezer Refolution Design



Environmental impact price from BMUV for the process



Closed cycle with air

- Application
 - Process cooling / production
 - Gas liquefaction
 - Cold trap
 - Recovery of solvents
 - Freeze drying/ Lyophilization
 - Freezers
 - Grinding of plastic
 - High-temperature superconductivity

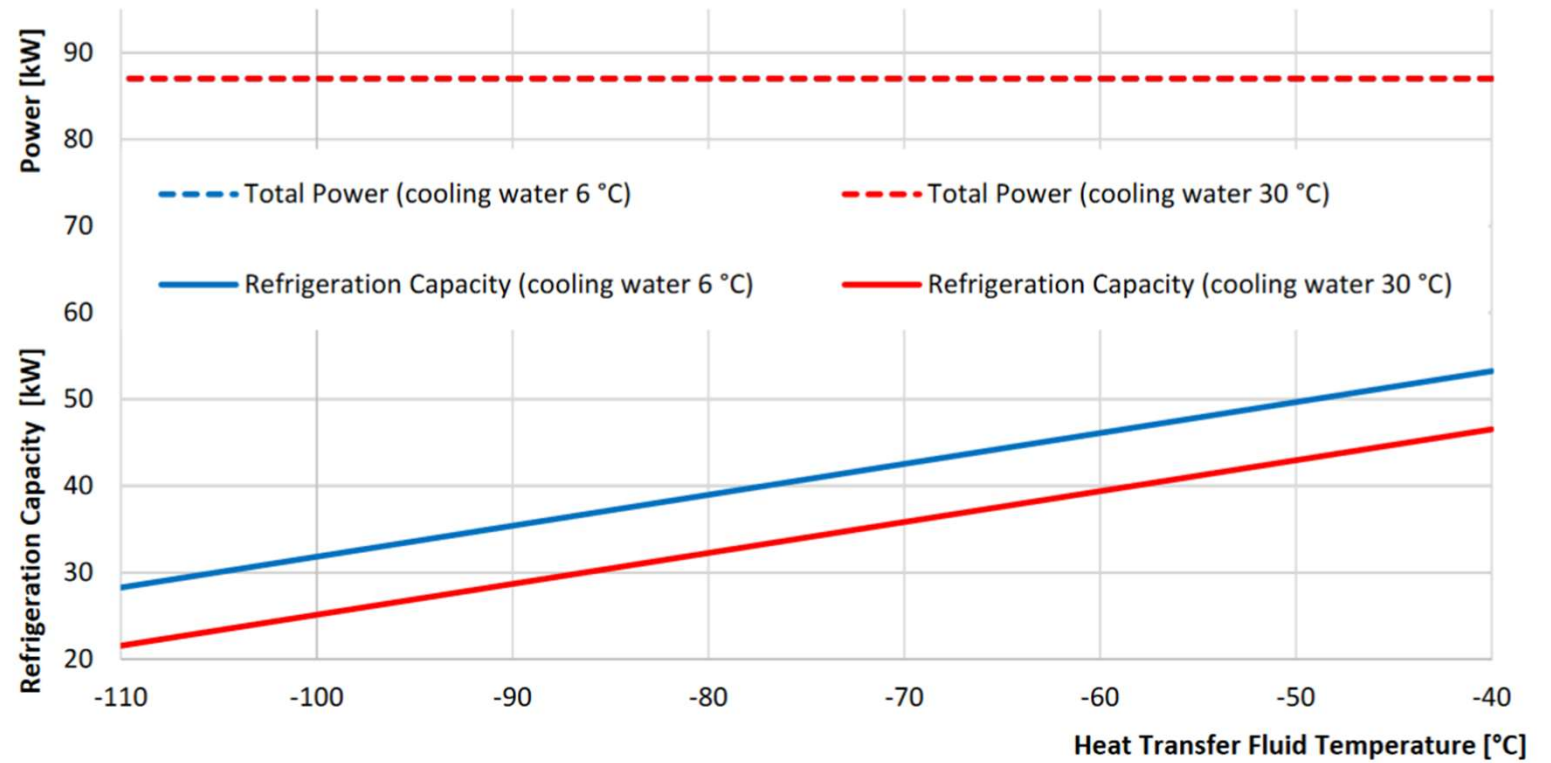
Special construction with Argon



MC80 C/W/T

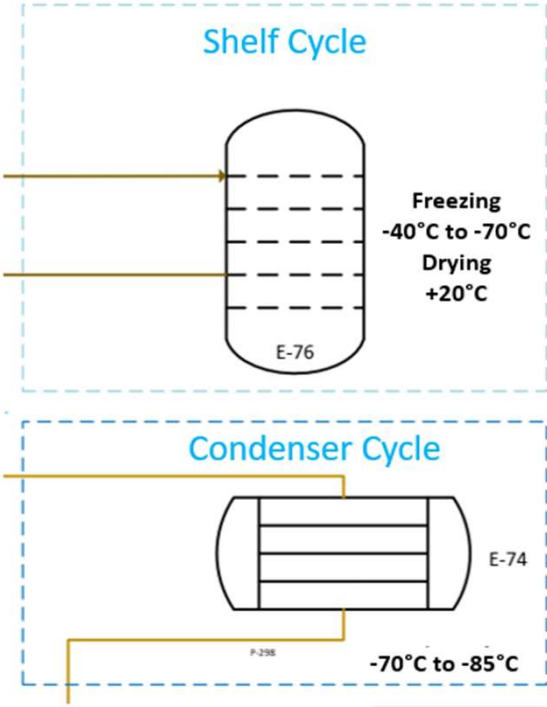


MIRAI Cold 80 T (MC 80 C/W/T) - Refrigeration Capacity & Power



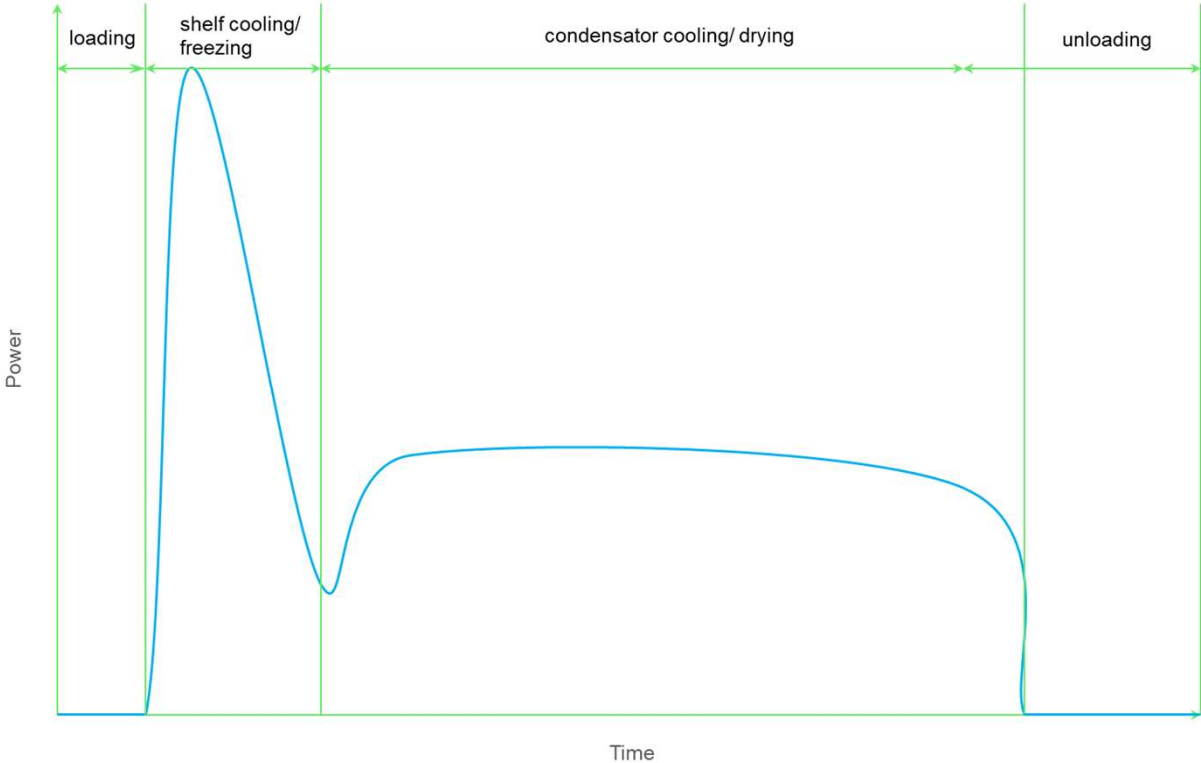
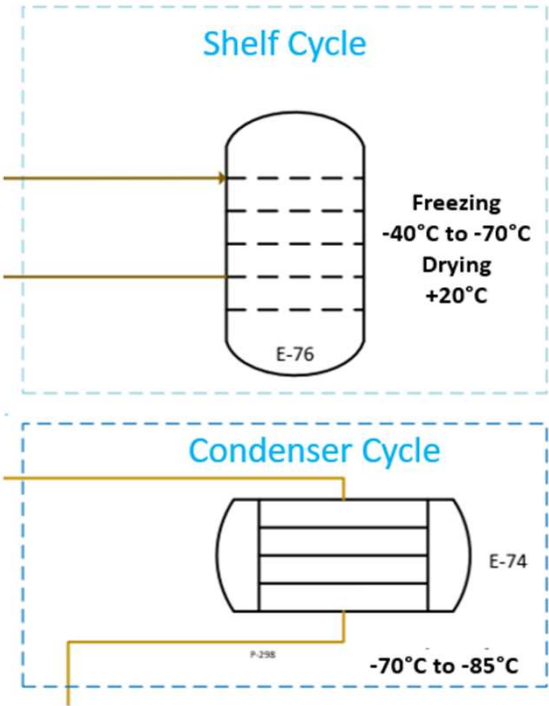
Lyophilization process

Freeze-Dryer



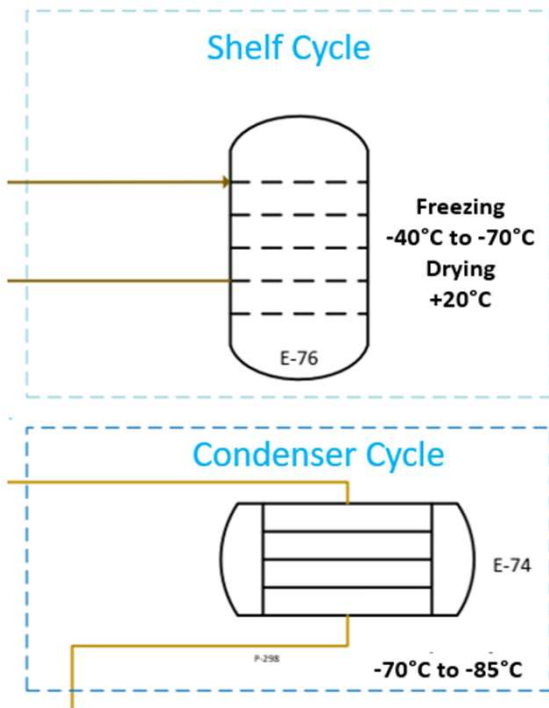
Lyophilization process from the view of refrigeration

Freeze-Dryer

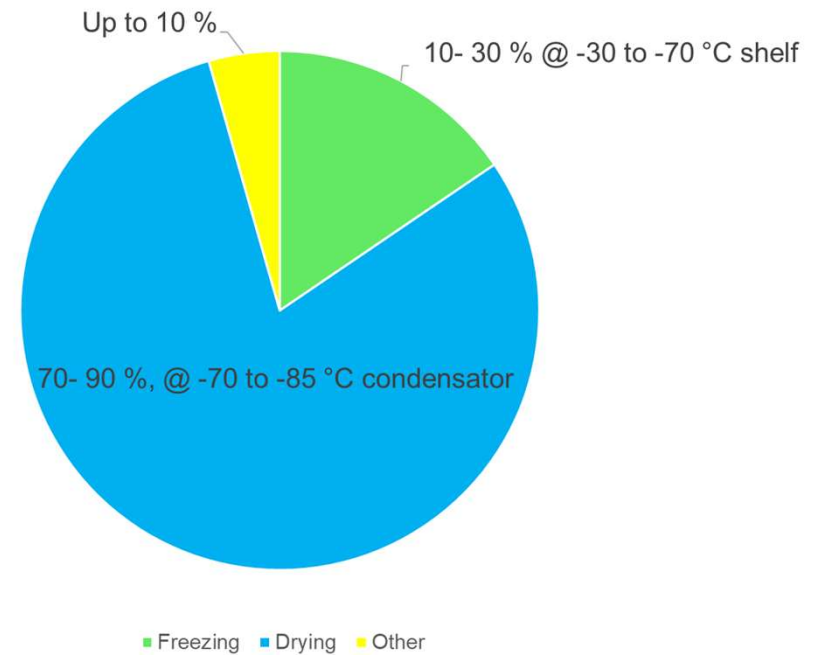


Lyophilization process from the view of refrigeration

Freeze-Dryer

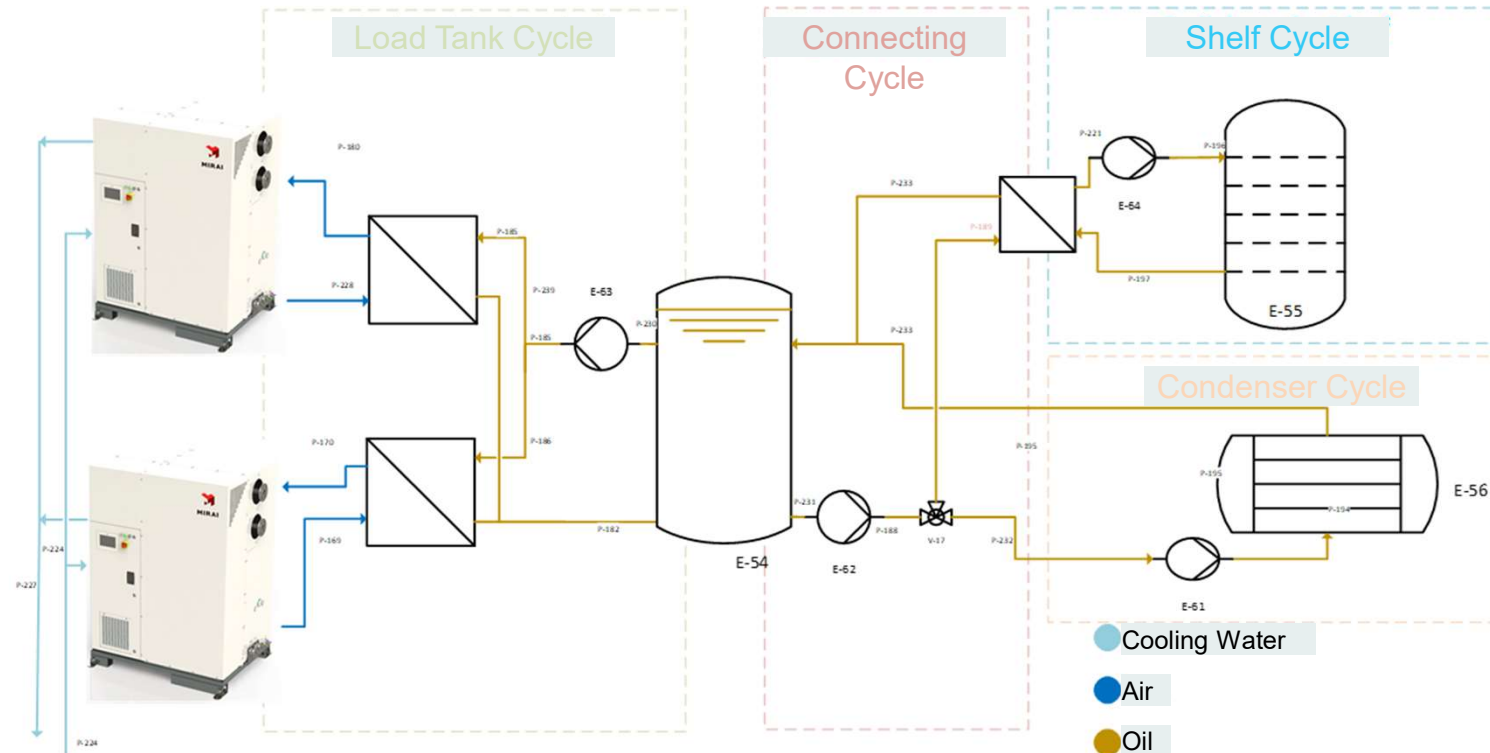


Energy distribution of lyophilization process



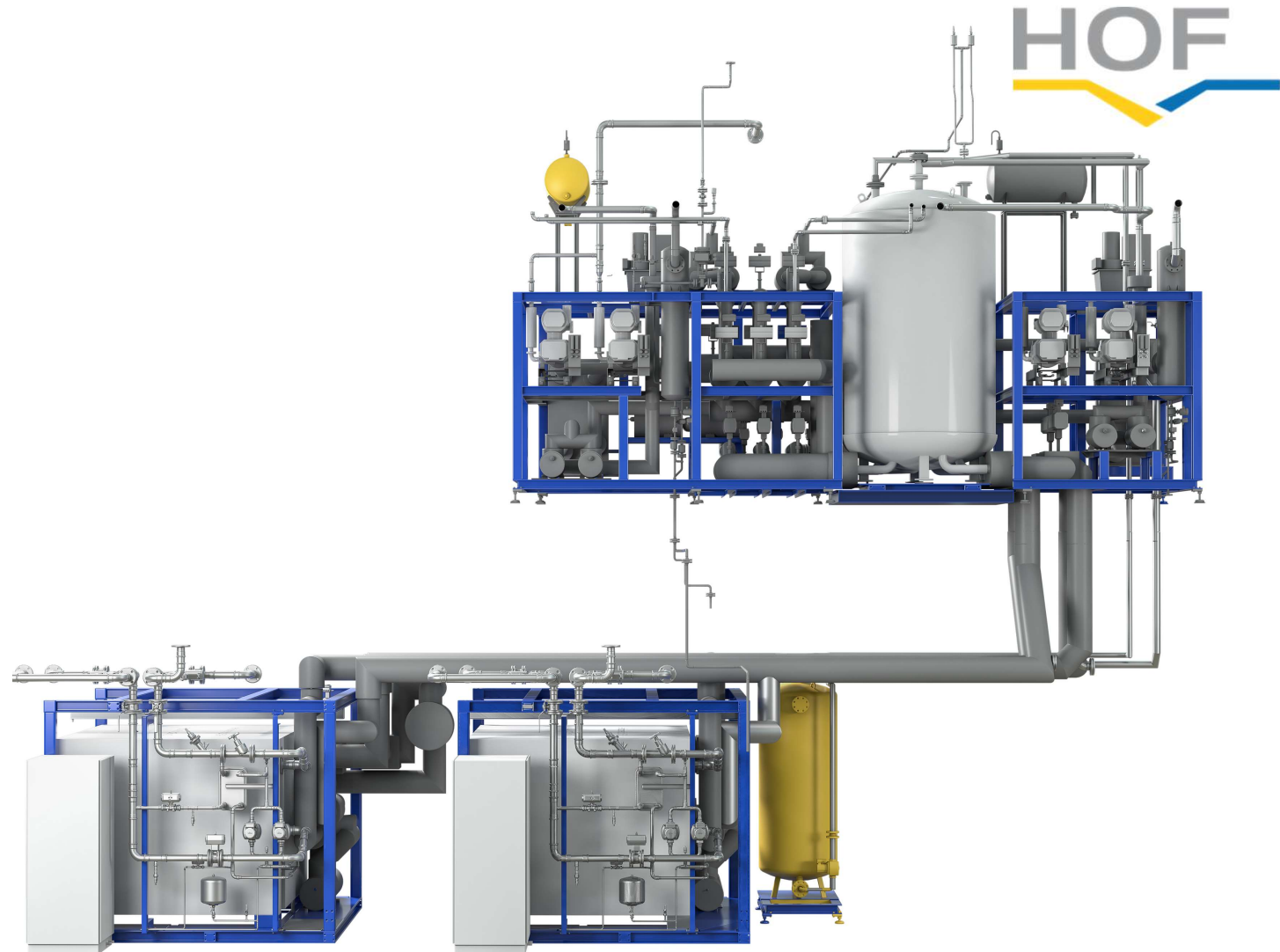
HOF-CryoBlizzard

Freeze dryer with air cycle refrigeration technology and load tank

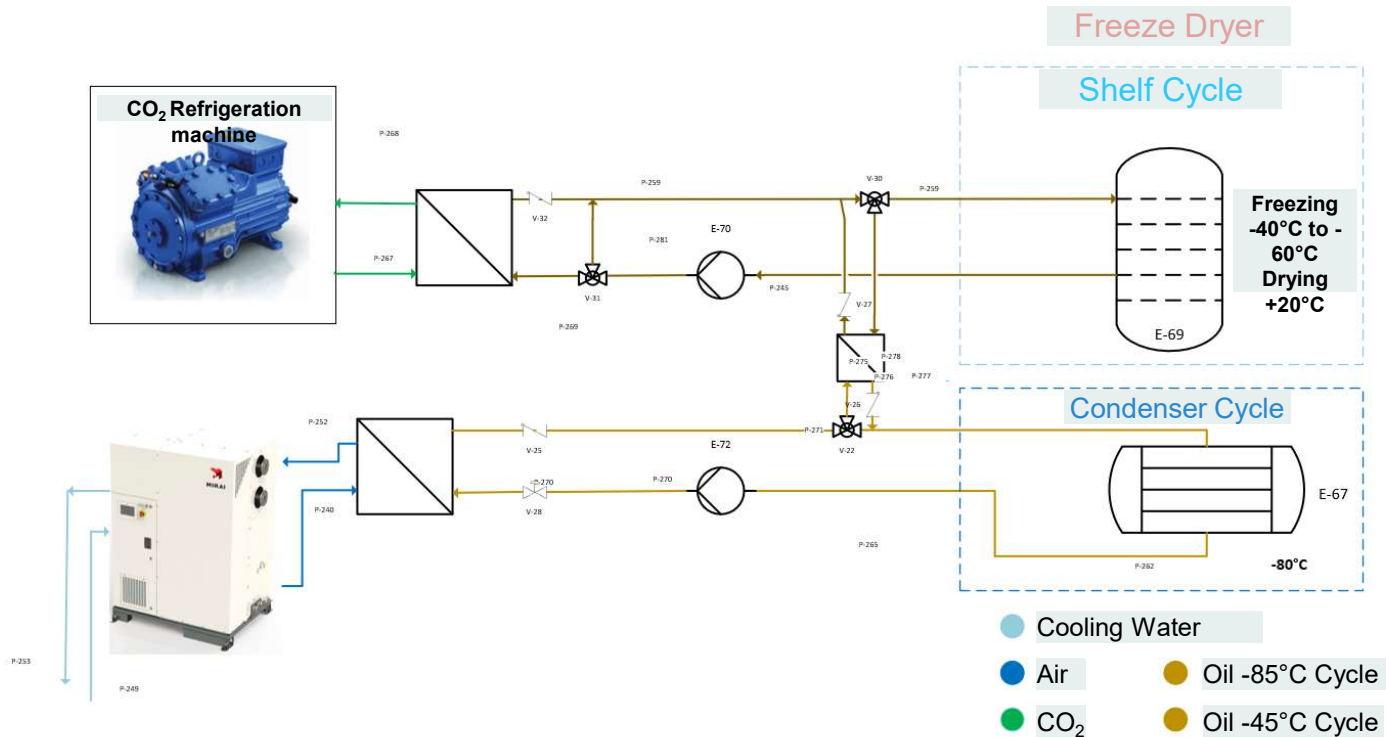


HOF-CryoBlizzard

- Centralized refrigeration plant
- Load tank with layering of 120K
- Reduce refrigeration demand with reduced simultaneity



GEA Lyophilization



Freez and thaw unit with air refrigeration



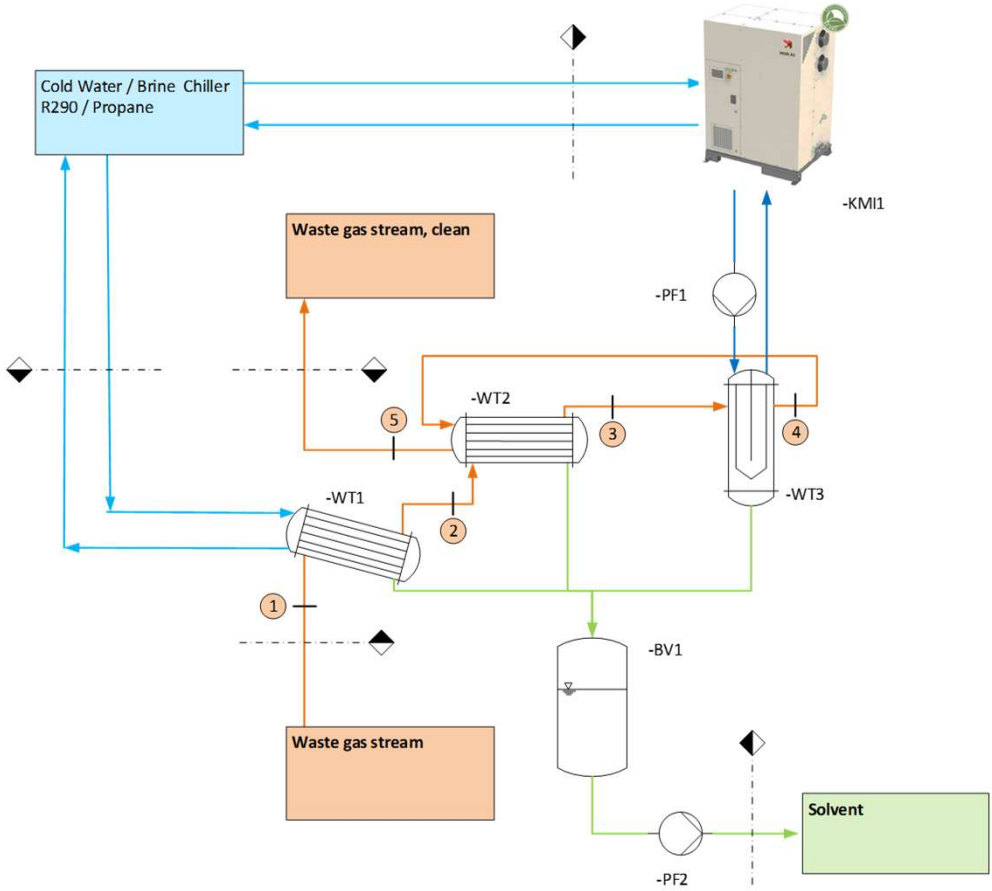
- Blood plasma freezing and thawing unit
- Compact - Integrated air refrigeration machine with PCM load tank



Solvent Recovery



© HOF-Sonderanlagenbau GmbH



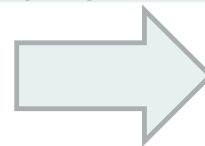
Messurment



Measurement of notified body

Average (max)

Abgasvolumenstrom	m ³ /h, norm, trocken	78,3
orgC (Propanäquivalent)	mg/m ³	8852,2
orgC (Propanäquivalent)	kg/h	0,241
orgC-gl.Mittelwert-30min-ppm	kg/h	0,136



Below 0,5 kg/h from "TA Luft"

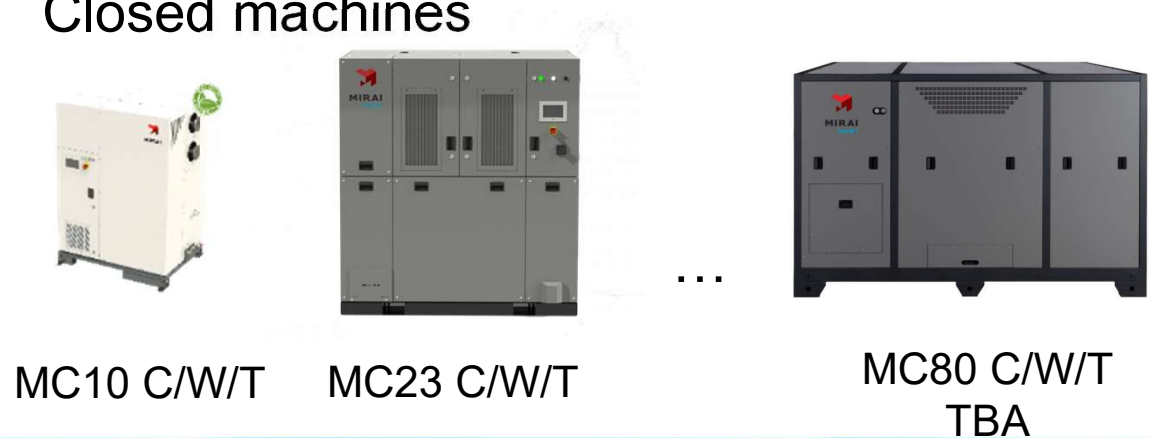
Advantages of air refrigeration from Mirai Intex

- Future-proof
- Environmentally friendly
- Long lifetime
- Fail-Safe
- Safe for humans
- Maintenance-friendly
- Flexible
- Efficient

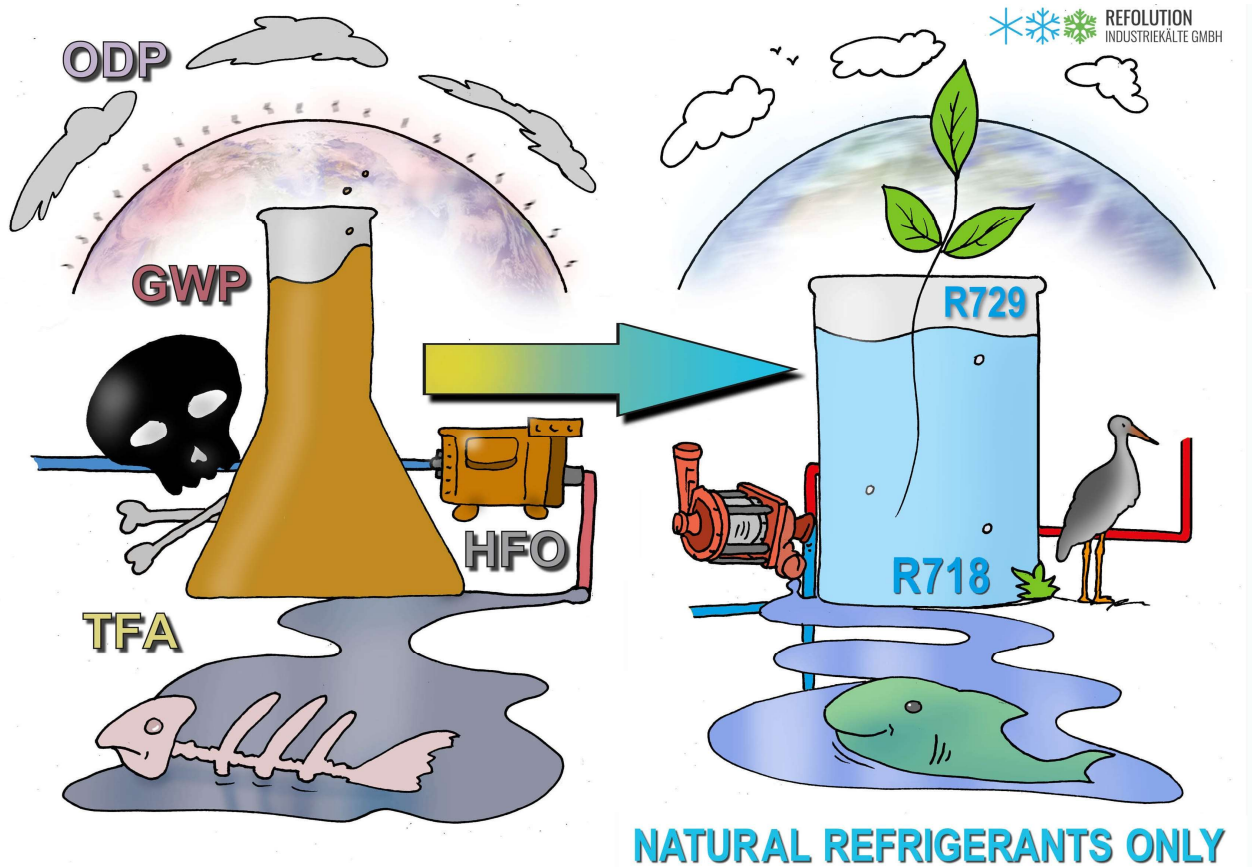
Open machines



Closed machines



It's time for your questions



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Petition link:
<http://chng.it/5BfD2x2d>



eurammon e. V. is always available as a sparring partner for questions on refrigeration with natural refrigerants.

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