



Business Case for
Natural Refrigerants

11-12/04/2018 – Beijing



LU-VE
GROUP
leadership with passion



HIGHLY EFFICIENT AIR COOLED HEAT EXCHANGERS FOR CO₂ APPLICATIONS

How to make CO₂ cycles efficient in Beijing thanks to the use of gas coolers with synergetic use of water spray and adiabatic panels

Livio Perrotta – LU-VE Group

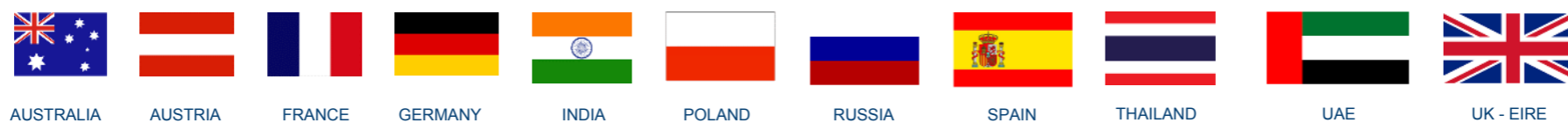
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AGENDA

- LU-VE GROUP
- THE GAS COOLER OUTLET TEMPERATURE IS A KEY PARAMETER FOR A HIGH-EFFICIENCY CO₂ CYCLE
- EMERITUS®: HOW TO REDUCE CO₂ OUTLET TEMPERATURE IN A GAS COOLER DURING THE WARMEST DAYS
- APPLICATION OF EMERITUS® IN A CO₂ TRANSCRITICAL REFRIGERATION PLANT IN BEIJING
- RESULTS AND CONCLUSIONS



12
production



11
commercial
offices

LU-VE is an international group of companies specializing in heat exchangers, cooling systems and components for Refrigeration, Air Conditioning and industrial processes



- ❑ 2,400 skilled employees
- ❑ 390,000 sqm. total surface area
- ❑ More than 160,000 sqm. covered area
- ❑ 2,500 sqm. of R&D Laboratories
- ❑ More than 80% of production exported to 100 countries
- ❑ Consolidated Turnover € 270 million (2017)
- ❑ Listed on the Milan Stock Exchange

Research & Development activity

LU-VE HAS ONE OF THE LARGEST PRIVATE LABORATORIES IN EUROPE, AND WORKS IN CLOSE COOPERATION WITH MILAN POLYTECHNIC UNIVERSITY AND MORE THAN 21 OTHER UNIVERSITIES ALL OVER THE WORLD



2010 – CO₂ TEST
LABORATORY



2004 – FIRST
TRANSCRITICAL
VENTILATED GAS COOLER
IN EUROPE

2004

COOP WETTINGEN - Zurig - Switzerland

LU-VE CO₂ UNIT COOLERS

LU-VE has designed a dedicated complete range of CO₂ unit coolers, commercial and industrial



40[bar] - 60 [bar] – 85 [bar]

ALL TESTED!

LU-VE CO₂ GAS COOLERS

LU-VE has designed a complete range for trans-critical and subcritical, commercial and industrial



MAXIMUM WORKING PRESSURE 130[bar]

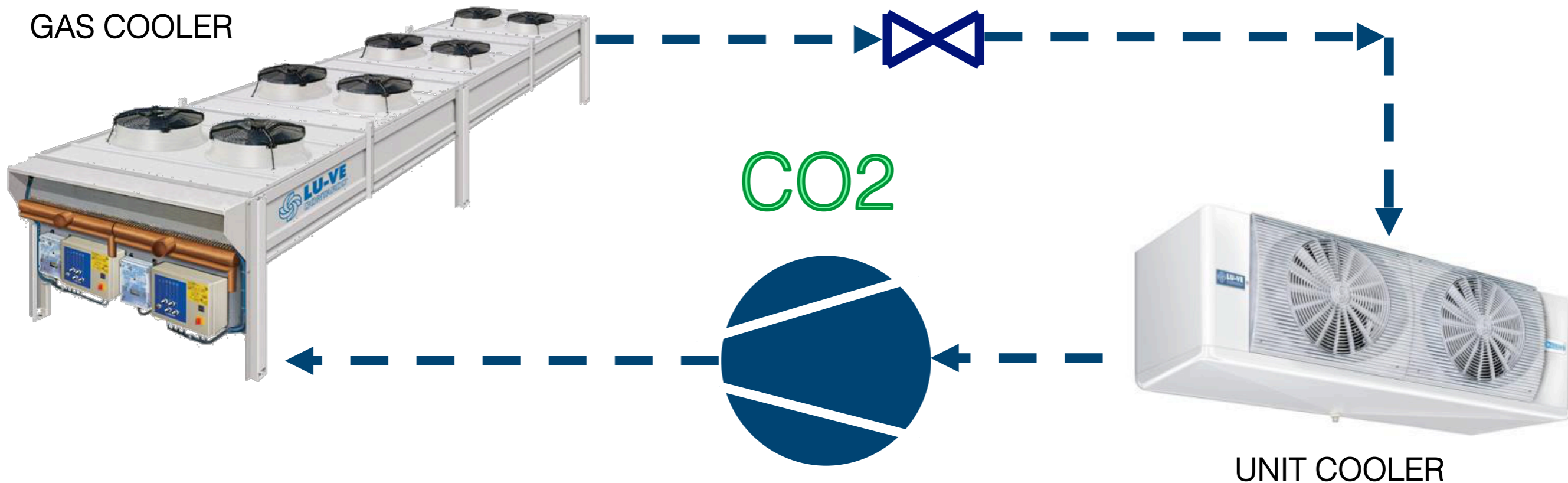
ALL TESTED!

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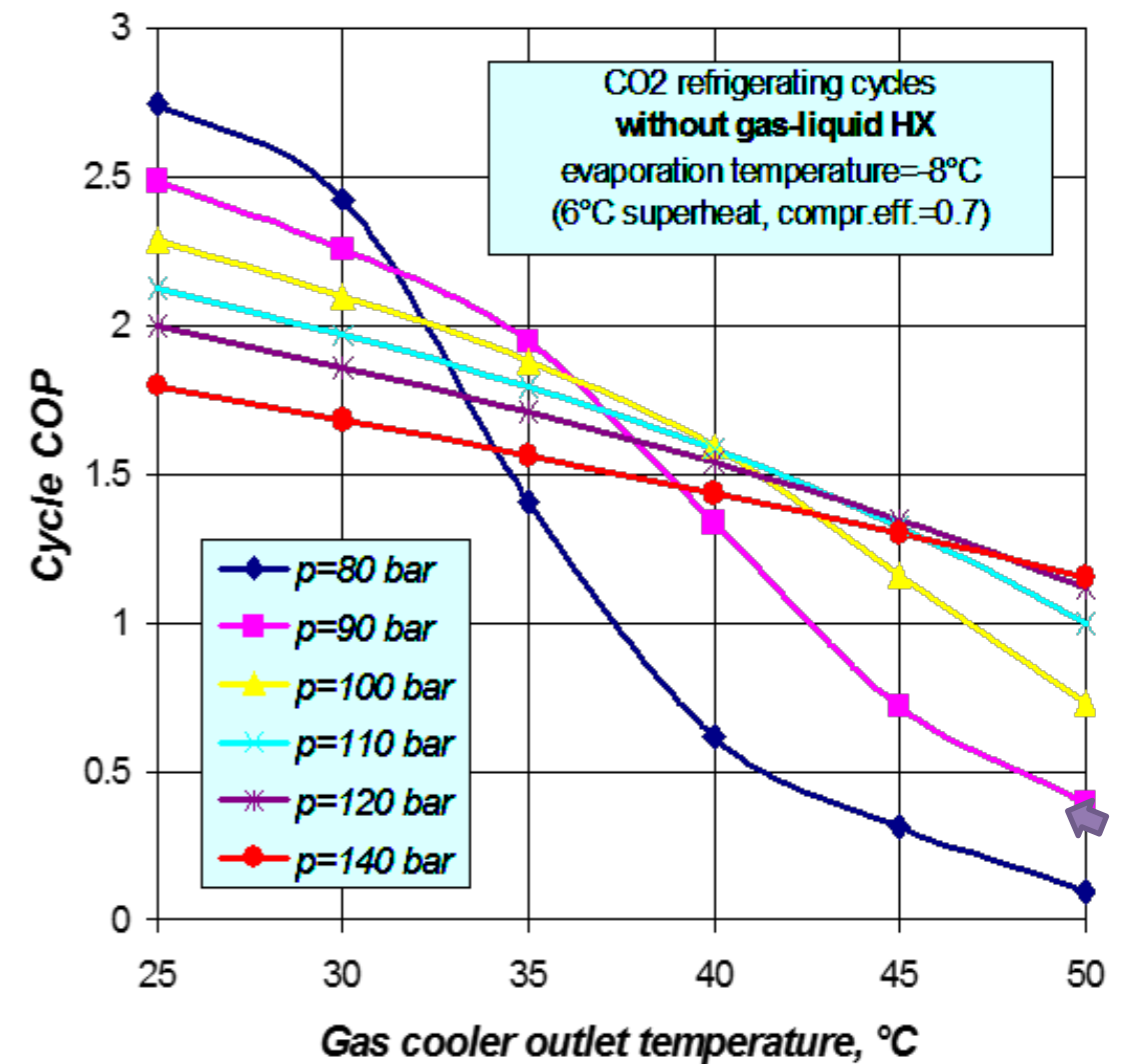
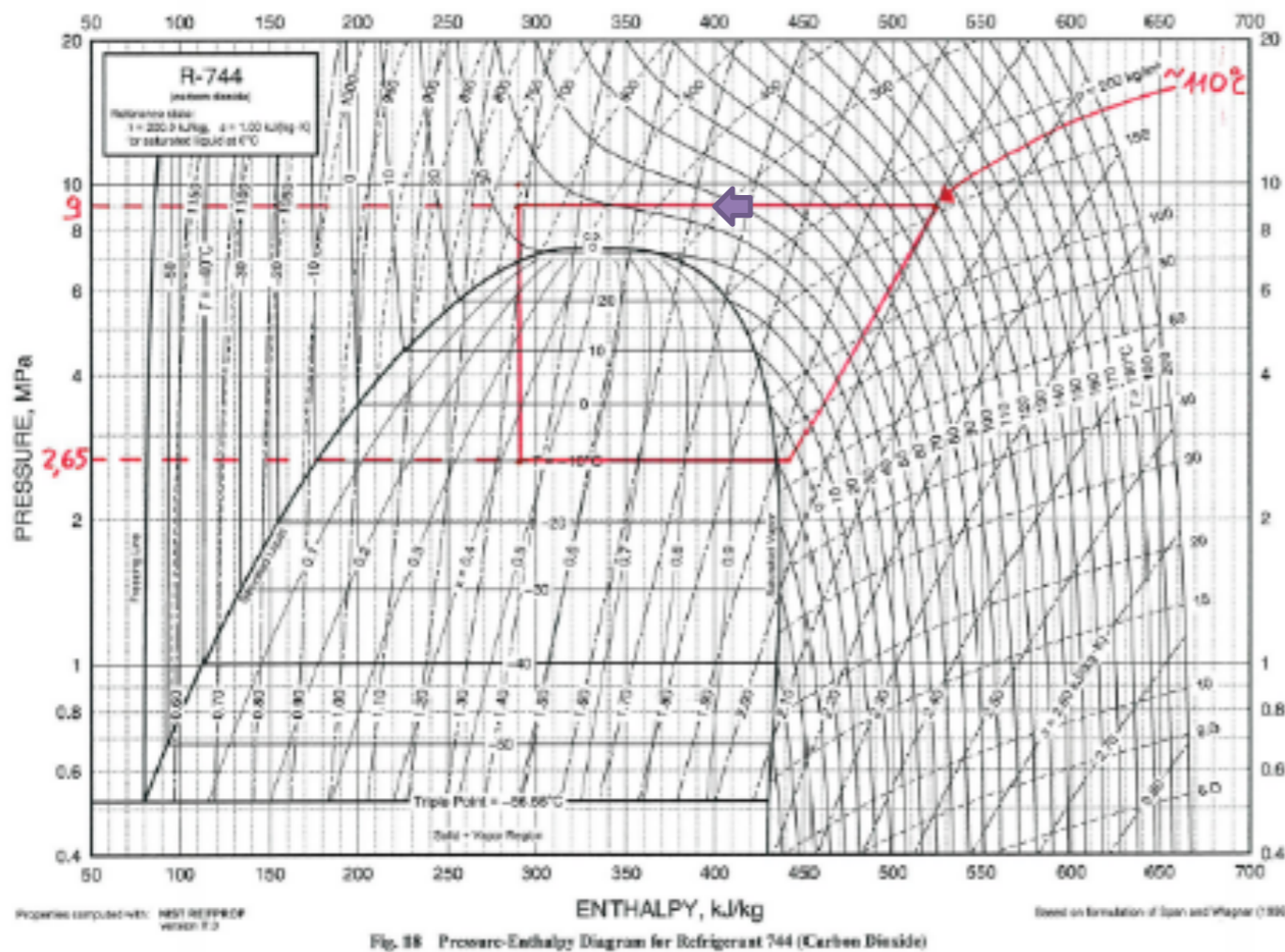
CO2 HEAT EXCHANGER

is one of the most important elements specifying operating costs in the refrigeration plant



SIMPLIFIED TRANSCRITICAL CYCLE

THE GAS COOLER OUTLET TEMPERATURE IS A KEY PARAMETER FOR A HIGH-EFFICIENCY CO₂ CYCLE



However, when the ambient temperature is high the traditional dry products start to give an outlet temperature which is too warm for efficient operation.

YESTERDAY QUESTION

WHAT IS THE MAXIMUM LATITUDE OF APPLICATION FOR A CO₂ TRANSCRITICAL PLANT?



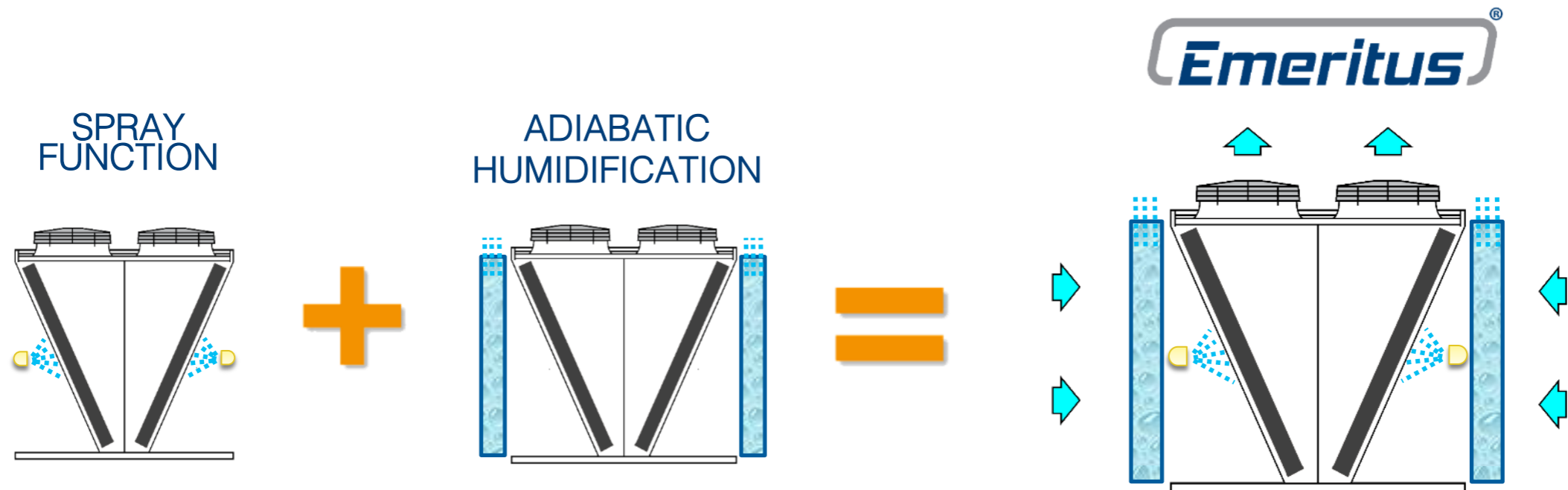
**EMERITUS® IS
THE NEW
TECHNOLOGY
ABLE TO EXTEND
THE AMBIENT
WORKING
CONDITIONS FOR
CO₂**

How to reduce CO₂ outlet temperature in a gas cooler during the warmest days?



EMERITUS[®] is the latest innovation developed for the range of gas coolers manufactured by LU-VE Exchangers. This new technological advance is the result of collaboration with the Polytechnic University of Milan.

HOW EMERITUS® WORKS

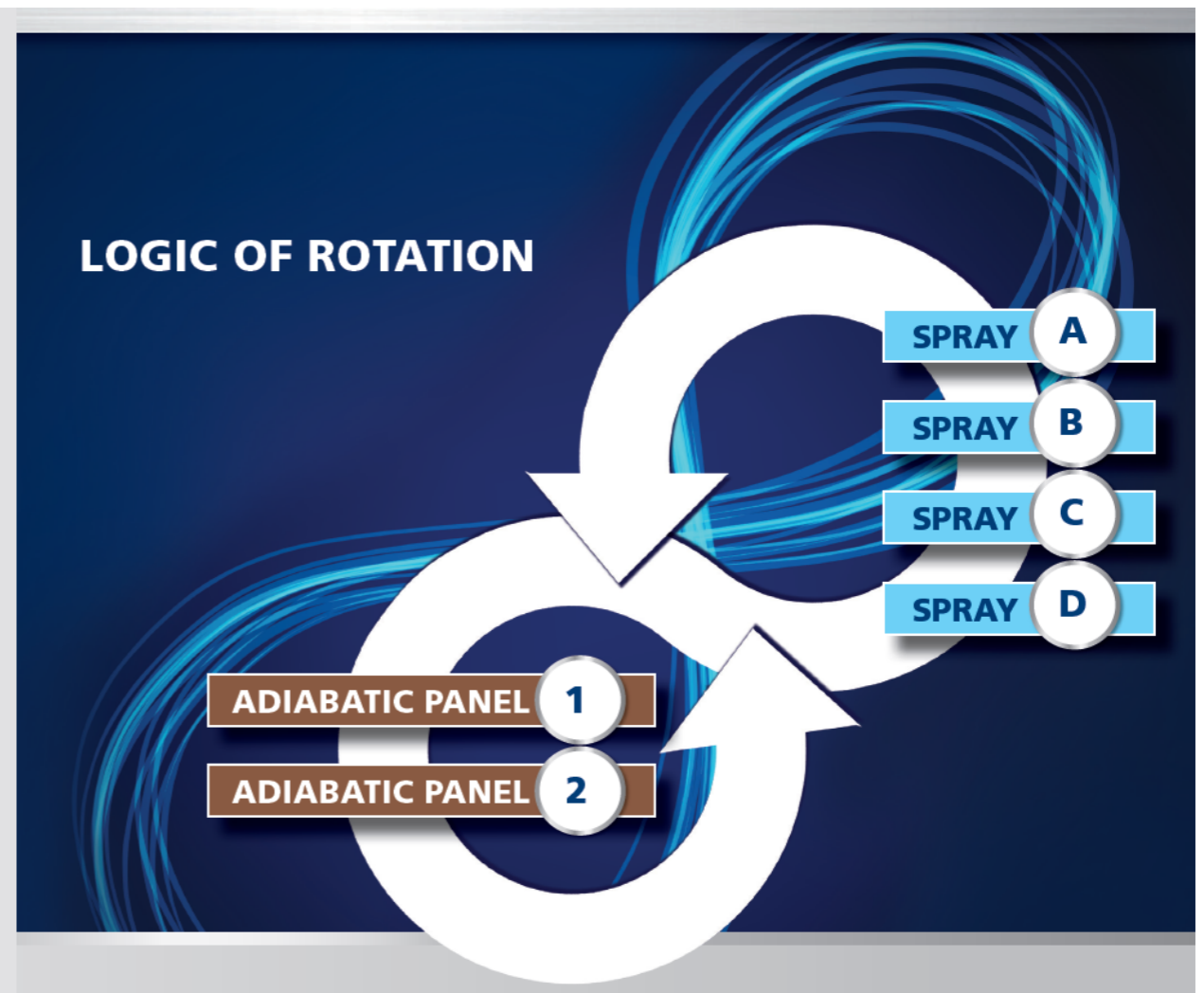
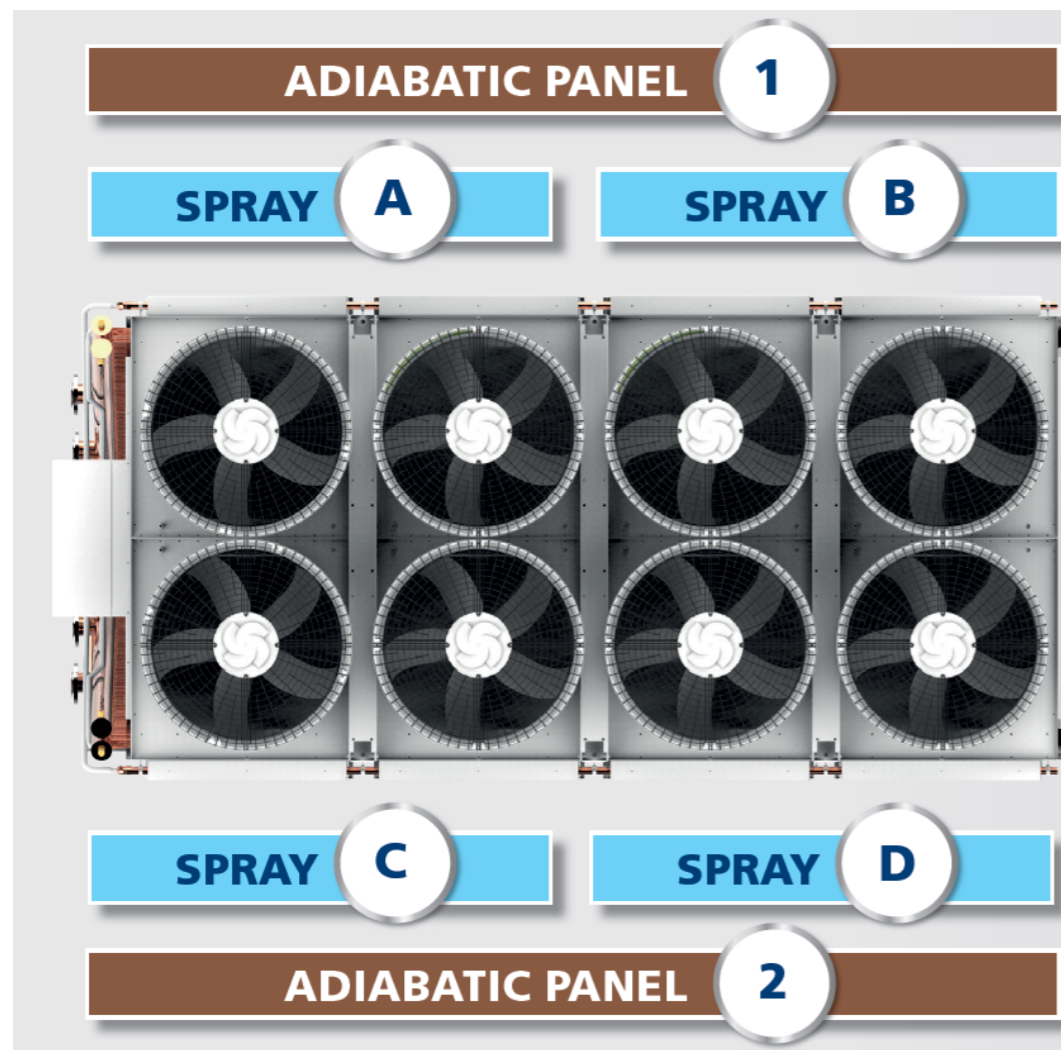


EMERITUS® TECHNOLOGY COMBINES THE SPRAY FUNCTION WITH ADIABATIC PRECOOLING. IN THIS WAY, THE SYSTEM EXPLOITS THE SYNERGY BETWEEN TWO EFFECTS: ADIABATIC HUMIDIFICATION AND EVAPORATION OF WATER ON THE COIL.

The Emeritus® system is patented.

HOW EMERITUS® WORKS

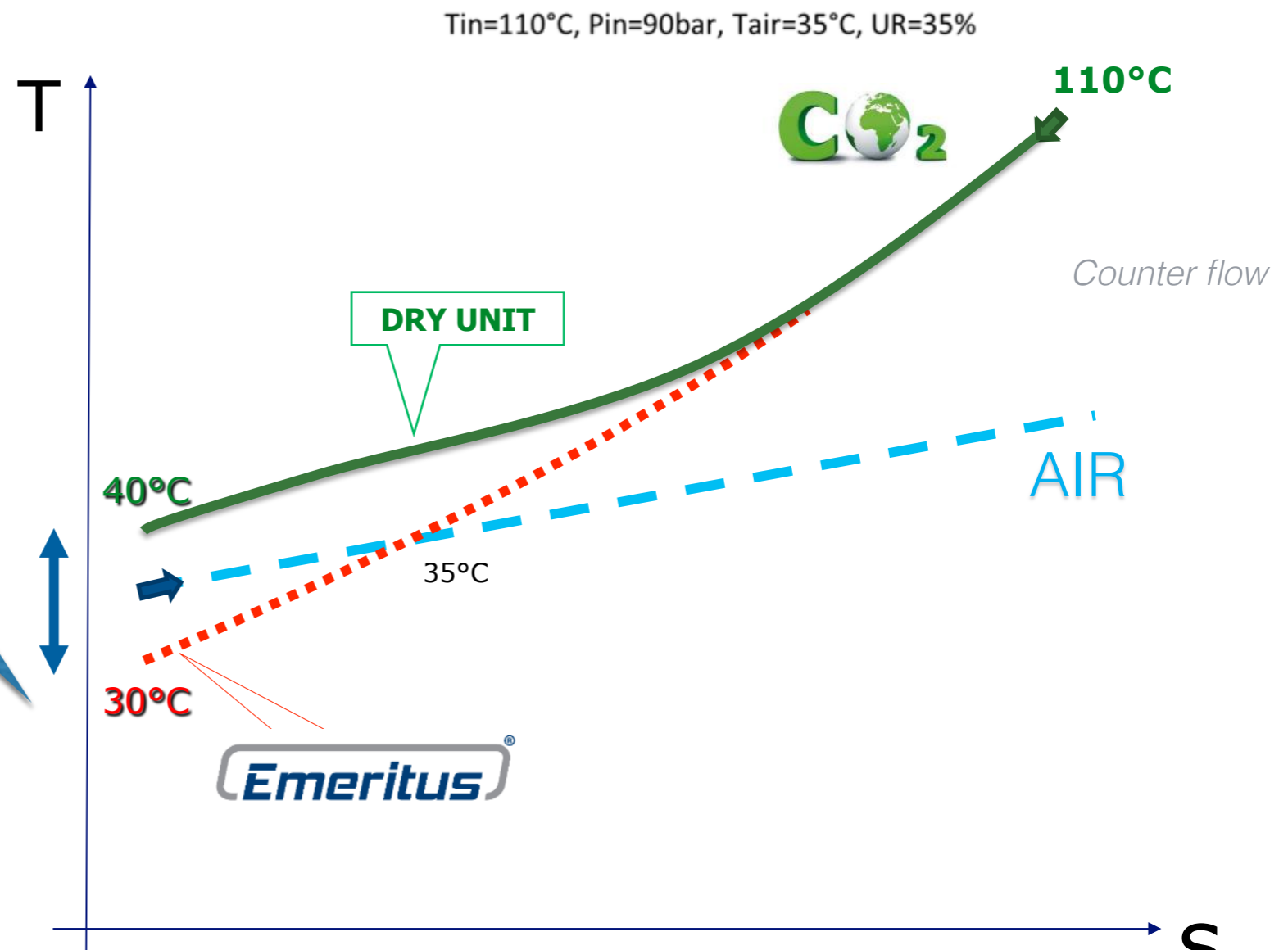
The system is divided in 6 sections, 2 adiabatic and 4 spray systems. A sophisticated regulation system, combined with EC fans, optimizes the numbers of hours per year of spray function with consequent water and energy savings.



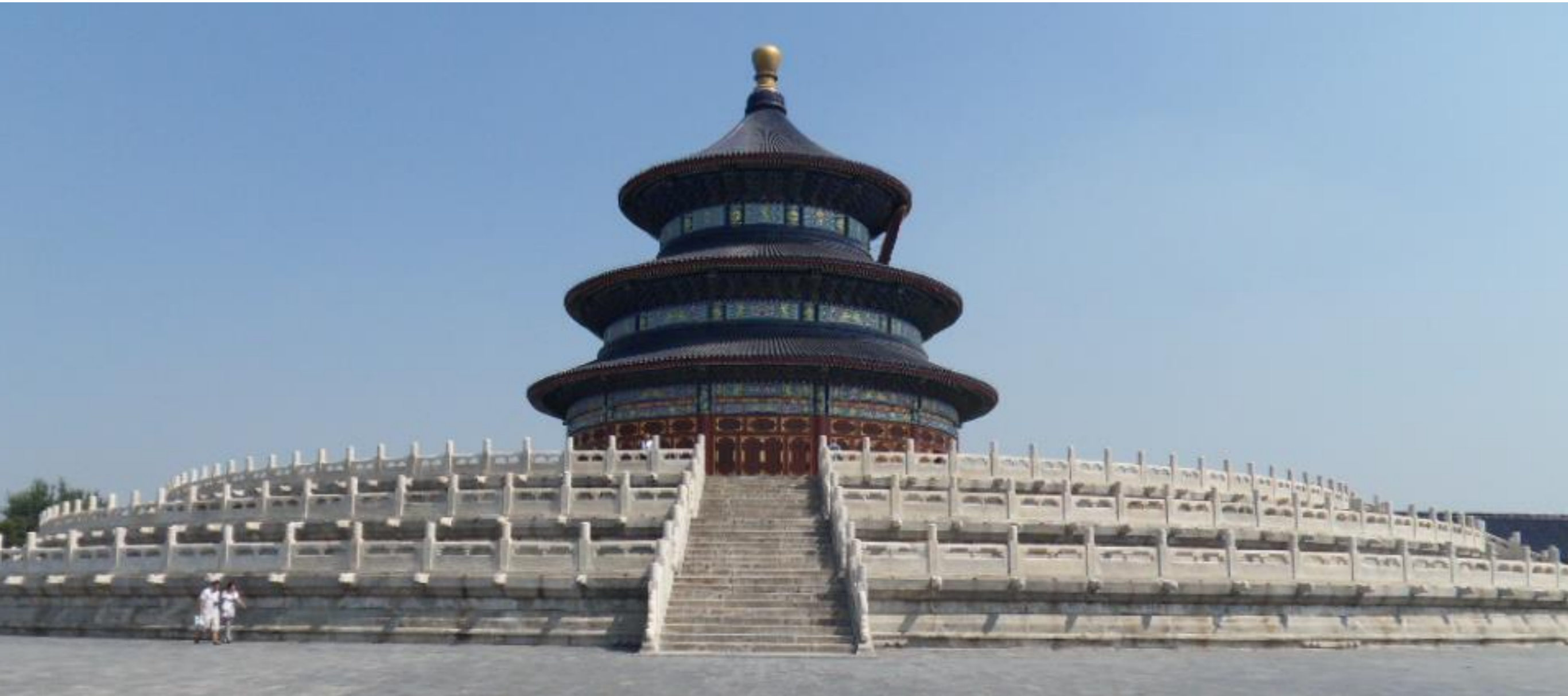
Thanks to EM **Emeritus** can reduce the outlet temperature during the warmest days working in hypercritical conditions

In this example a reduction of 10 K of the CO₂ has a positive consequent impact on the COP of the system.

a COP increase of 69%* has been obtained during the transcritical operation



*hypothesis of a simple cycle with evaporation temperature of -8°C. The COP goes from 1.31 (temp. T_{out} CO₂ gas at 40°C) to 2.21 (T_{out} CO₂ gas at 30°C)

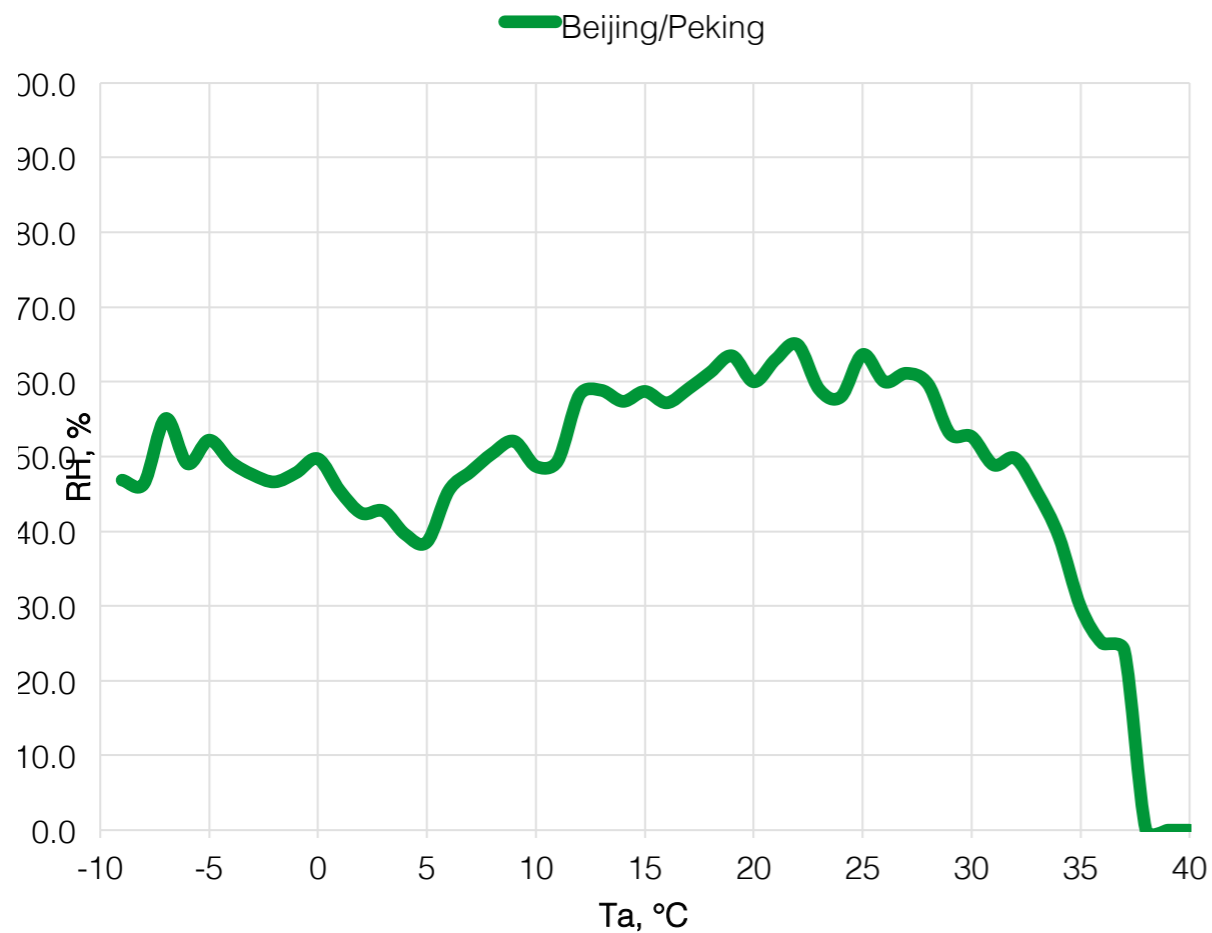


APPLICATION OF EMERITUS[®] IN A CO₂ TRANSCRITICAL REFRIGERATION PLANT IN BEIJING

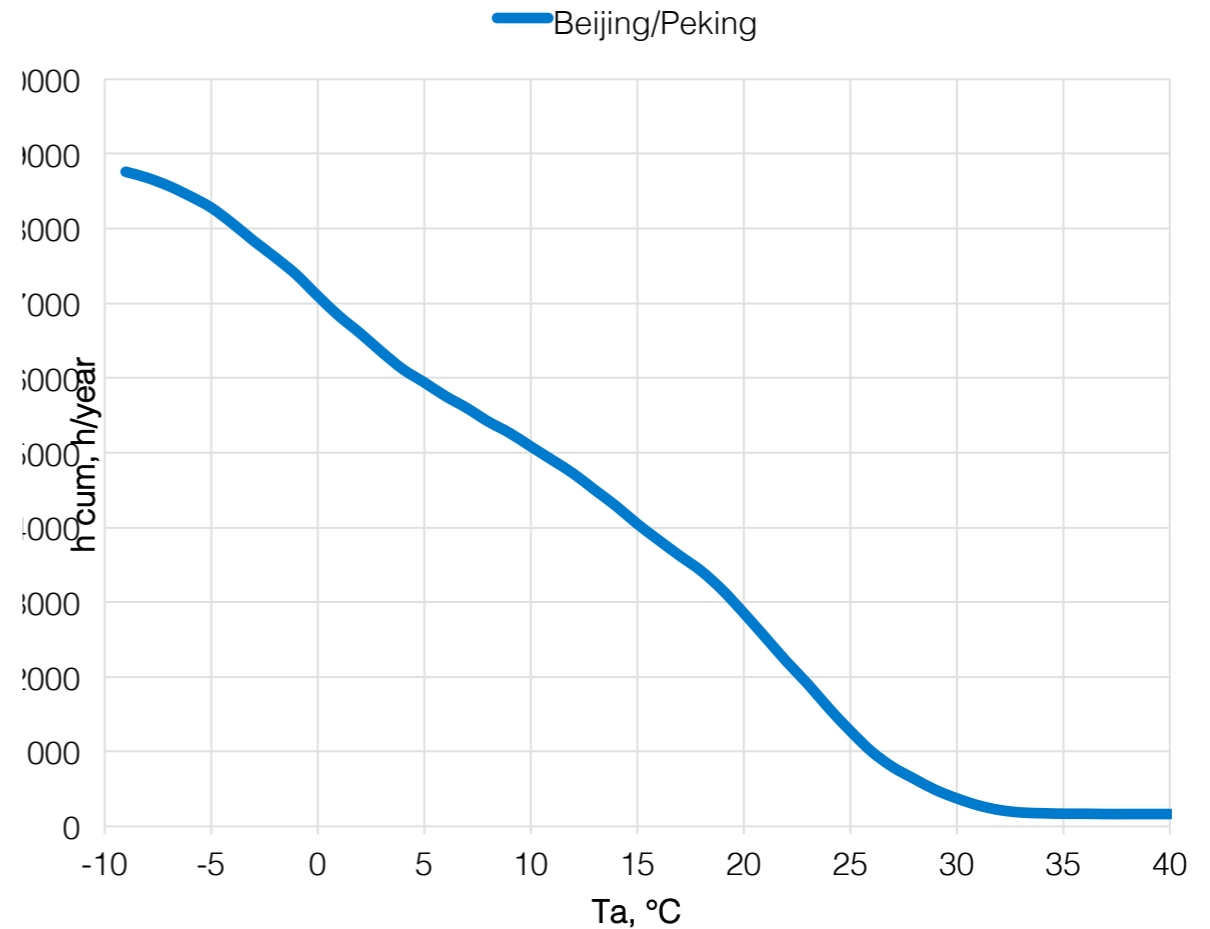
ANNUAL DISTRIBUTION PROFILE

BEIJING

In the figures the average historical annual distribution of the relative humidity and the ambient temperature in Beijing is indicated.



Relative humidity as a function of air temperature



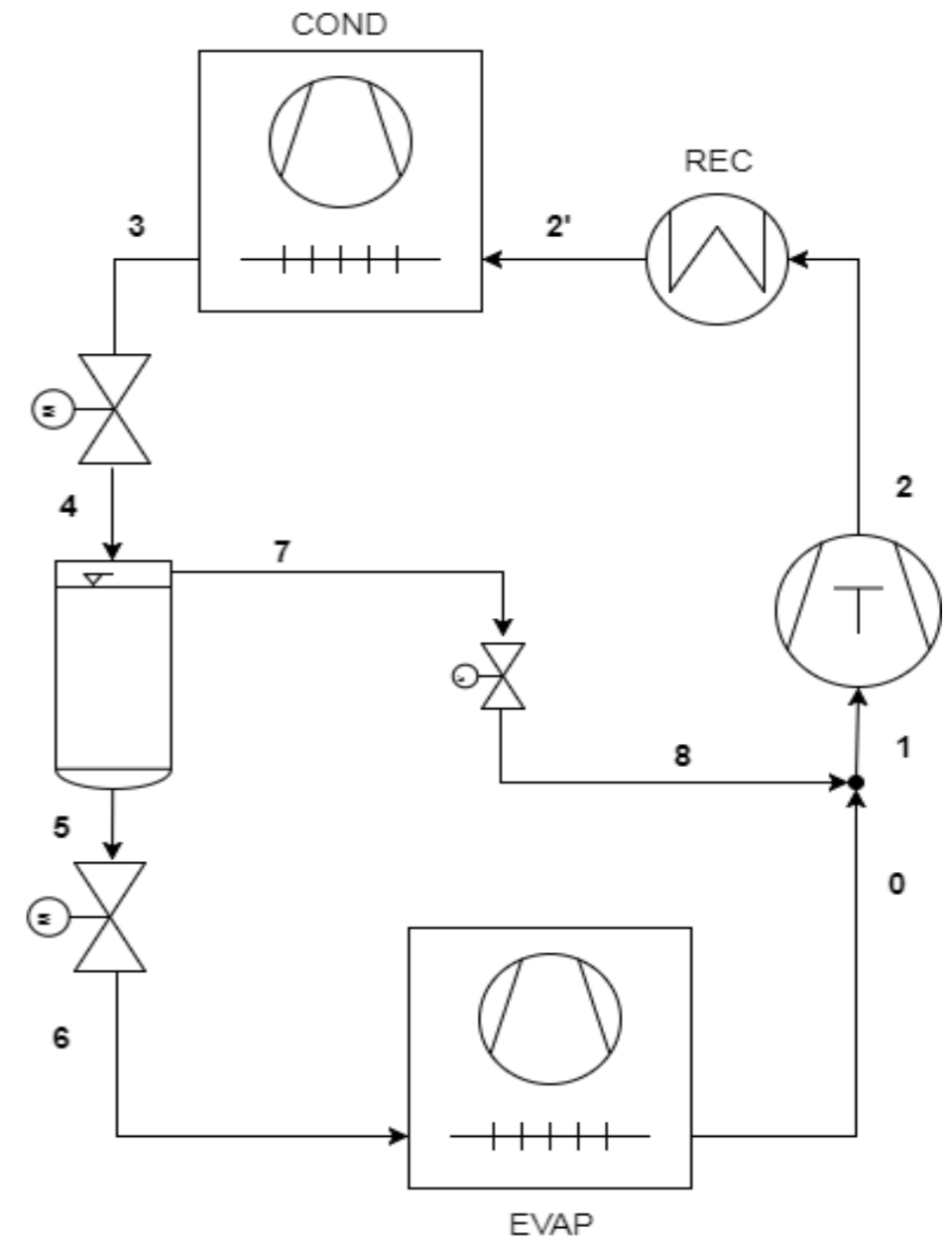
Air temperature distribution per hours/year
(CUMULATIVE DIAGRAM)

THE CASE STUDY

An industrial refrigeration plant working in transcritical/subcritical CO₂ operation is considered in the simulation.

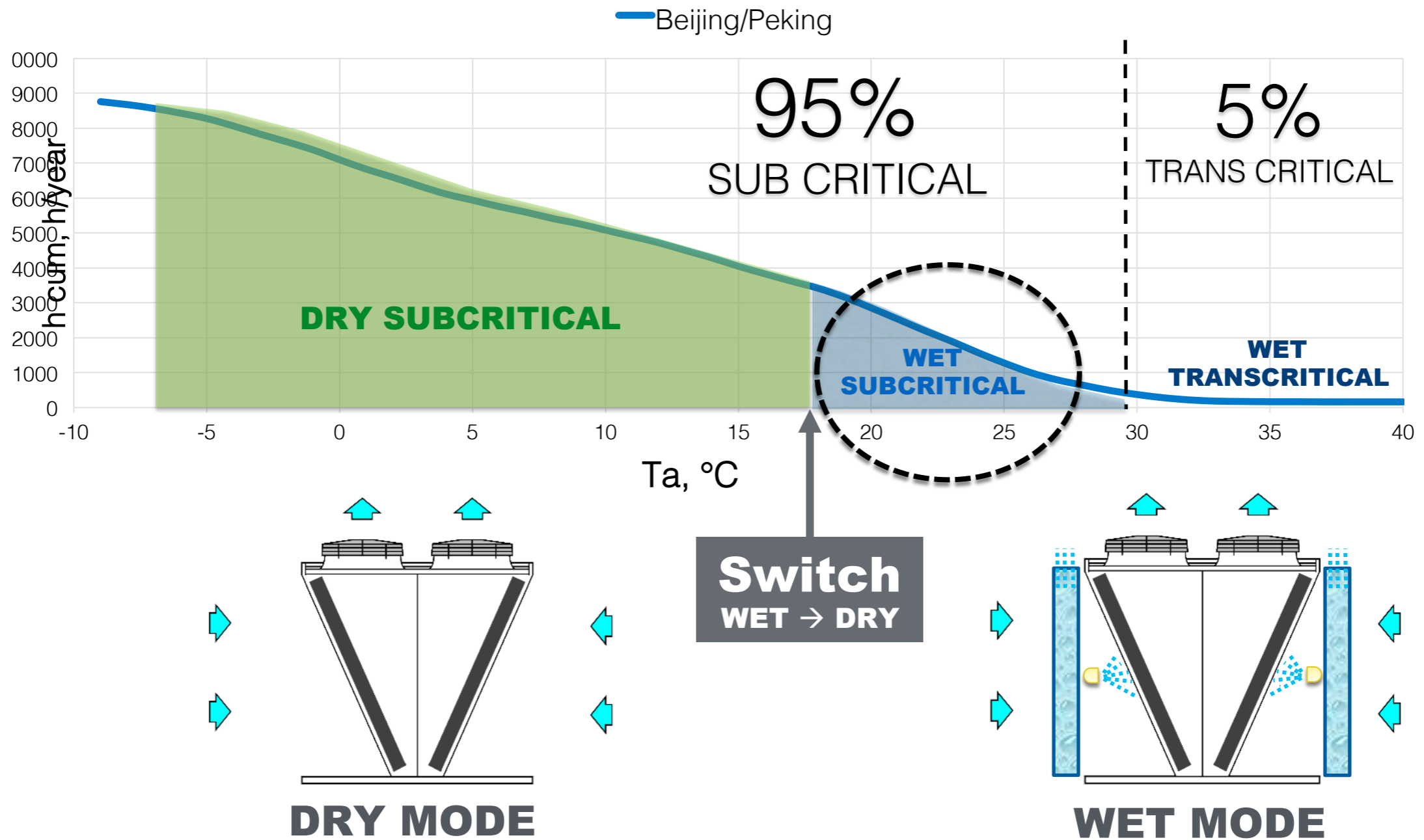
Design data:

- Refrigeration capacity required: 250 kW.
- Evaporation temperature: -9 °C (typical supermarket positive application)



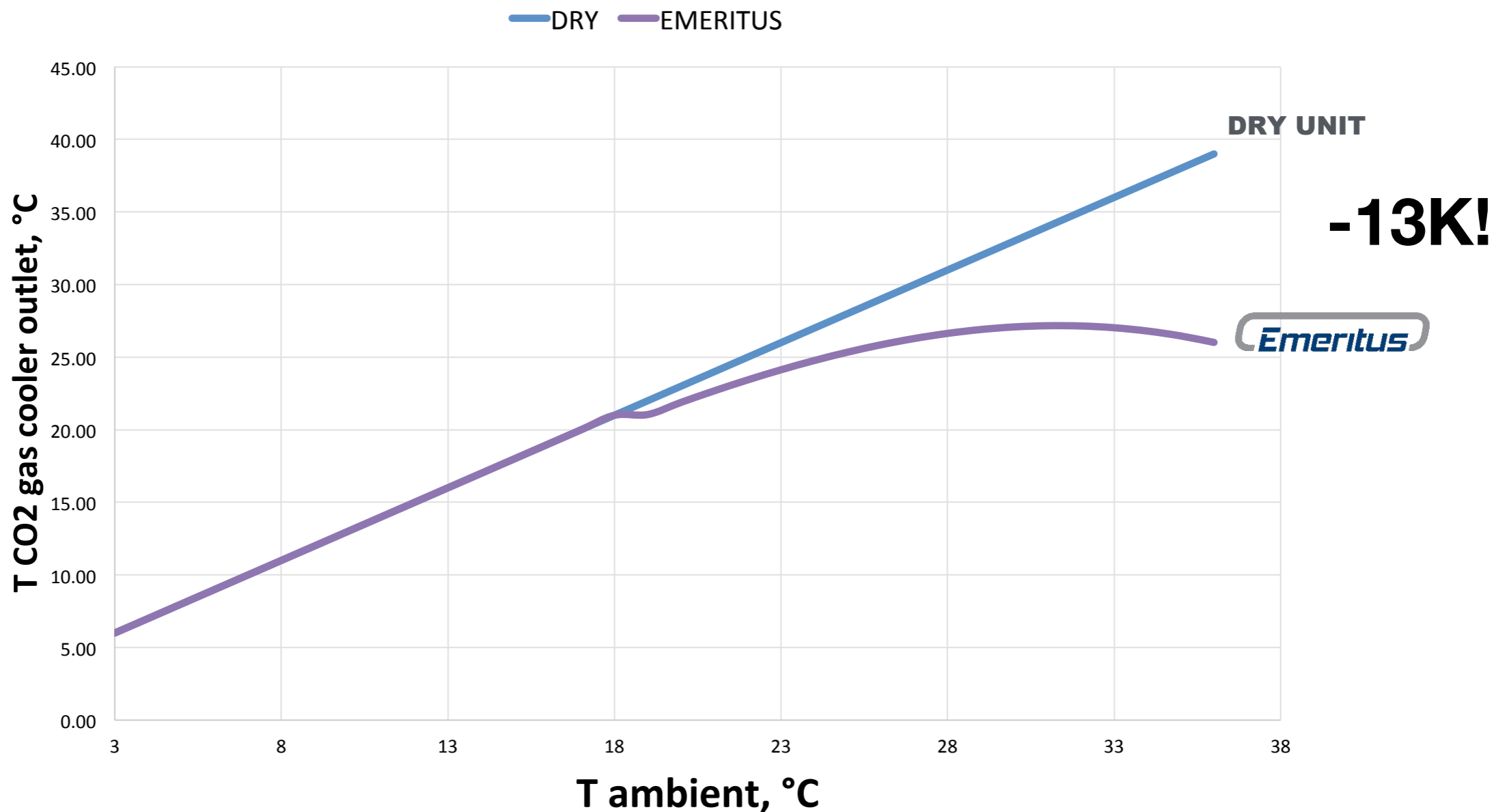
Beijing operating conditions

For a large number of hours the gas cooler works in subcritical operation. The WET condition gives a good contribution not only in the transcritical but also in the subcritical operation.



OUTLET CO2 GAS COOLER TEMPERATURE

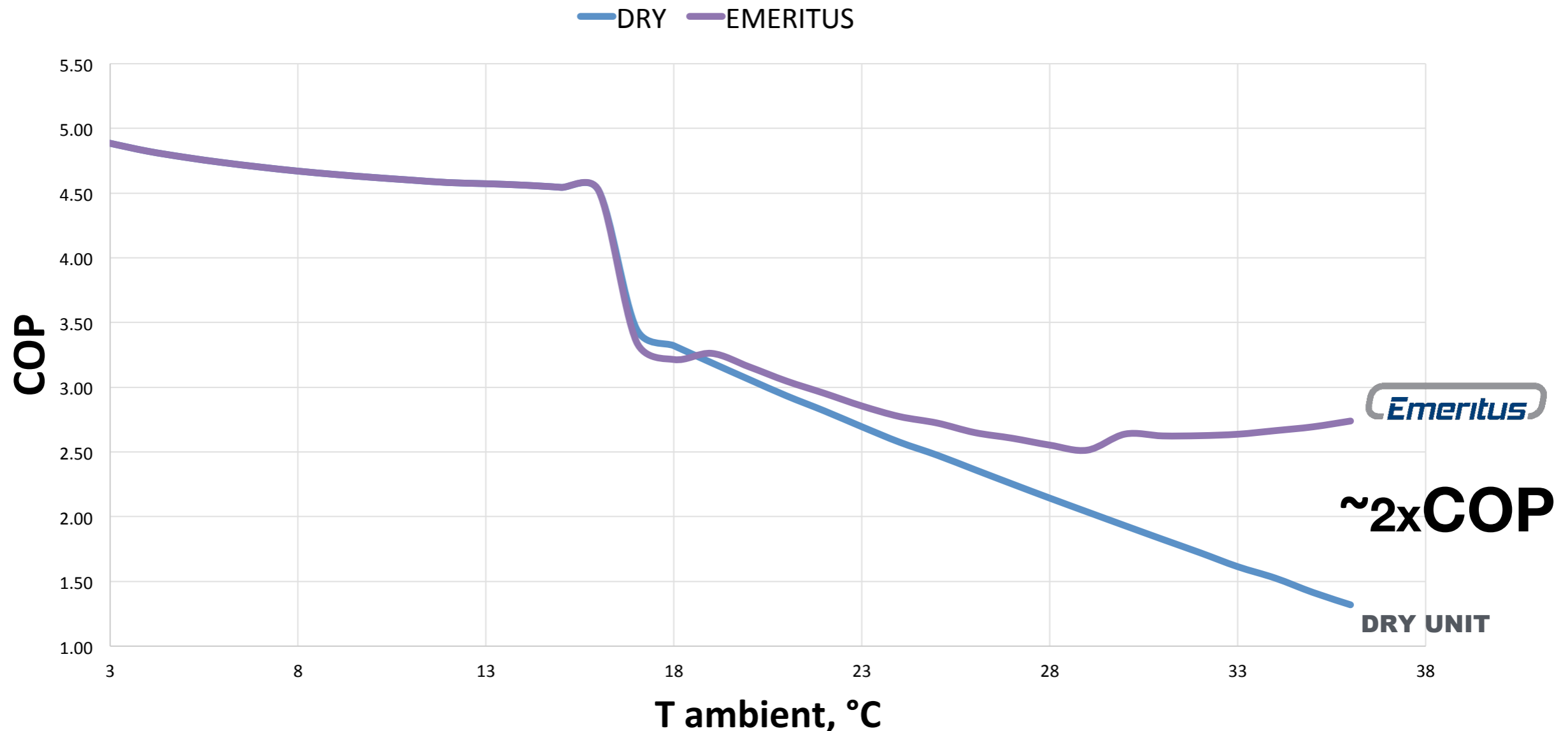
Compared to the dry gas cooler, **EMERITUS®** allows an important reduction of the **CO2 outlet temperature during the warmest temperatures.**



The gas cooler performance is calculated with LU-VE in house software, developed together with Politechnic University of Milan, calibrated with laboratory test results in LU-VE R&D

COP SIMULATION RESULTS

The consequence is an important increasing of the COP during the warmest days of the year. We can see that **the wet solutions show better overall performance in the year compared to the dry solution.**



The COP distribution is calculated with LU-VE in house software, developed together with Politechnic University of Milan, calibrated with laboratory test results in LU-VE R&D

SEASONAL COP

	COP winter	COP summer	COP average
Beijing	4.49	2.94	3.54

Seasonal COP of the cycle with an average 3,54

OPERATING COSTS BALANCE

	compressor	fans	water	O&M	total
DRY GAS COOLER	97.5%	2.52%	0.00%	0.03%	100.0%
EMERITUS GAS COOLER	85.6%	2.51%	2.78%	0.30%	91.2%
	-12%				-9%

(~ 60,000 ¥ / year)

The reference is the total cost of the DRY solution. Cost of the compressors is the greatest part of the total cost, more than 90%. The fans energy consumption, the water and the operating and maintenance costs are negligible. Compared to the DRY solution, the EMERITUS WET version saves up to 9% of the yearly costs.

CONCLUSIONS

The case study demonstrates that is possible to:

Extend ambient
working conditions

Obtain a short
payback time
Emeritus vs dry
(about 18 months)

The gas cooler
investment is “Free”
in about 7 years
just with energy
saving

Extra saving
downsizing the
compressor





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Thank you very much!

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