



Associazione Italiana Costruttori Macchine
Impianti, Attrezzature per la Produzione
la Lavorazione e la Conservazione Alimentare

Environmentally sustainable growth REFRIGERATION SYSTEMS



Associazione Italiana Costruttori Macchine
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Workshop “ Alternative agli HFC e opportunità per il sistema Italia

ISPRA – 21 Ottobre 2016
Maurizio Orlandi



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Commercial Refrigeration



Specific concept cases

Power Racks

Cold Rooms

Installation

Service & Maintenance

Project Management

Professional Training

Retrofitting

Energy Management

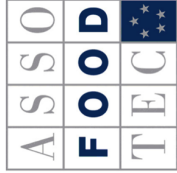


From 1° prep study ecodesign

Table 10-3: Commercial refrigerators' and freezers' energy consumption in the EU25

Appliance	EU-25 stock electricity consumption in 2006 (TWh)	Number of equipment	Share of total tertiary el consumption
Remote open vertical chilled multi deck cabinets	37,04	1.312.630	5,5%
Remote open horizontal frozen island	5,11	172.117	0,8%
Plug in one door beverage cooler	16,25	6.323.941	2,4%
Plug in horizontal ice-cream freezer	4,45	2.709.285	0,7%
Spiral cold vending machine	2,98	1.092.956	0,4%
TOTAL	65,83	11.610.930	9,8%

Source: Calculations based on Monier et al. (2007) and Odyssee database



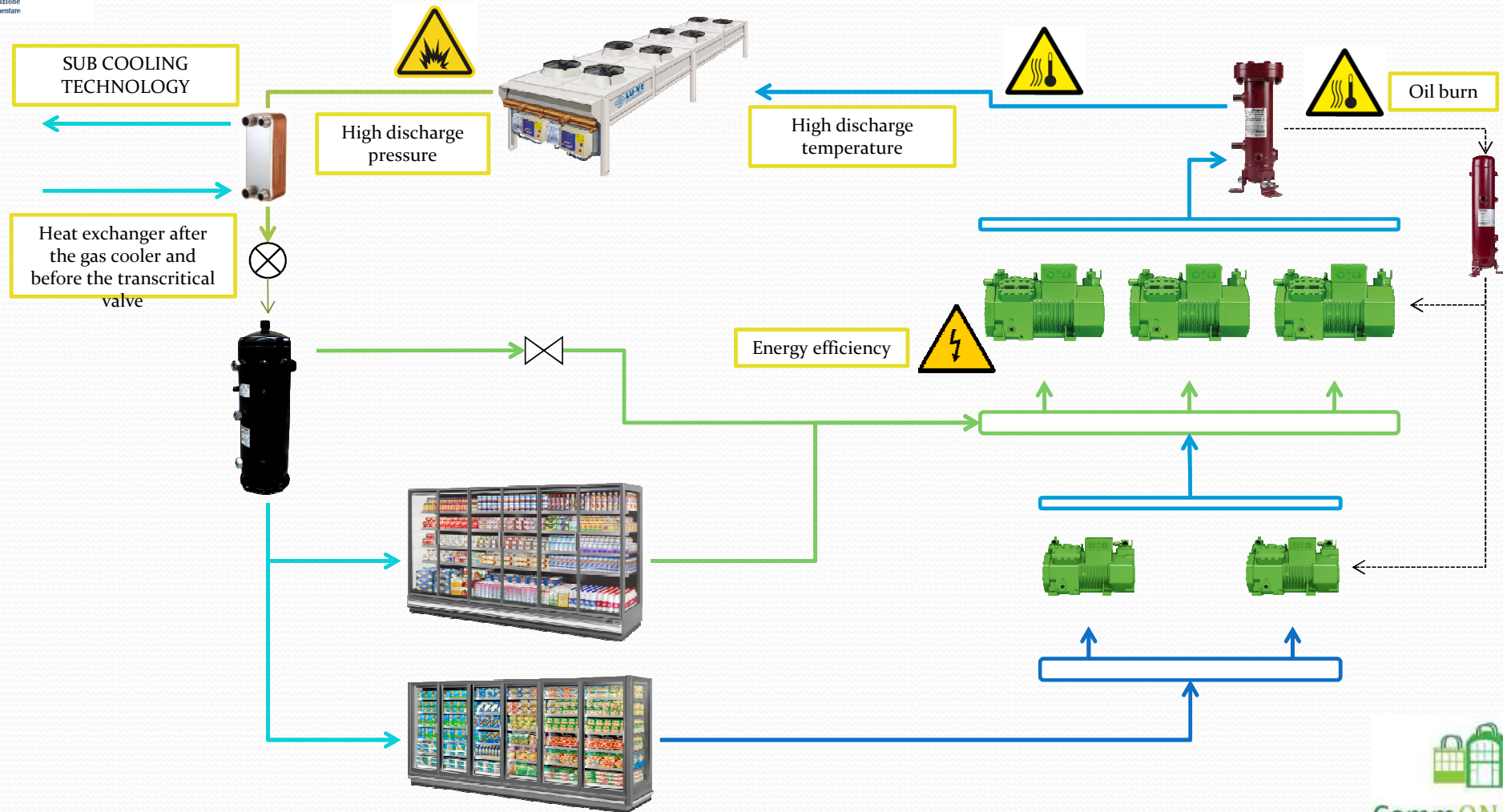
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Sistemi a CO2



Sub-cooling technology

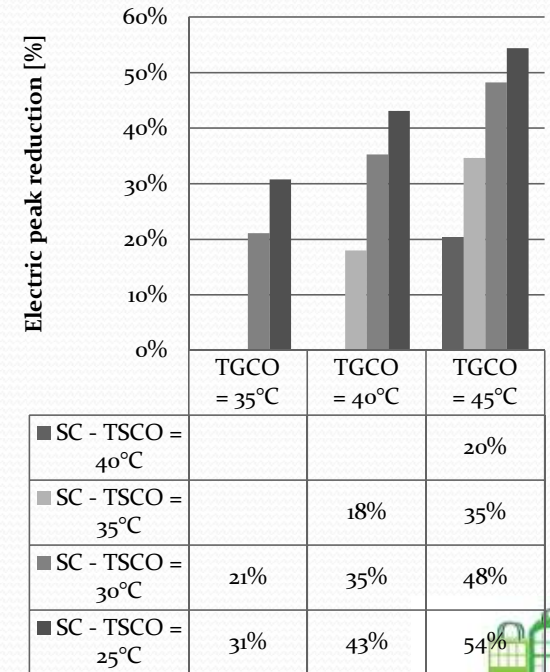
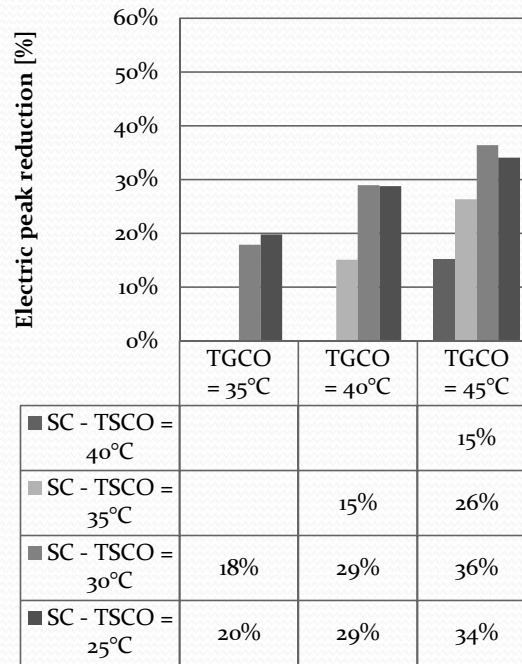
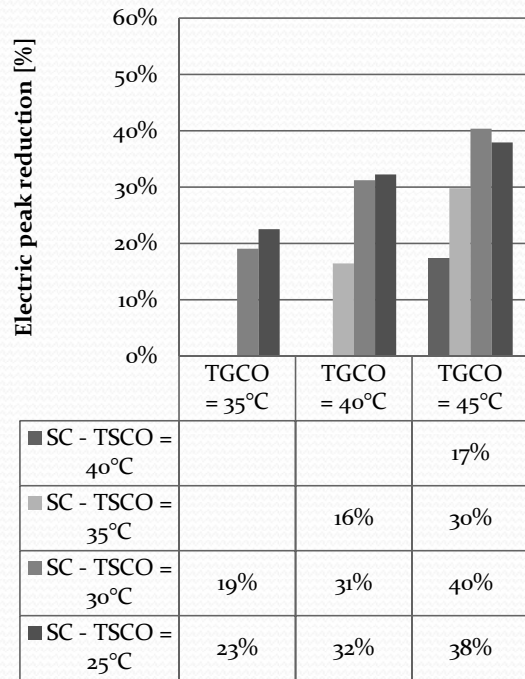


Peak saving

Peak saving with SC from the three field test:

System	Mechanical system	A/C system	Groundwater
Peak pressure saving	~10bar (at +40°C)	~20bar (at +45°C)	~15bar (at +35°C)
Peak energy saving	~ 25%	~ 36%	~ 30%

Peak saving for different combination of Tgco/Tsco:



Yearly simulated saving

Yearly simulated saving with sub-cooling*:

Location	Cold climate	Mid climate	Warm climate
T < %30 time/year	+4.5°C	+13.0°C	+20.0°C
T average year	+9.0°C	+18.0°C	+26.0°C
T < %70 time/year	+13.0°C	+23.0°C	+32.0°C
TSC	137MWh/year	214 MWh/year	399 MWh/year
TSC w SC	136MWh/year	203 MWh/year	339 MWh/year
Saving	-0.5%	-5%	-15%

*Three different climate has been used to simulate the effect of sub-cooling on the TSC system with 100kW cooling demand and 14kW sub-cooling tech. Simulation are based on the Text-Pgco correlations obtained from field tests. An year (hourly based) external temperature profile has been used as climate reference.

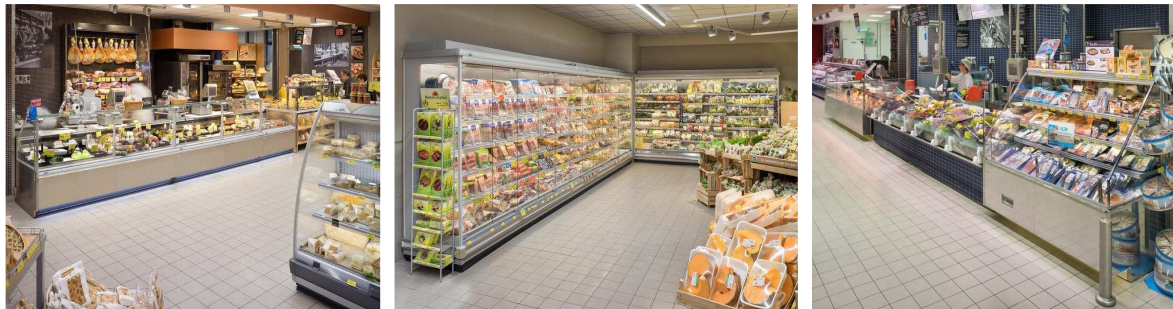


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Reggio Emilia



- Opening date: 2015, July 28th
- Surface: 1,000 sqm
- Refrigerant: MT/LT CO2 booster – 70 kW MT net + 7 kW LT
- Mechanical sub-cooler (water chiller) to improve cycle efficiency
- Energy consumption -20% vs R404A



ECO₂ Large



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Consum supermarket, Paterna (Valencia)



- Opening date: 2016, February 25th
- Surface: 1,500 sqm
- Refrigerant: MT/LT CO2 booster – 80 kW MT net + 20 kW LT
- Provider: EPTA IBERIA
- Mechanical sub-cooler (water chiller) to improve cycle efficiency
- Sanitary water 100% heat reclaim



ECO₂ Large

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Morris Fresh IGA, Innaloo (Perth)



- Opening date: April 2015
- Surface: 1,400 sqm
- Refrigerant: MT/LT CO₂ booster – 80 kW MT net + 20 kW LT
- Provider: AJ BAKER PTY LTD (EPTA official distributor)
- Power costs are up to 25% less than similar sized CO₂ / R134a installation.
- TEWI -55% (saving of over 4,400 tonnes CO₂-e) vs CO₂ / R134a



ECO₂ Small

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Sub-cooling: evolution

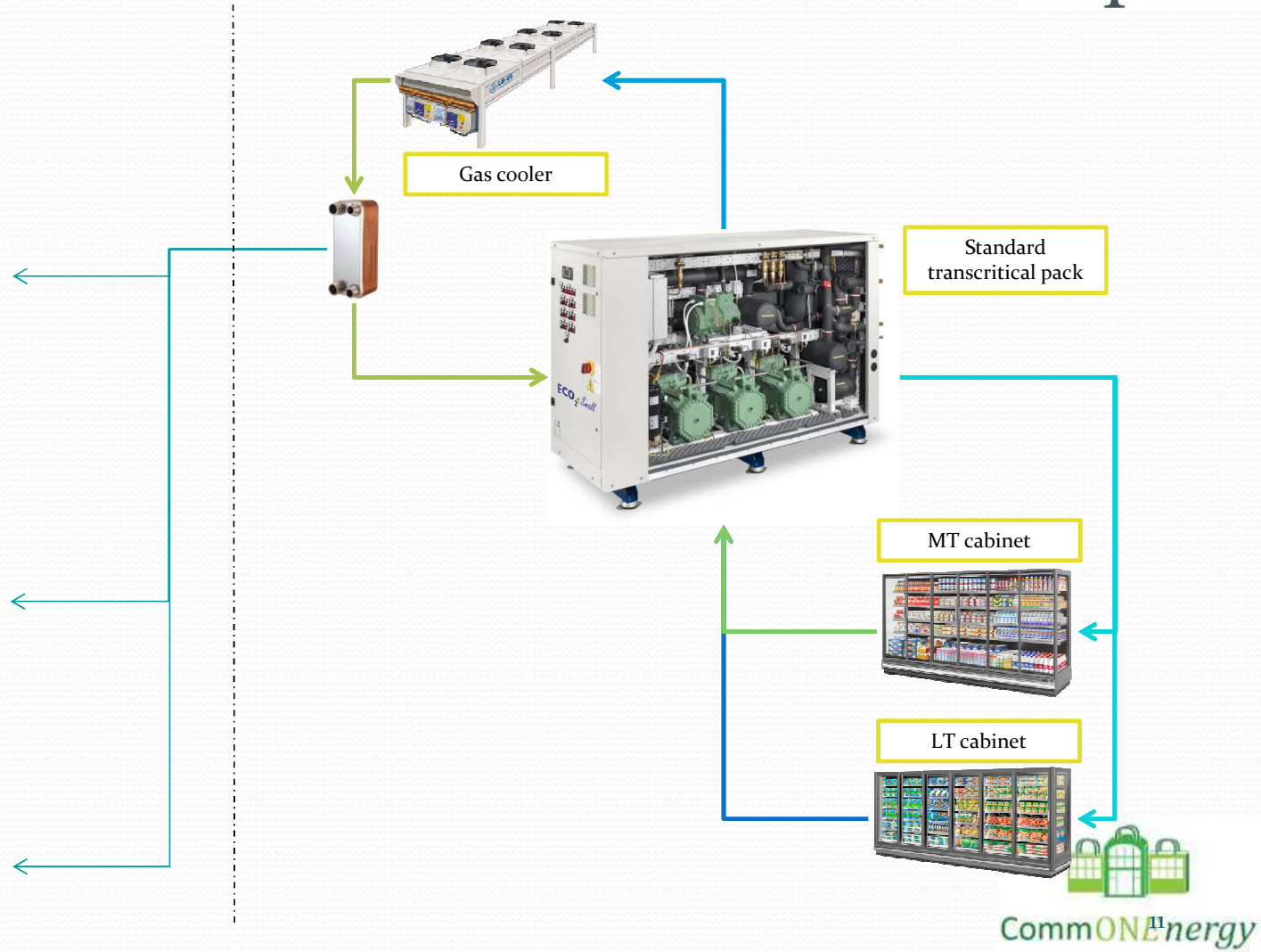
Dedicate
motocondensing



A/C system



Groundwater



Three level

Nominal Plant
Cooling 40 kW

4.5 kW

Hot Water
Over door
heater

Heat X 1

21 kW

Warm Water
Store Heat

Heat X 2

Load
Evaporator

Heat X 3

Plant

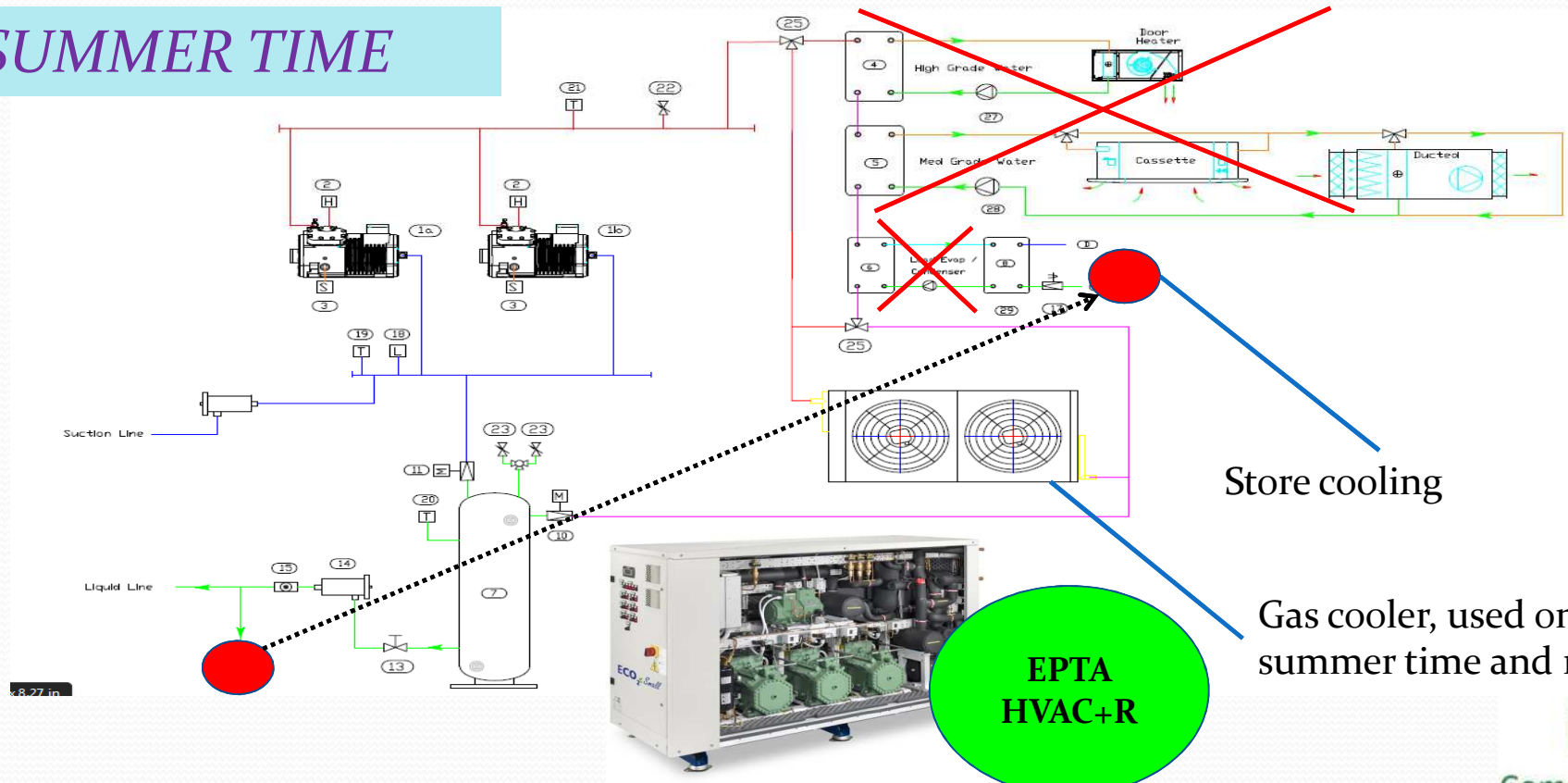
Pack



Gas Cooler

Optimized transcritical booster CO2 system

SUMMER TIME

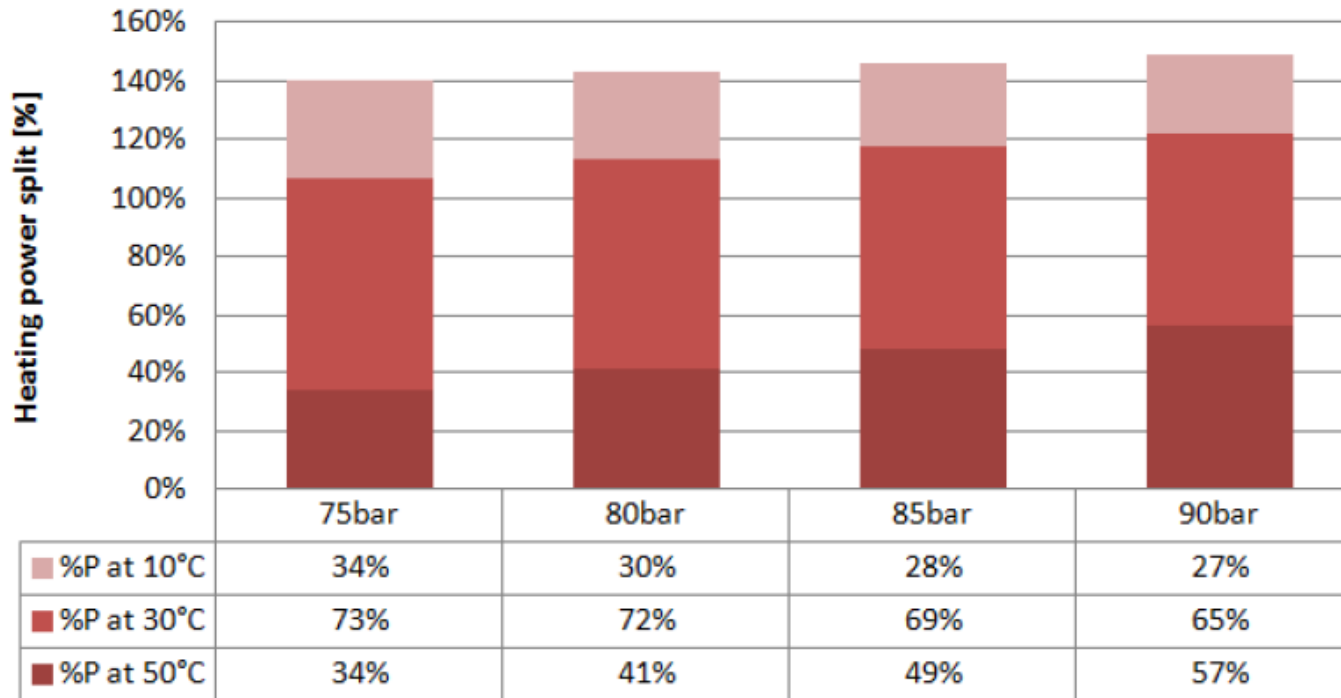


Store cooling

Gas cooler, used only in summer time and mid season

**EPTA
HVAC+R**

Heating Power





Horwich Site Installation

Recovery
Module



R 744 Pack



Ducted and Cassette Units



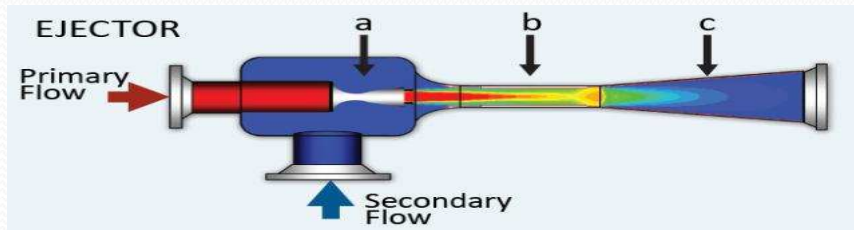
Over-door Heater



By kind permission of Mr Adrian Crowther of the Cooperative Group

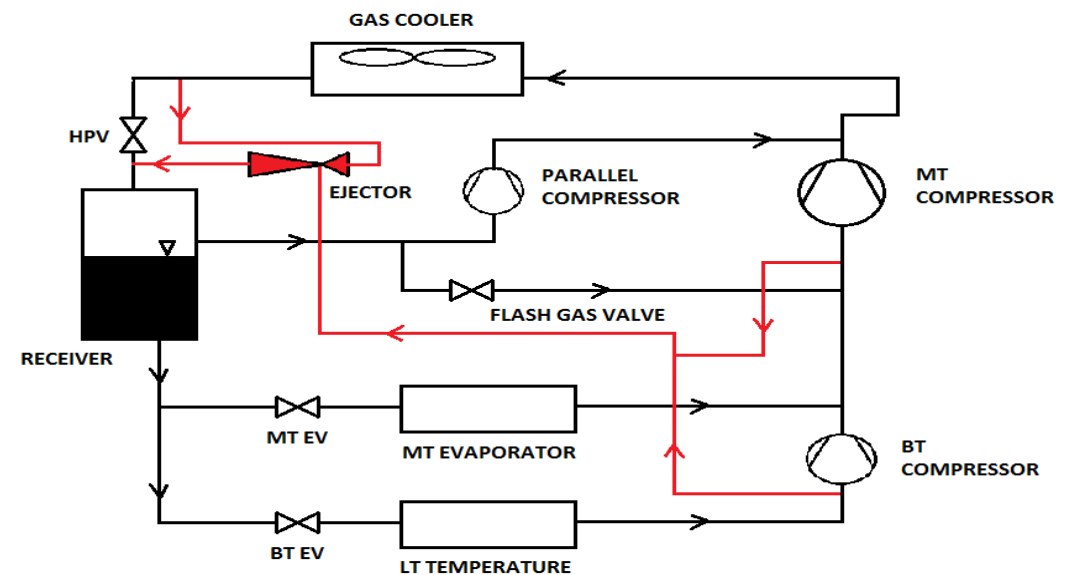
Advanced Solutions for your Store

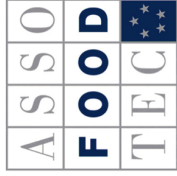
Ejector Technology



In synthesis:

- Decreasing of refrigerant feeding the main compressors
- Increasing of intermediate pressure
- Decreasing of power consumption





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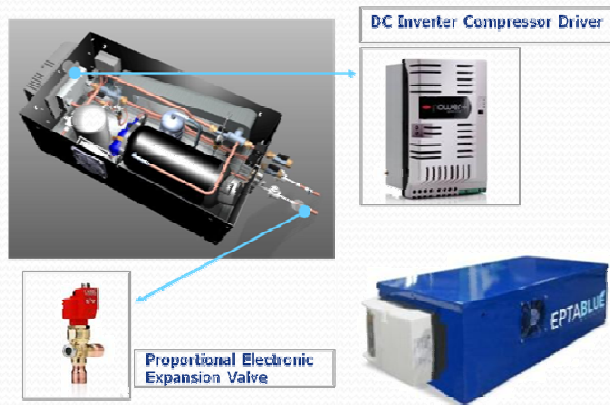
Sistemi ad anello ad acqua



Water Loop



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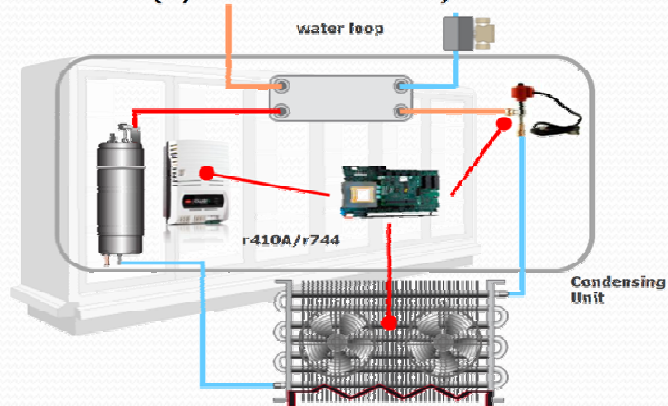


STORE LAYOUT

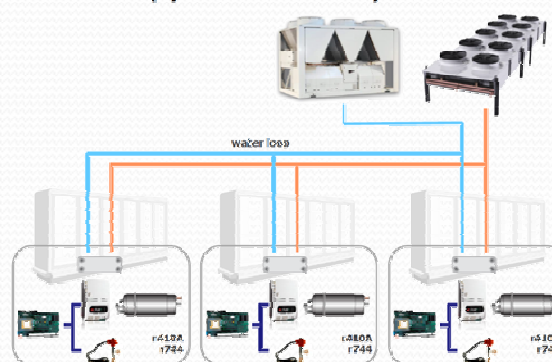
Simple, economical and practical

- ✓ Single loop for MT/LT
- ✓ No subcooling chiller
- ✓ No technical room nor installation work
- ✓ No perceptible noise
- ✓ No equipment outdoor
- ✓ Warm climate version and new extended limits
- ✓ Freezing protected up to -25°C (glycol)

CONCEPT (system schematics)



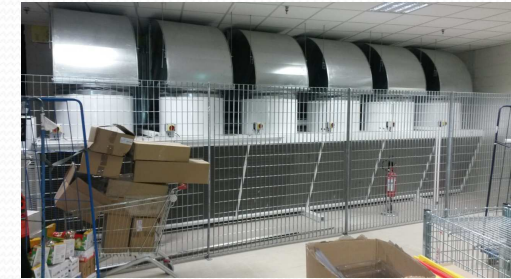
CONCEPT (system schematics)





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Parma



- Opening date: 2015, December 8th
- Surface: 1,000 sqm
- Cabinets: 74 kW MT + 8 kW LT
- Provider: COSTAN
- Mechanical water chiller for LT
and free cooling for MT





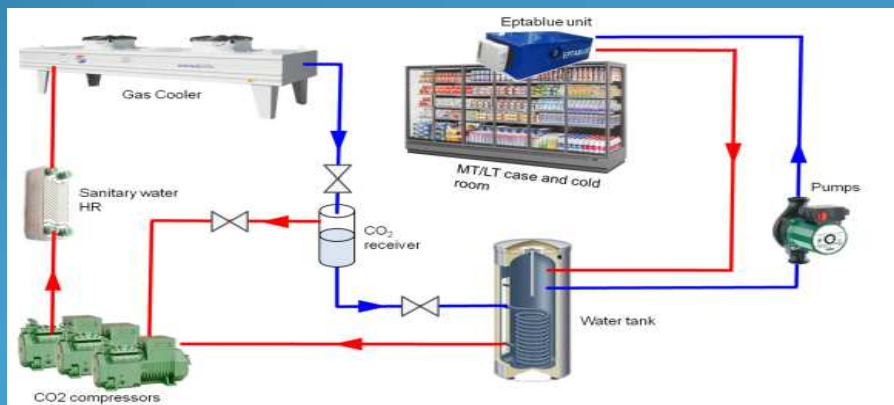
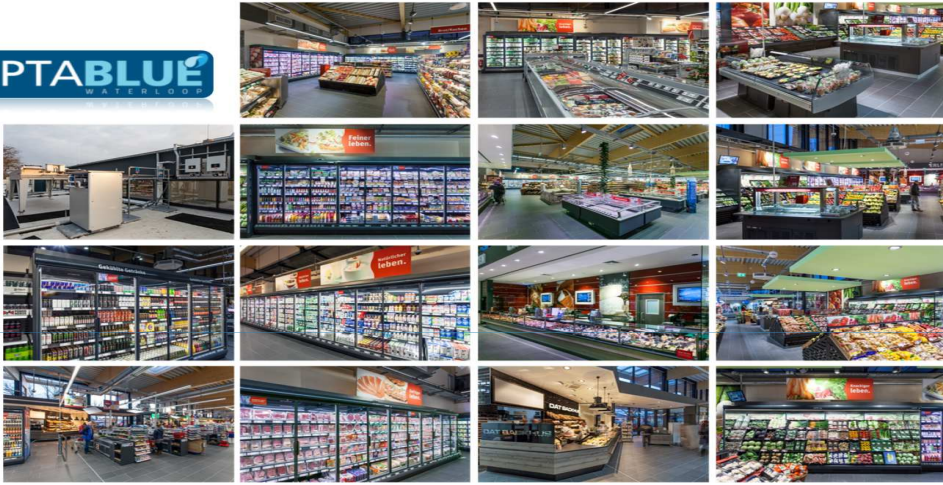
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EPTABLU 2.0 Advanced

EPTABLU 2.0
WATERLOOP



EPTABLU
WATERLOOP



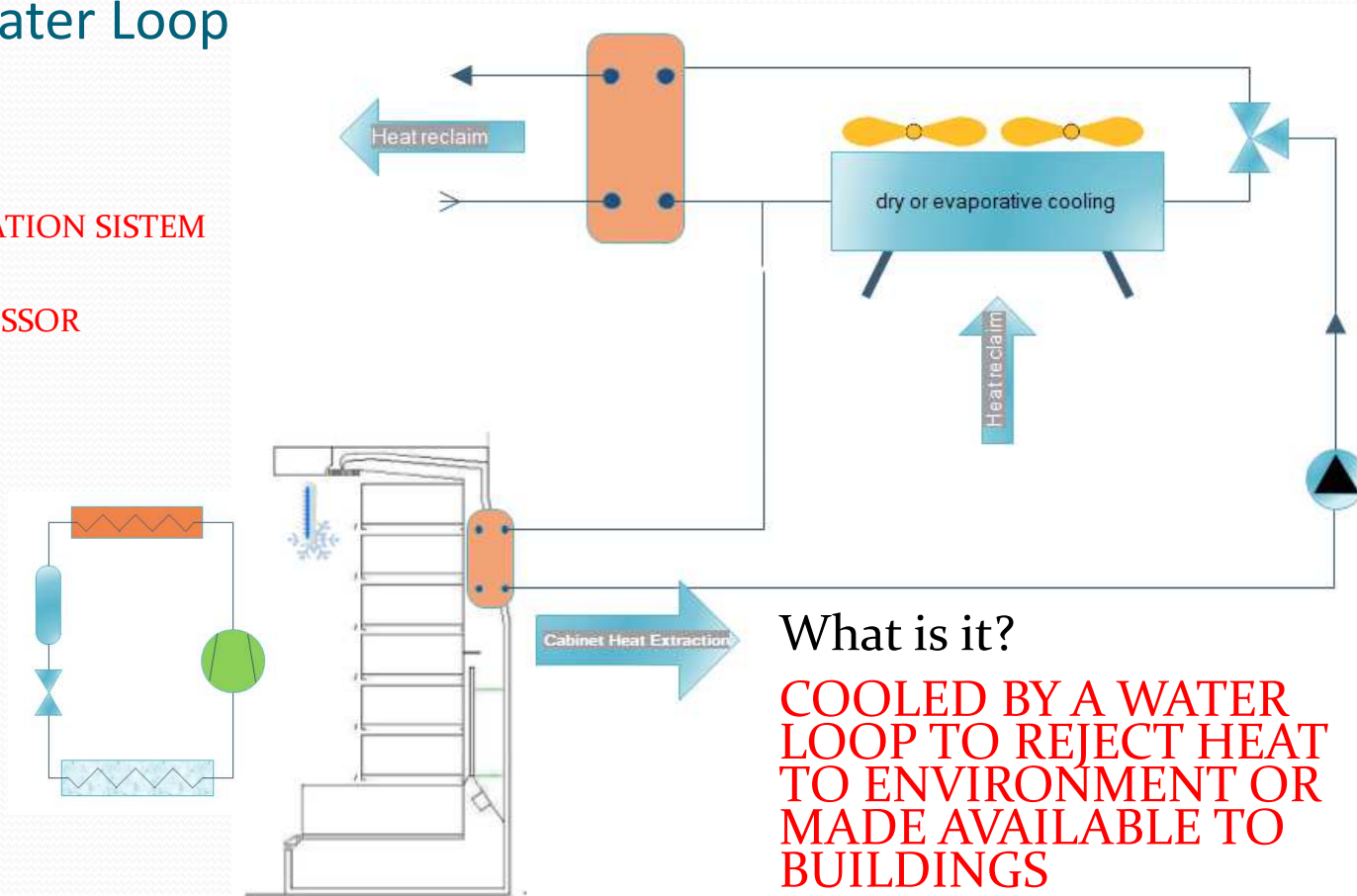
- Opening date: January 2016
- Surface: 1,100 sqm
- Cabinets: 70m vertical MT/LT, 10m serve overs
- Cooling capacity 51KW MT + 10 kW LT
- Pay back time 2 years vs R404A



Self Contained Water Loop

What is it?

A **SEALED CO₂ REFRIGERATION SYSTEM**
SOME KG OF CHARGE
VARIABLE SPEED COMPRESSOR



What is it?

**COOLED BY A WATER
LOOP TO REJECT HEAT
TO ENVIRONMENT OR
MADE AVAILABLE TO
BUILDINGS**

Water Loop Advantages

- Sealed unit that in fiels require only connection to power grid and water
- Each unit can be optimized in construction and in working mode for its specific need (Tev)
- Very reduced charge
- Very simple plant
- Easyness of integration with HVAC or heat reclaim
- On the other side:
- an additional heat exchange interface with its delta T come in
- To maximize advantages an additional HP will help to interface HVAC but with increased capital cost



The built prototype unit

Vertical chilled display cabinet

Double glass hinged door

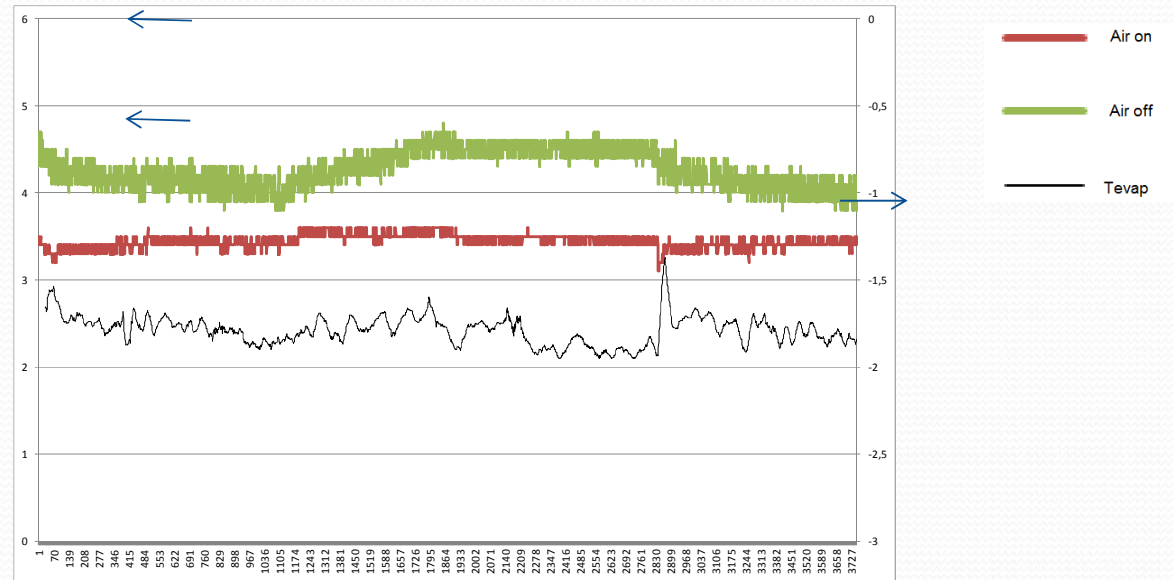
M1 performance

No openings during test



Working temperature

- Indoor temperature varied between 17°C to 24°C from night and day
- Tw varied from 26°C to 39°C deg
- A thermostats kept the T air out at +2.
- Resulting Tev around -3°C
- **Time costant of display cabinet much longer than the refrigeration CO₂ loop**



This prototype was tested replicating the field conditions, and the results were merged with environmental data from the field in order to generate a forecast of the performances of a commercial installation



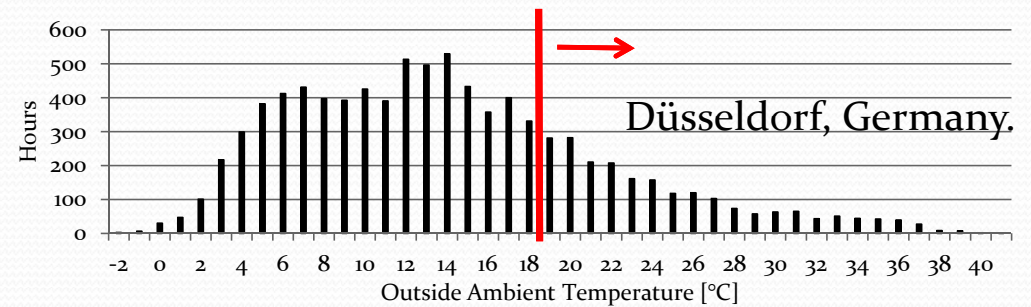
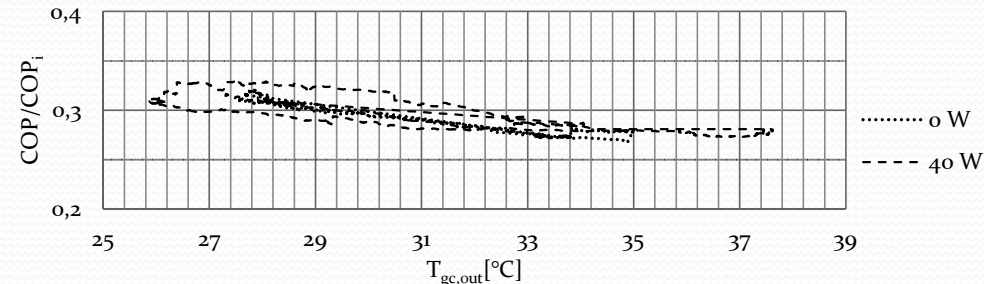
Summer seasonal COP

- We introduced a reference to a carnot eq. $T_{ev}/(T_{w_avg}-T_{ev})$ trying to decouple the environment variation
- Adding 40 W at the air return do not substantially change η_{II}
- There is a clear dependency on T_w ($T_{u,gc}$) but also some variations linked with T indoor

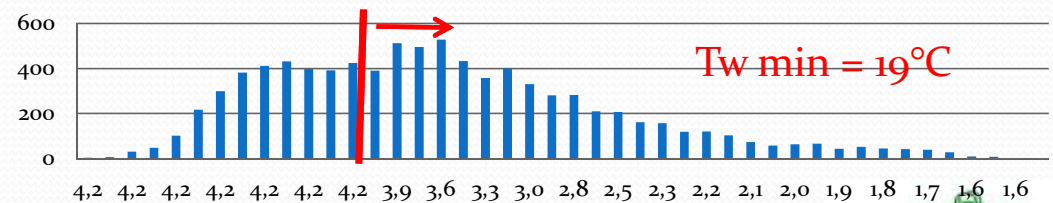
Assuming:

- Costant load,
- DT dry cooler 7°C assumed costant
- Limited min T_w 20°C

$$COP_Y = Q_{TOT} / W_{TOT} = 3,28$$

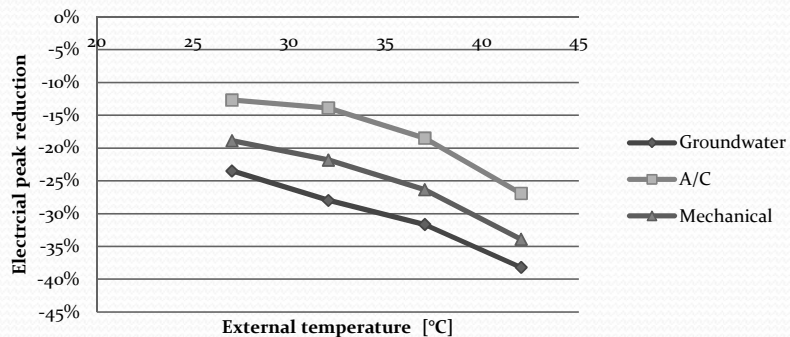


COP Distribution



Super and Hypermarket: mechanical sub-cooling

- Several techniques are available to expand the convenient use of CO₂ in warm climate regions
- Our experience from different stores in Southern Europe, South America and Australia show it is possible to achieve outstanding efficiency levels without cost or safety compromises
- With ambient temperature high exceeding the +35°C, even +50°C as in the case of the Australian plant, subcooling technology is a viable solution
- The reduction of the pressure is responsible also for the reduction in the energy peak and, as consequence, in the energy consumption



Store	UM	South Europe	South Europe	Australia	Australia
Store size	[kW]	95	102	85	80
Subcooling method	[-]	No sub-cooling	Groundwater	A/C	Dedicate Chiller
Subcooling power	[kW]	-	37	35	14



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Conclusioni



- In 2015 more than 50% of delivered systems in Europe are CO₂ based
- F-Gas has contributed to raise attention to the responsible choice of technologies and refrigerants, but support and training proved to be essential in this process
- Capillary, efficient and skilled technical back-up are the key to reach new markets
- Competence management is the essential asset to better serve our clients
- A one-size-fits-all product offer can't adequately or profitably achieve the customer expectations, therefore we diversify our technological palette
- Waterloop systems show an outstanding TCO profile and represent an innovative perspective to natural refrigeration
- R+HVAC building integrated systems are the key to convey all energy needs into one NR technological platform that will in future ensure new expansion for NR



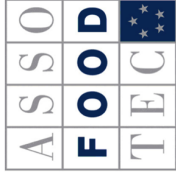
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2020 GWP_{MAX} 2500

2022 GWP_{MAX} 150





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Thank you !

