

First integrations of industrialized Magnetic Cooling



...devices into refrigerated cabinets

Key figures

270+	Patents covering +40 countries	€ 35M	R&D and Industrial raised resources
10	A successful 10-year R&D phase	30	Highly skilled employees

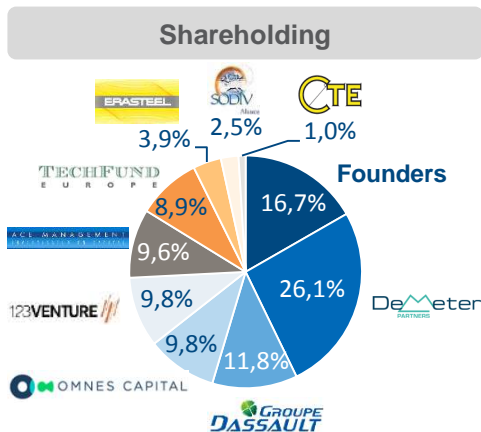
Main International Partners



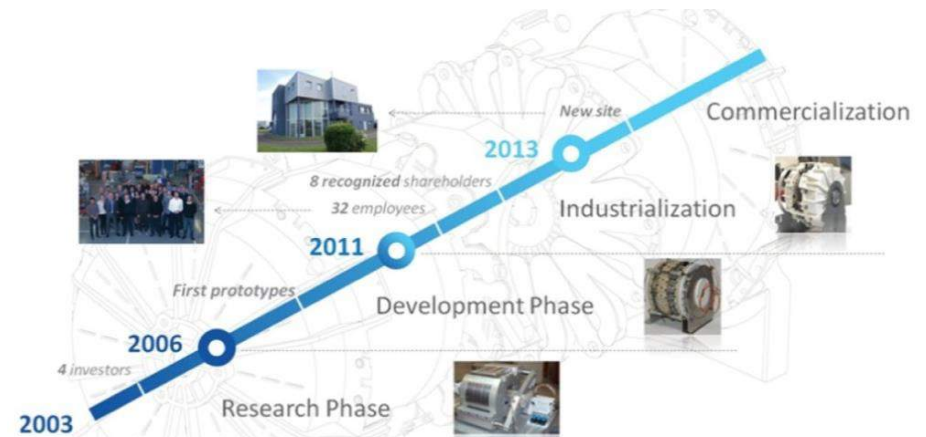
Recent Awards



Shareholding structure and management



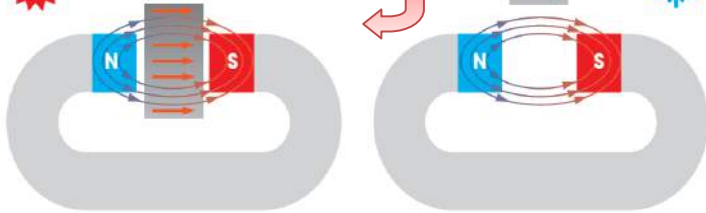
- Management**
- **Christian Muller**
Founder, CEO and CSO
 - **Jean-François Maire**
General Manager
 - **Vincent Delecourt**
Director Sales & Marketing



The company is now entering the commercialization process by starting partnerships with OEM's and manufacturers for preparing the product launch (West Europe , America)

Based on the
MAGNETOCALORIC PRINCIPLE

Heating



Cooling

*Magnetic
Refrigeration,
getting energy
from temperature
changes in a
material*

$$E = m \cdot Cp \cdot \Delta T$$



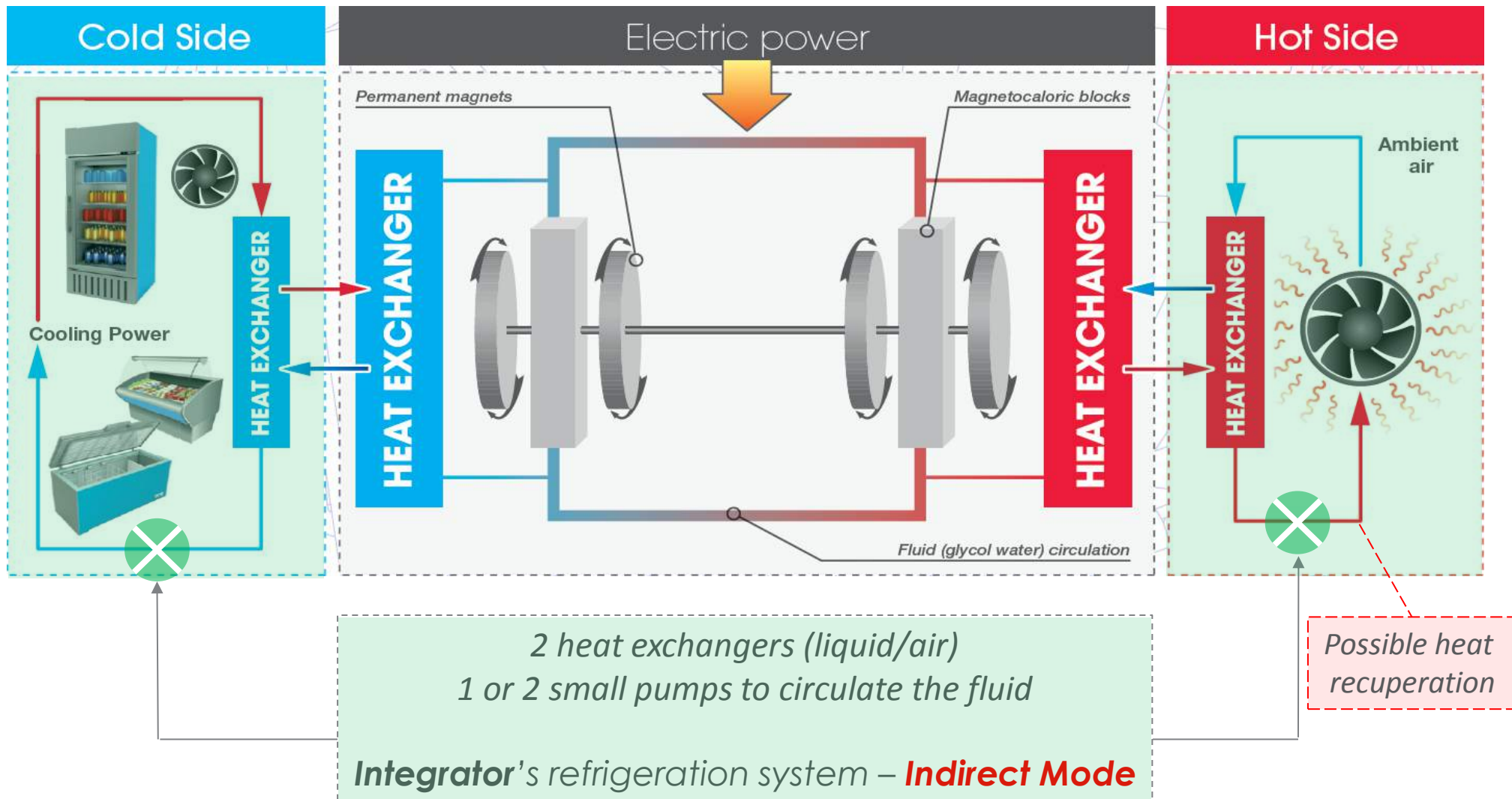
- No refrigerant gas (water based coolant liquid)
- Better energy consumption ratio (COP)
- **Reduced noise and maintenance** (expected)
- Designed firstly for the **Commercial Refrigeration**

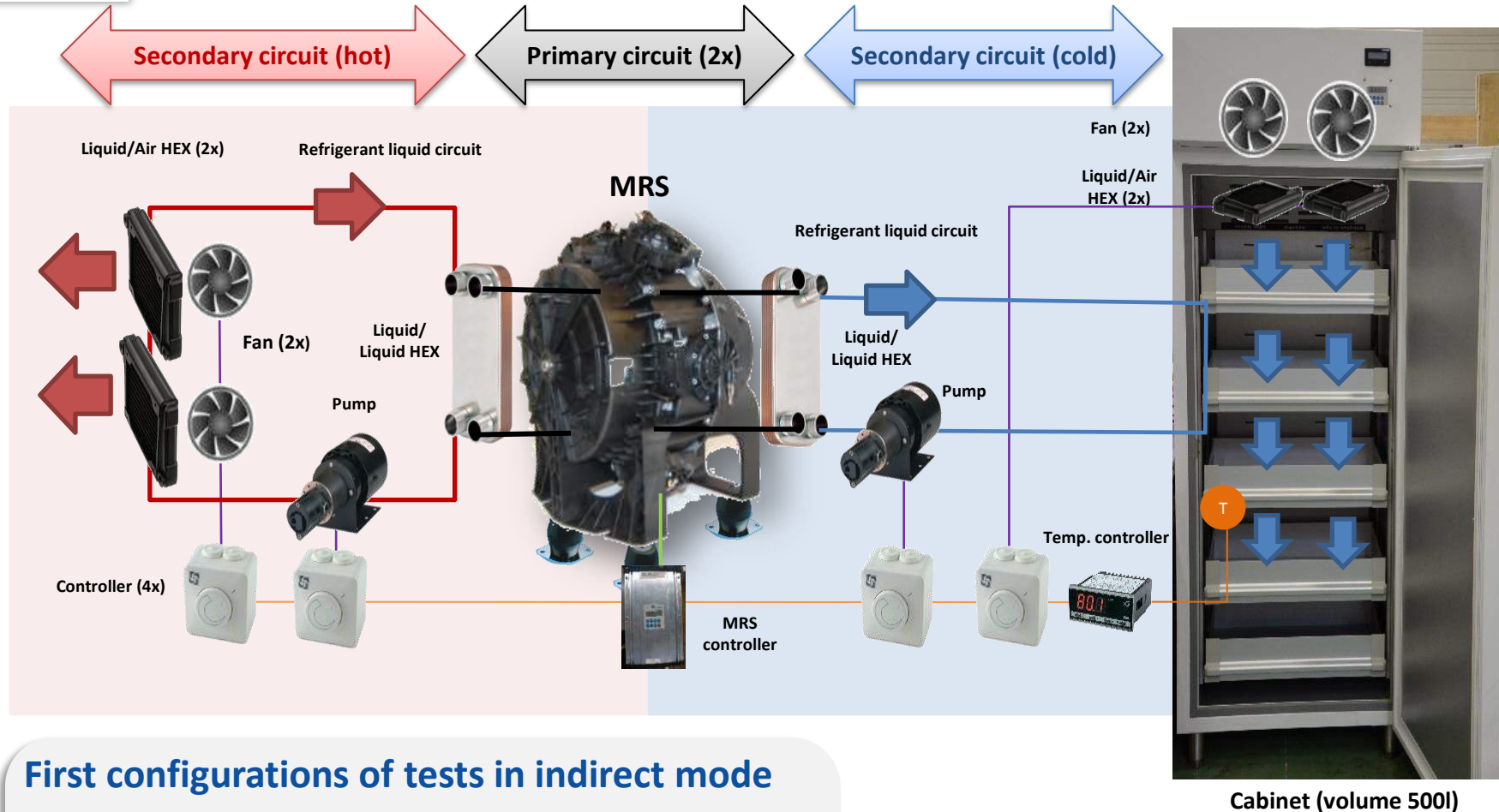


**First generation of machines
(150-700W)**



Product integration into refrigeration systems





First configurations of tests in indirect mode

- On-going tests in Direct Mode
- Realized with specific Heat Exchangers and Fans adapted for magnetic refrigeration

Measurements in indirect mode

- Cabinet volume **500 liters (17.7 scf)**
- Admissible ambient temperature **from 15°C to 25°C (~75°F)**
- Power consumption **35W (120 Btu/h)**
- Cooling power **200W (680 Btu/h)**
- Motor speed **116 rpm (1,93 Hz)**

T liquid	+4°C	+4,9°C	+6,6°C
T air (ref. position)	+5,3°C	+6,7°C	+8,5°C
ΔT liquid/air	1,3 K	1,8 K	1,9 K



**Equipment integration
test bench**

Cooling Power : 200 W (680 Btu/h)

(*) Magnetic Refrigerator (F = 1,1 Hz)

	Absorbed Power	
	W	
Hydraulic mode	Indirect mode	
Pumps	8	
MRS * (motor efficiency 90%)	35	COP 5,7
Fans (heat ex. hot)	3	
Fans (heat ex. Cold)	3	
Total	49	
Total COP	4,08	

() Standard Butane Refrigerator**

	Absorbed Power	
	W	
Pumps	-	
Compressor	79	COP 2,5
Fans condensor	12	
Fans evaporator	13	
Total	104	
Total COP	1,92	

COP Comparison between a magnetic refrigerator and a standard bottle cooler

Energy Savings >50% , a key factor for future value proposition

(*) Machine with first generation magneto caloric alloys

(**) Measures done by an OEM, partner of Cooltech

Heat exchanger (Liquid/Air)

- **Collaboration** with manufacturers to design adapted HEX (Automotive, Electronics industry)
- **Parameters:** mini-channels (1/32 inch) and high density of finned coils

The **Key** interface

Maximize the energy output while maintaining enough energy in the system for the regeneration cycle



➔ ΔT adjusted to the MRS behaviour (low thermal pinch, optimized thermal balance)

Magneto caloric Materials

- **New generations** of alloys (2 K/Tesla => 3,5 Kelvin/Tesla)
- **Additional manufacturers** (Vac, BASF, Erasteel,...)

The **Key** element

Generate the internal energy that is amplified (Magnetic Cooling cycles)



➔ an emerging industry

Direct vs. Indirect Mode

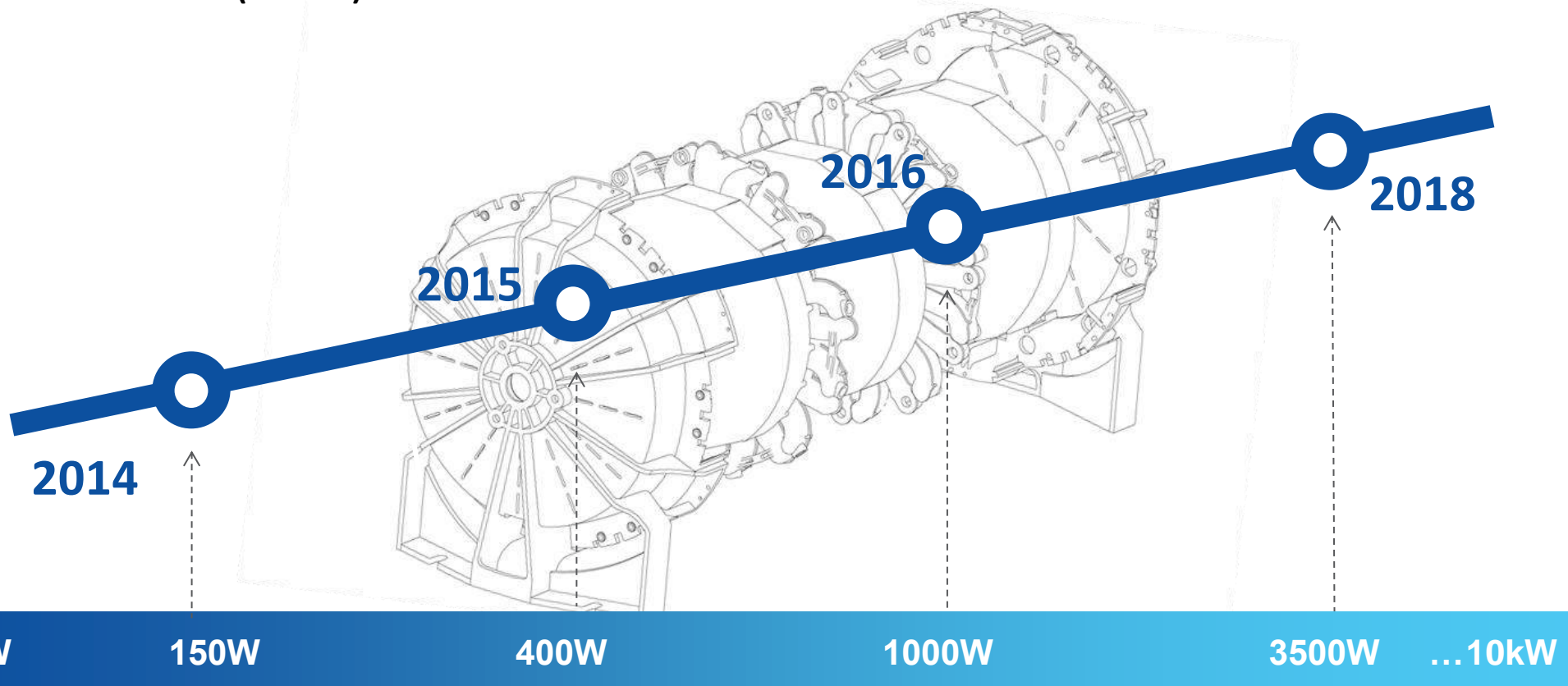
- Increase the span of **temperature (by +5 °C)** and global thermal efficiency
- Increase the **COP (~ +20%)**

Internal parameters

- Frequency (from 1 Hz to 3hz)
- Magnetic alloys (new generation)
- Optimized electric motor

New design of machines

- Very low temperature
- Increase **cooling power**



A huge market potential to be gradually addressed

Commercial Refrigeration



Air-Conditioning



Domestic Refrigeration



Transport



Next steps (2015-2016)

- Continue doing **equipment optimizations** before the product launch in several market segments
- Start new **partnerships** (manufacturers, OEMs, food industrials) in new geographies (America,..)
- Complementary **development** for further applications with new product specifications

Magnetic Cooling... a relevant complement of natural refrigerants developments initiative

In line with the already existing and forthcoming regulations



A key opportunity to provide differentiation in the fields of Refrigeration and Air conditioning



U.S. DEPARTMENT OF
ENERGY





business case
natural refrigerants

25 & 26 June - Atlanta, Georgia

Cooltech Applications
www.cooltech-applications.com