Small size transcritical carbon dioxide refrigeration system with the innovative CapaFlex capacity control

Steady-state cycle yearly simulations

EUROPE

Atmosphere
19-21 November 2018
Riva del Garda
Centro Congressi Lido 1

Frascold®

Over 80 years in refrigeration and air conditioning solutions

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AGENDA

Frascold

Application Development

A new technology

Model description

Results of the yearly simulations

Conclusion

About Frascold

Our Company

MORE THAN
200
EMPLOYEES

PRESENT IN
86 countries

6 business units

ITALY, USA, CHINA, INDIA, RUSSIA and AUSTRALIA

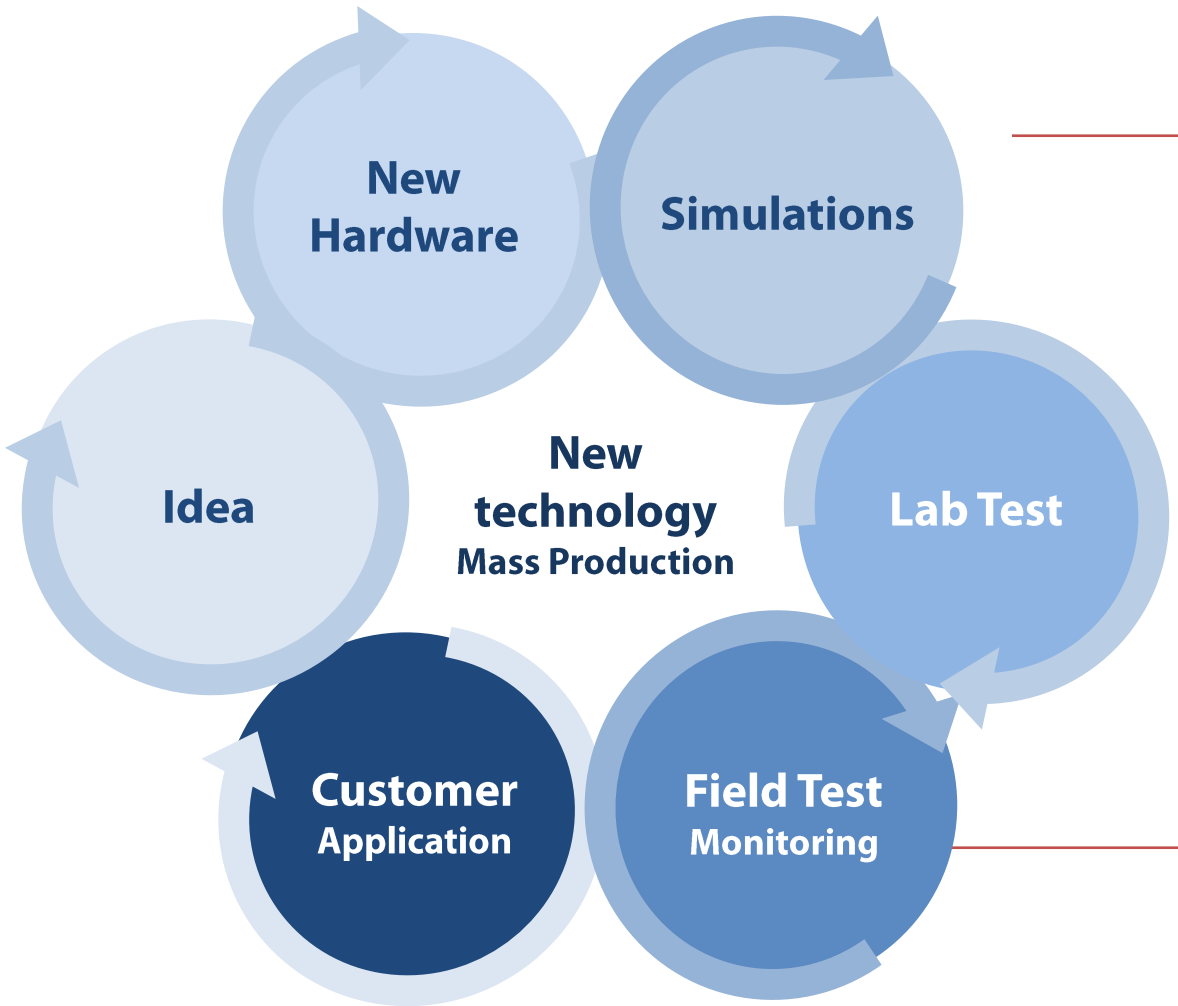
70.000
COMPRESSORS PER YEAR

Production Capacity

Frascold®

New Development

Application and Product development



Collaboration with University of Padova and CNR
CO2 development

Simulations support the technology development

UNIPD is the main university engaged in refrigeration

Lab test confirms the simulations and the hardware mechanical behavior

Field Test validate the application

Monitoring the installations is the way forward for validating

A new Technology

CapaFlex – Frascold Capacity Control

Stepless capacity control

Transcritical CO_2 equipment can for the first time be stepless controlled and energy efficient without the use of a variable frequency driver

Decrease installation and maintenance cost

Easy installation or replacement
Easy to control with existing control signals

Secure your cooling system running

If any control malfunction occurs, the system operates at full load and compressor runs at full capacity;
Uninterrupted operation of the cooling system is ensured.

CO_2 Capacity Control

Innovative System

Stepless Operations

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Model description

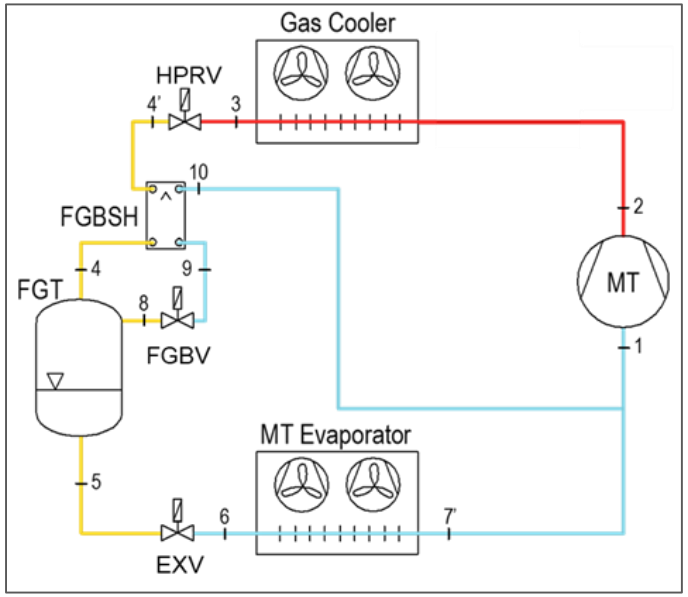
Simulation software FSS3 developed by Frascold

- Steady-state models of refrigeration cycles;
- Integration of **compressors efficiency curves** based on laboratory test;
- Cooling load profile dependent on the external ambient temperature;

Ref capacity MT [kW]:	11,00
Load profile with ambient temperature	Linear
Nominal load ambient temperature [°C]:	32,00
Minimum load ambient temperature [°C]:	10,00
Minimum load fraction [%]	50,00

- High pressure control strategy

High pressure control strategy			
T1 [°C]:	4,00	DTap cond [K]:	3,00
T2 [°C]:	18,00	DTsc cond [K]:	3,00
T3 [°C]:	28,00	DTap GC [K]:	3,00

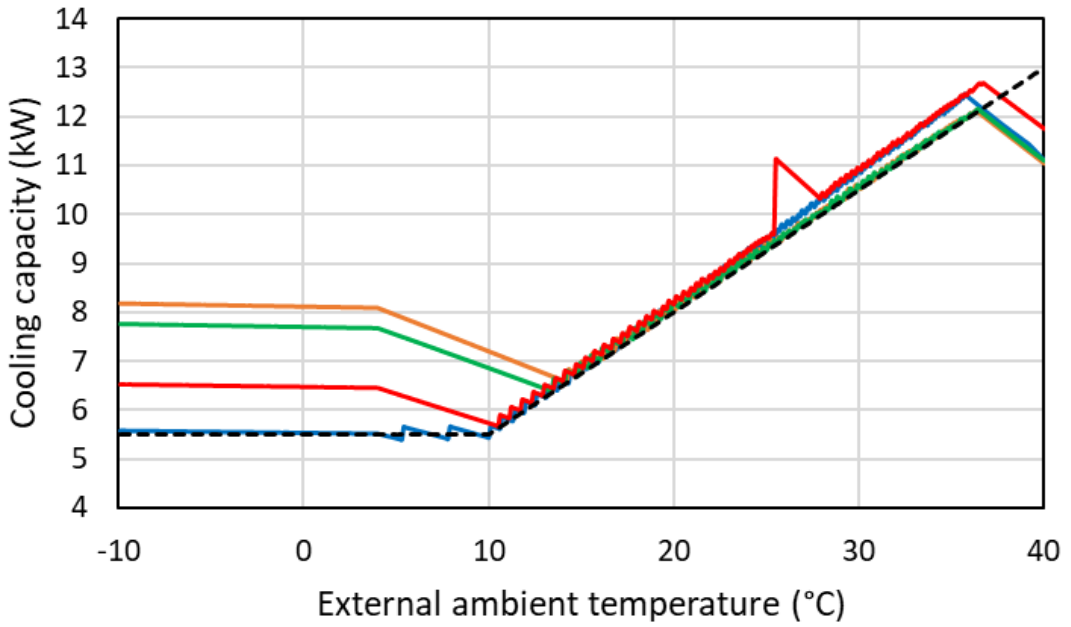


Simulation case

Location	Milano
Refrigeration capacity	11kW (t_{ext} = 32°C)
Evaporation termperature	-8°C
Evaporator superheating	7 K
Piping superheating	Dependent on the external temperature
Intermediate pressure	37 bar

Model description

Simulation software FSS3 developed by Frascold

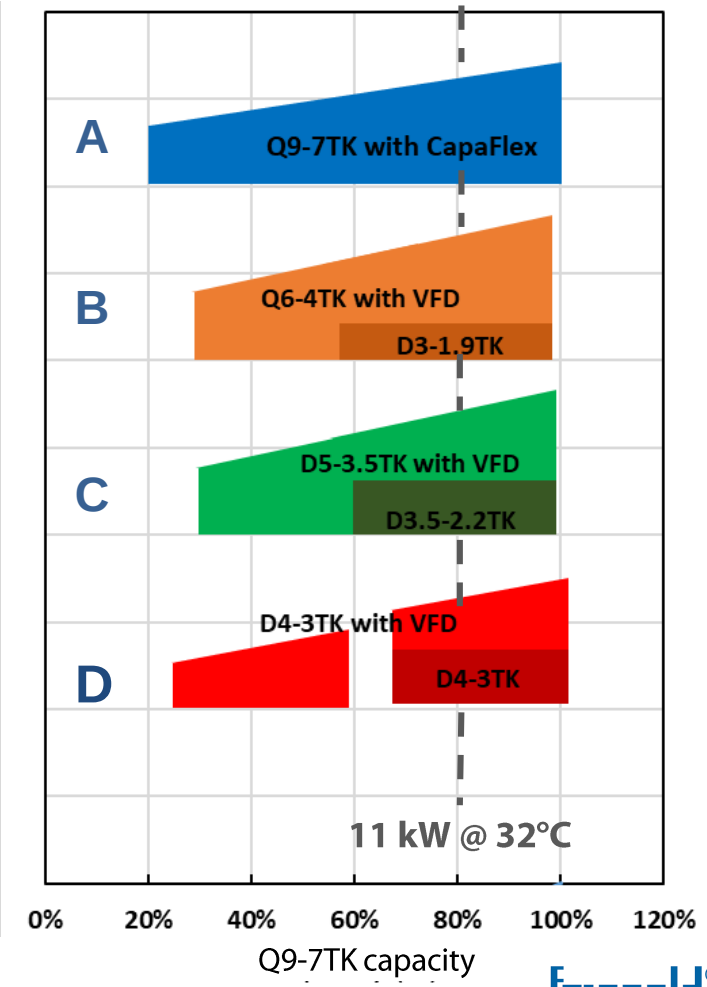


Single compressor with **CapaFlex**

One compressor with **Variable Frequency Driver** (VFD) (30Hz – 70Hz) and one fixed speed compressor (50Hz)

A
B
C
D

Four different compressor configurations



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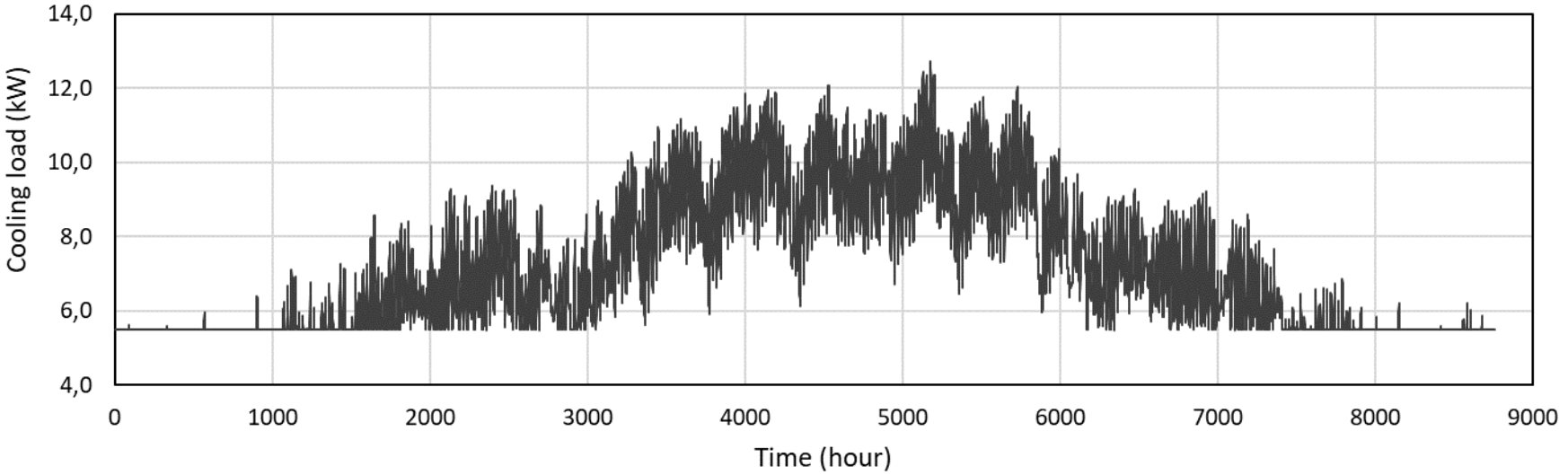
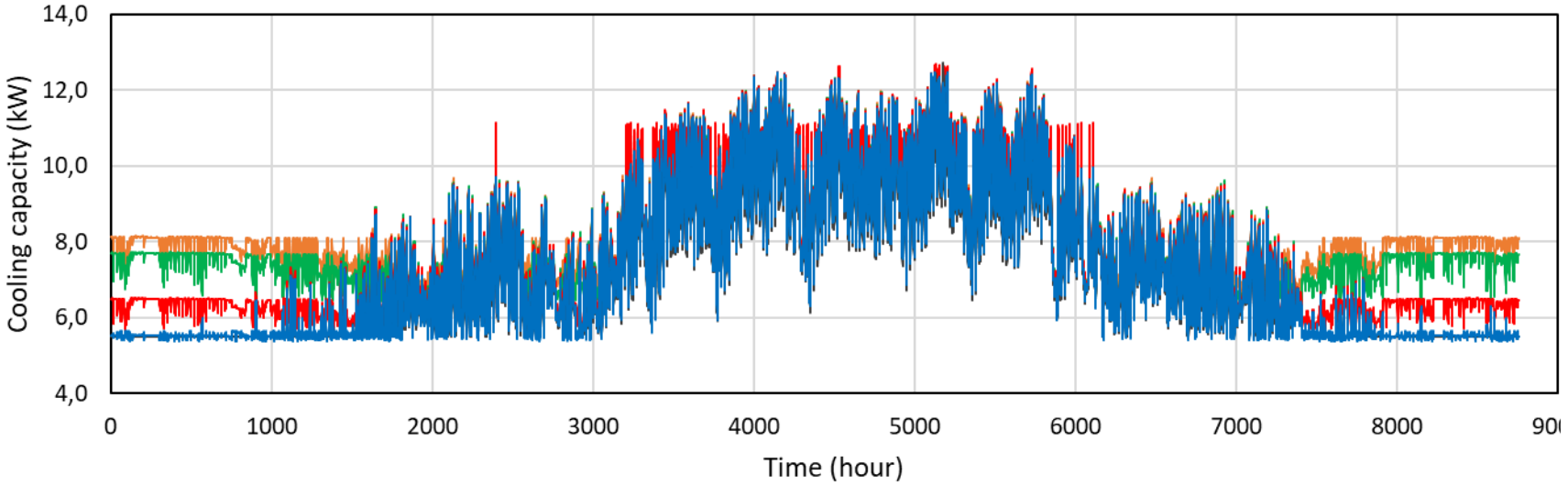
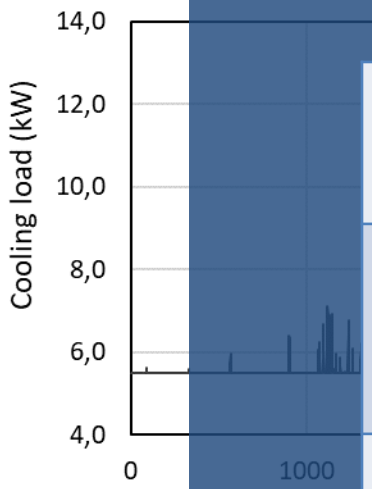
Results of the yearly simulations

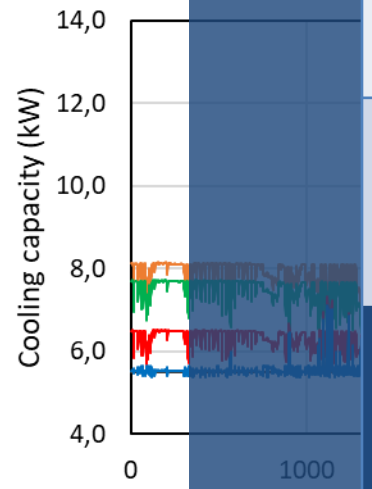


Required cooling energy
62 850 kWh / year



Results of the yearly simulations





Required cooling energy: 62 850 kWh

	Q9-7TK with CapaFlex	Q6-4TK with VFD and D3-1.9TK	Q5-3.5TK with VFD and D3.5-2.2TK	D4-3TK with VFD and D4-3TK
Provided cooling energy	63 870 kWh	72 410 kWh	70 850 kWh	67 000 kWh
Electrical energy consumption	26 000 kWh	23 880 kWh	22 000 kWh	21 600 kWh
Cooling load mismatch (max – mean – min)	4% 1% -10%	47% 19% -10%	41% 15% -10%	19% 7% -6%
Estimation of required number of compressor start and stops*	<10	4 100	3 900	3 100

*Number of effective start and stop of fixed speed compressor + hourly cooling load mismatch > 8.5%

Conclusion

A single compressor with CapaFlex allows a wider capacity variation compared to a single compressor with VFD

The same capacity regulation range can only be obtained by coupling a compressor with VFD and a fixed speed compressor.

Yearly simulations were performed to compare small size carbon dioxide transcritical refrigeration systems with similar capacity regulation range

- The performance of the systems are affected by the capacity regulation technology (CapaFlex or VFD) with reference to the cooling load profile (variation range); The CapaFlex configuration at capacity higher than 80% (high ambient temperature) is more efficient than the other systems with VFD, while the configurations with VFD result more efficient when the cooling load are lower (lower ambient temperature);
- The CapaFlex is able to follow the cooling load in a smoother way; that means reduced number of start and stops of the compressors.

THANKS!

Team **Frascold**