

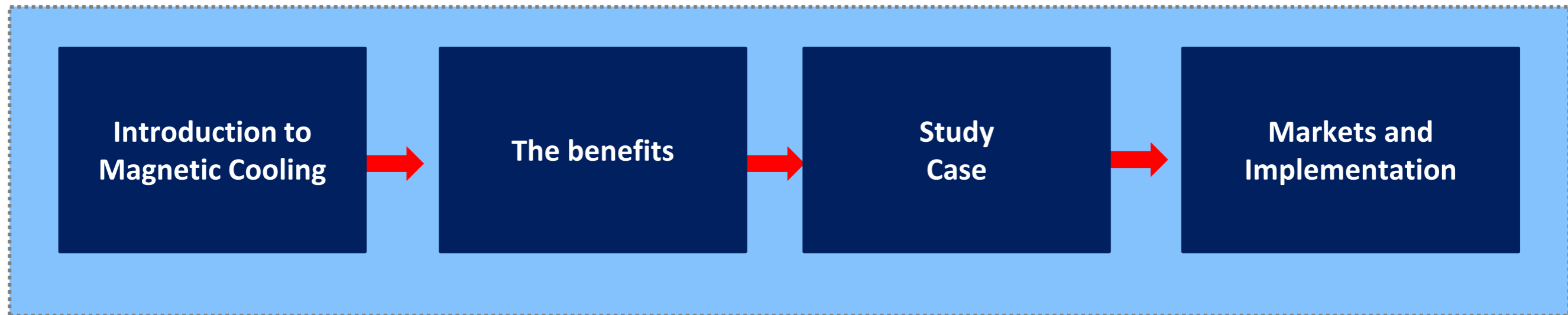


ATMO sphere



Magnetic Refrigeration

Study Case





Environmental challenge

- Increasing **restrictive regulations** on refrigerant gases (*F-gas, EPA...*)
- Impact of refrigeration on **Climate Change** (already 10% of GHG emissions)

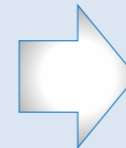


- A **gas-free** solution
- **Eliminating** the HFCs emissions
- Reducing **carbon footprint** through energy savings (high COP).



Economic Challenge

- **Refrigeration: 17%** of the world's electric consumption
- Limited efficiency provided by gas standard refrigeration systems



- **High energy efficiency** up to 40-50% energy savings
- **Global cost reduction** Maintenance reduced, extended life time



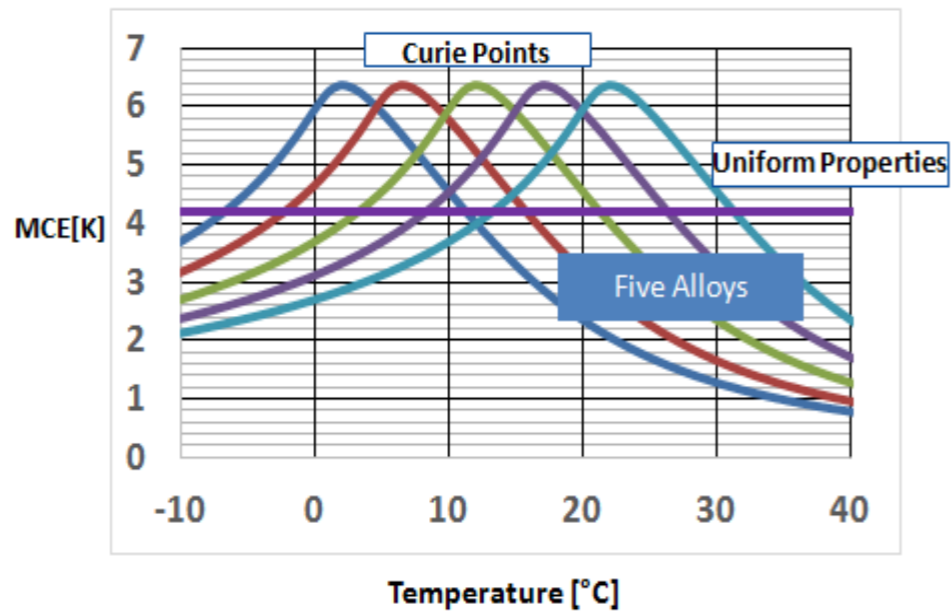
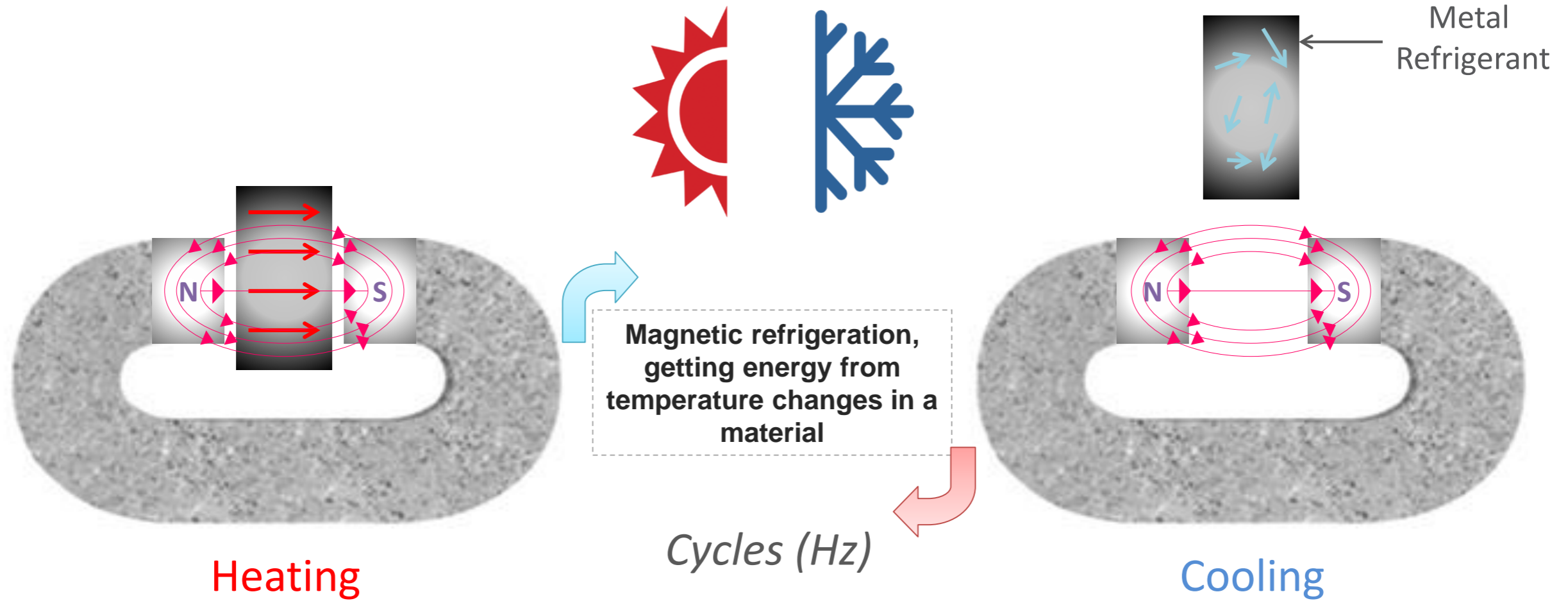
Technical Challenge

- High pressure systems
- Maintenance costs
- Noise and vibrations



- **Safer system**, low pressure and low rotational speed
- Less **noise** and **vibrations**

Magnetic Refrigeration: Physical Principle



$$E = m C_p \Delta t$$

How did we get there?



Deployment: The M.R.S



Product Industrialization



Development



Research Phase



2003

2010

2013

2017



New Development

300+ patents



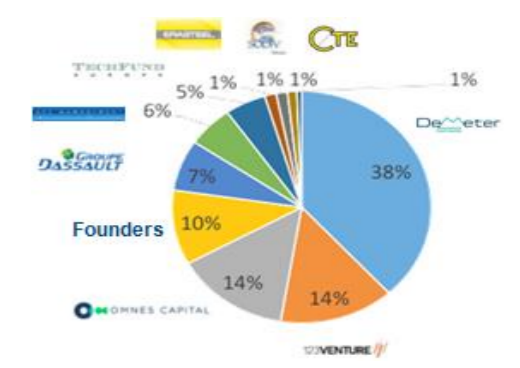
Facility (Holtzheim)



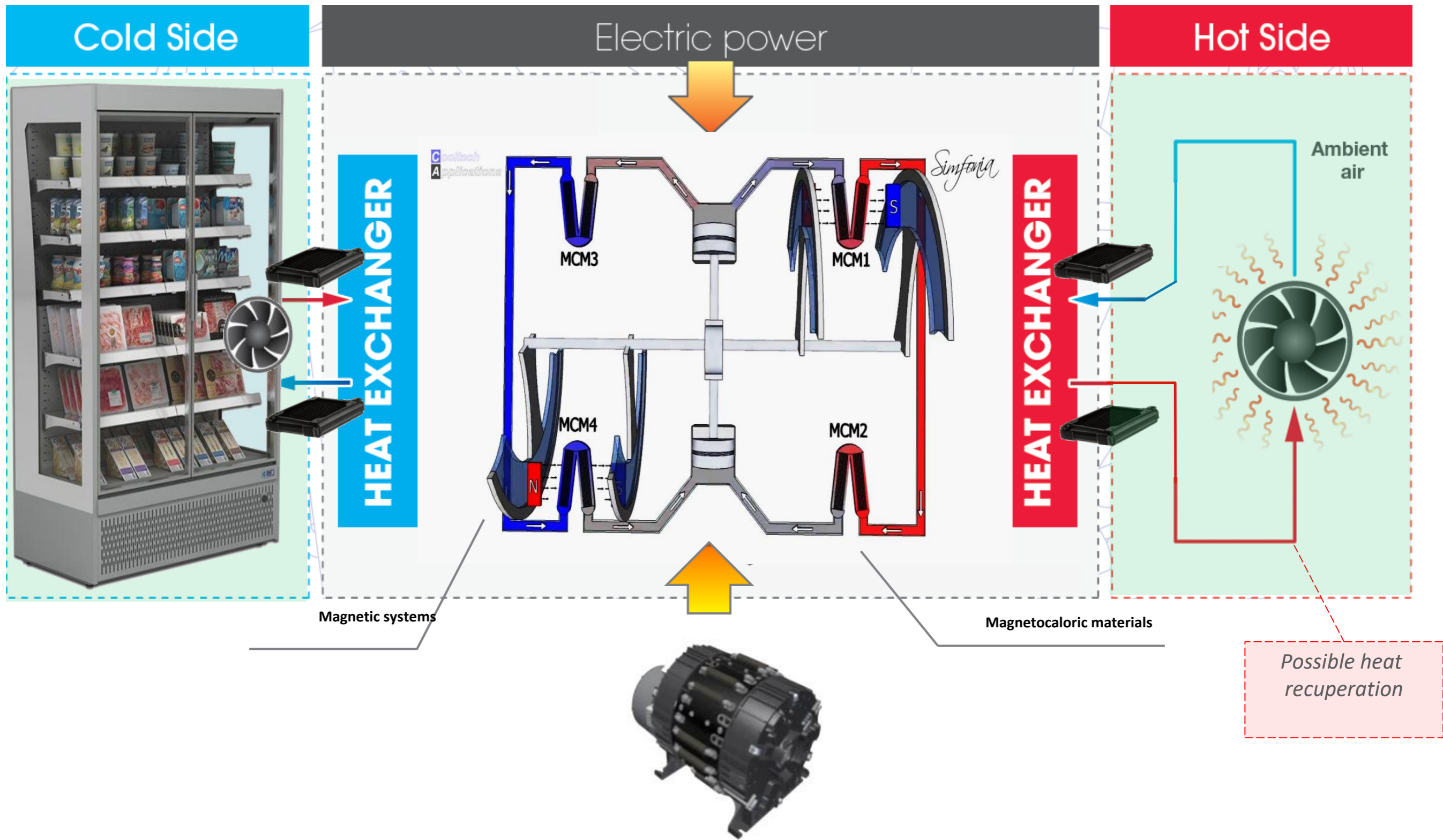
€38M invested



Shareholding



Simple integration into refrigerating equipment



Current demonstration & test phase at end user sites

Specifications

- Cabinet
 - ◆ Volume: **500 L**
 - ◆ Load: **30 kg** of beverages

- Magnetocaloric device
 - ◆ Magnetocaloric frequency: **1.9 Hz**
 - ◆ Magnetic field: **0.8 T**

Performances

- Air temperature regulated @ **+2°C**
- **Regulation mode:** on/off with hysteresis (Duty rate < 50% @ 24°C room temperature)

Cabinet's power consumption comparison*

- Original: 1.0 kWh/24h (HFC gas based compressor)
- w/ Compact MRS : 0.4 kWh/24H

* Measures done with a medical refrigerator

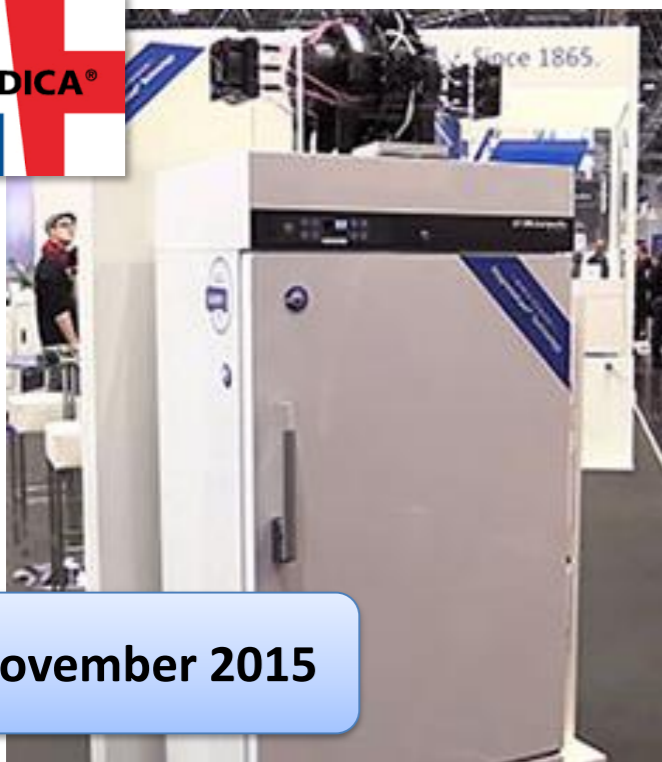


Integration & tests

Demonstrations & validations

...

Deployment



November 2015

- First Integration with OEMs
- Exhibitions at trade shows

2015-2016



August 2016

- Product Integrations
- Validation at end users' sites

2016-2017

Display cases



Kitchen equipment



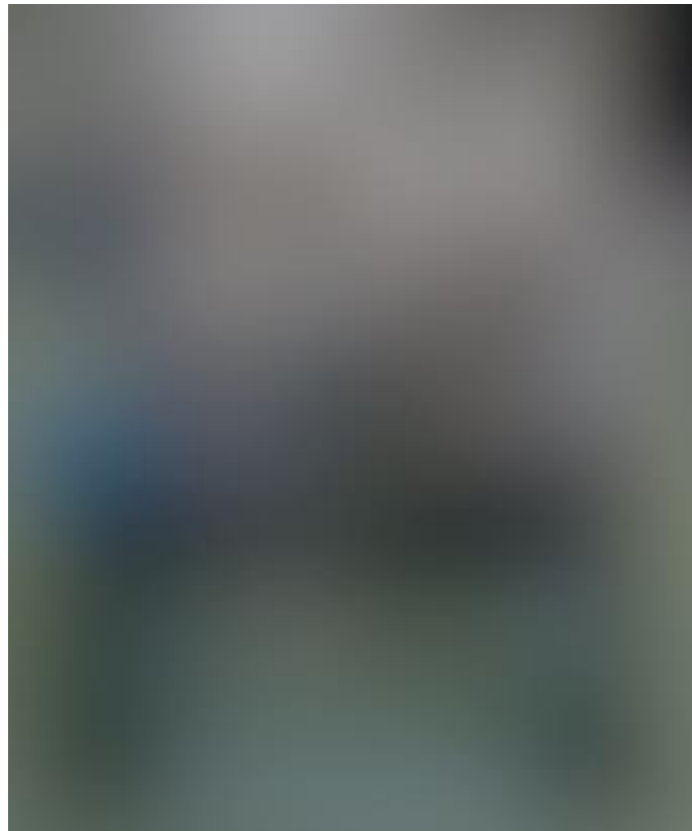
Medical refrigeration



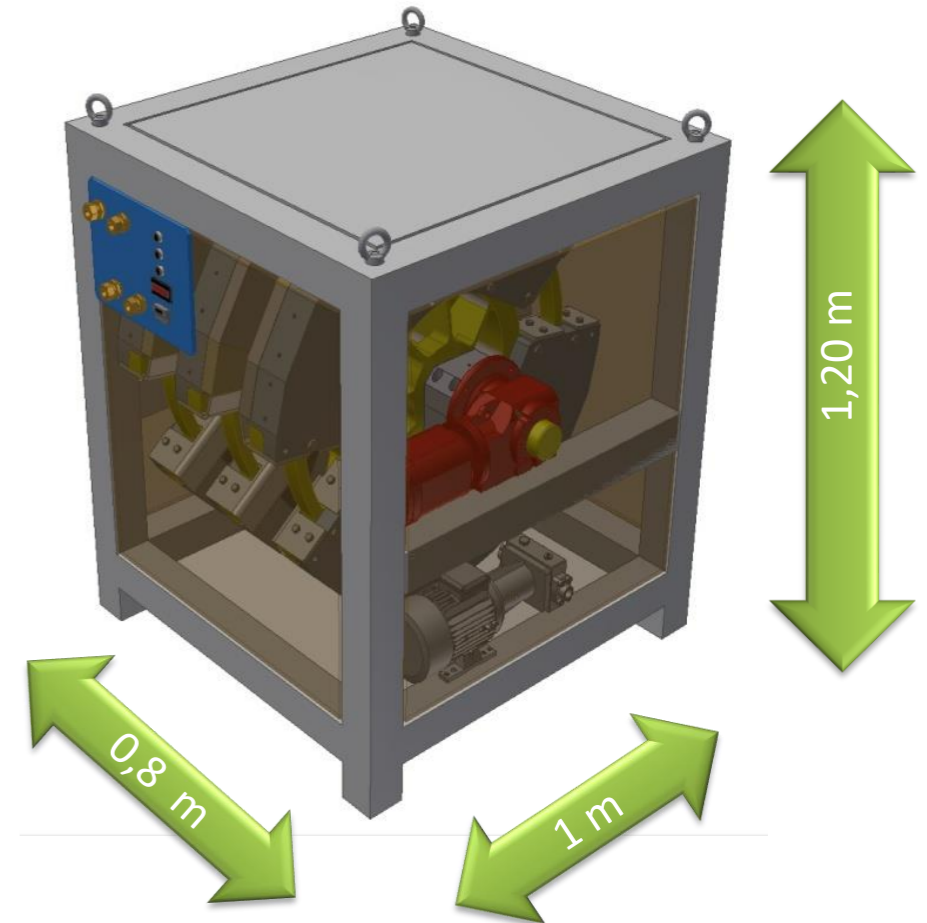
Beverage coolers



New Development : Scalable 35 KW MRS



2016- Prototype



2019- 35 KW unit

- No refrigerant gas
- Down to -5°C in cold temperature
- high COP . Above 65% of COP Carnot (included pump, HEX & motorization)
- Scalable in units from 35KW to 100 KW and over (combined units)

Comparison Cooltech's MRS with CO2 rack systems

Low temp = -31°C
 Med Temp. = -8°C
 Outlet Temp. = +30°C

Unit of 102 KW – e.g CO₂ racks



Cooling power (kW)	Power consumption (kW)	P maxi (bars)	Size (m)	Weight of Rack (kg)	Volume (m3)
44 (14 low temp)	44	100	3,5 x 1 x 1,8	2 300	6
102 (14 low temp)	86	100	3,5 x 1 x 1,8	2 300	6

*Unit of 105 KW – Scalable MRS
 (3 modules of 35kW)*



Scalable MRS
 Med Temp. = -5°C
 Outlet Temp. = +30°C
 COP ≈ 5*
 No gas

Cooling Power (kW)	Power Consumption (kW)	Rotation Speed (RPM)	P maxi (bars)	Size (m)	Weight (kg)	Volume (m3)
105	21 (*)	18 to 27	2,5	3,3 x 1,2 x 1,4	3 000	5,4

**Estimations based on 65% of COP_{Carnot}*

Four Case Studies –ROI and TCO analysis

- 1- Store 100% positive cooling with R744 (CO2) -120 KW
- 2- Store with R449A (HFO) – 120 KW
- 3- Refrigerated warehouse with R744 (CO2) – 290 KW
- 4- Data Center with Ammonia (NH3) – 2 MW

Case Study	1	2	3	4
Energy Yearly Savings w/ magnetic cooling (in kWh/year)	114 000	133 036	166 065	972 539
ROI France (in year)	3,7	5,2	3,1	
ROI Spain (in year)	1,8	2,6	1,5	1,6
ROI Germany (in year)	1,1	1,5	0,9	1
TCO (€) w/o magnetic cooling	393 000	381 280	655 303	3 822 836
TCO (€) w/ magnetic cooling	260 200	275 444	435 238	2 636 857

TCO is calculated for a 10 year period, including yearly maintenance and electricity cost at 0.1 €/kWh (average in Europe)*

- Maintenance costs: 15% of Capex /year with compressors based racks vs. 7% Capex/year for MRS
- Study made with a large contractor in Europe

Total Addressable Market Segmentation

Refrigeration

Air conditioning

Plug-ins (Commercial & Medical refrigeration)



0,3-2 kW

10.5M

Domestic



30-300W

160M

Residential



1-5kW

140M

Transport



3-30 kW

70M

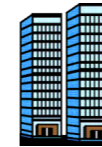
Refrigeration racks (commercial ref)**



10-100 kW

0.5 M

Buildings**



5-30kW

12M

Storage, industrial refrigeration**



10-500 kW

1M

Others (cold room, transport,..)**



1-20 kW

2.5M

Industrial**



50-500 kW

1 M

~175 million units / year*

~220 million units / year*

Compact MRS

Scalable MRS

Yearly sales volume

**Estimated yearly sales of compressors

** Sales volume are estimations made on the basis of internal studies

All the figures are estimated on the basis of external and internal studies, with a margin of error

2016-2019

Up to 1000W

Kitchen equip.



Display cabinets & Coolers



Medical refrigerators



From 2019 and onwards

40 KW and over

Remote rack systems & Cold rooms



Industrial cooling (chillers)



Commercial Air Conditioning



Heat pumps



Transport & Domestic applications



Company

Cooltech, **leader** in magnetic refrigeration systems
First player to deploy magnetic refrigeration technology
Patent portfolio covering all application areas, at world level

Product

Magnetic Systems are the best ecological and eco-efficient alternative to gas compressor

- No refrigerant gas (GWP= 0)
- Energy saving (up to 50%)
- Safety (low pressure system)
- Comfort in use (reduced noise and vibrations)
- Reduced maintenance costs
- Can address a very large temperature span

Price

Higher **CAPEX**, but much lower **OPEX** = Lower **TCO** and Pay-back time



ATMO
sphere

Thank you very much!