United Technologies

Building & Industrial Systems

CRH 2015 Ozone2Climate Industry Roundtable

CO_2 Supermarket Refrigeration in Warm Climates

April 9th, 2015

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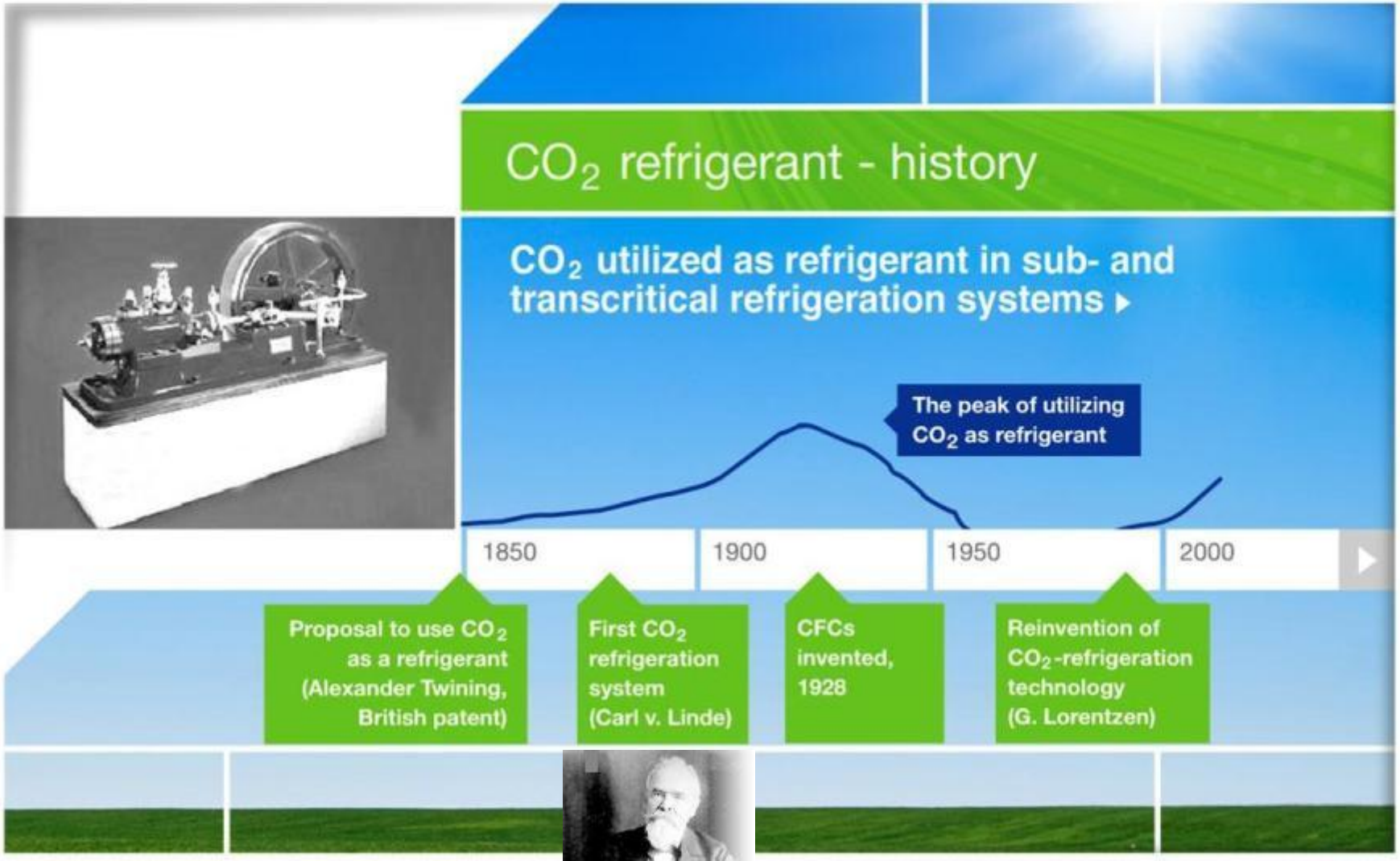
UNEP

FECO

CRAA

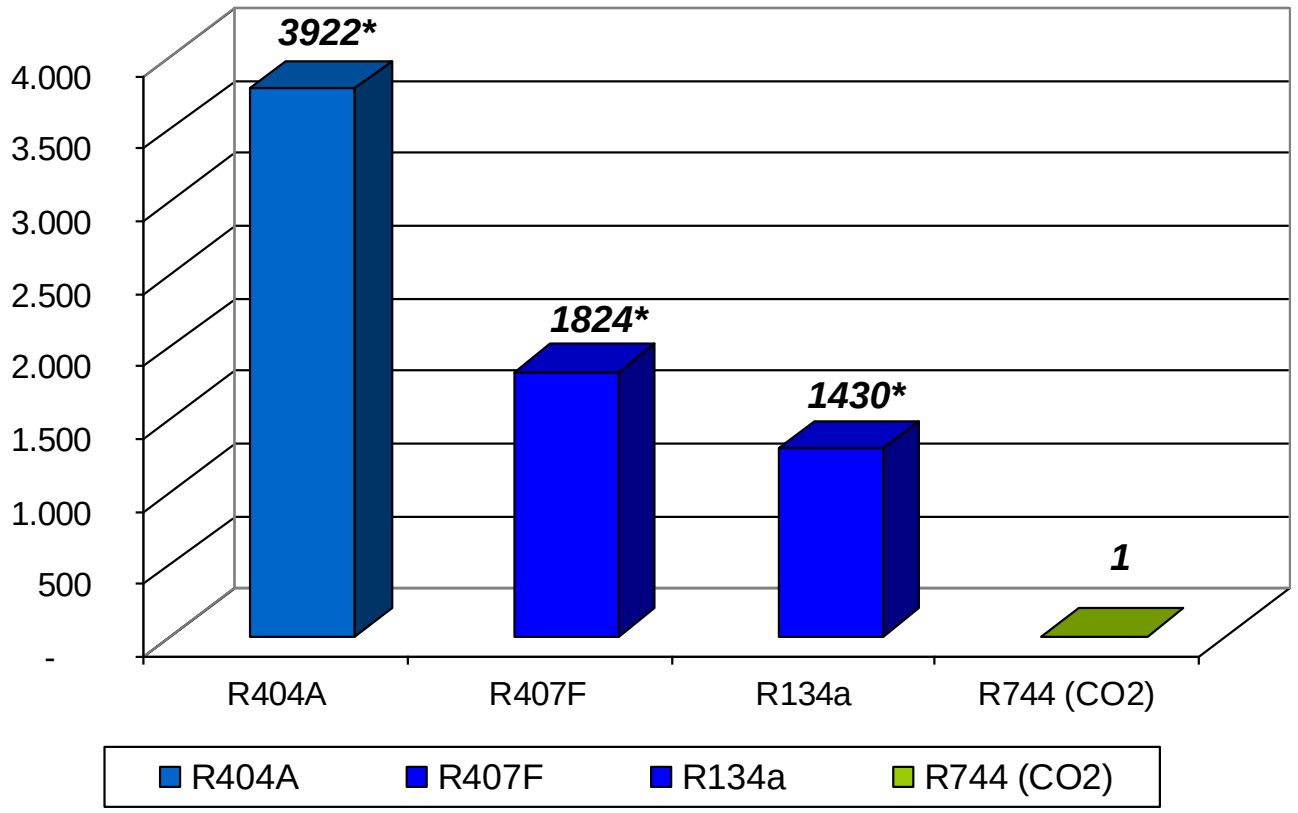
CO_2 TECHNOLOGY EVOLUTION

Invention and reinvention of CO_2 refrigeration technology



CO_2 TECHNOLOGY EVOLUTION

Direct GWP of CO_2 substantially lower

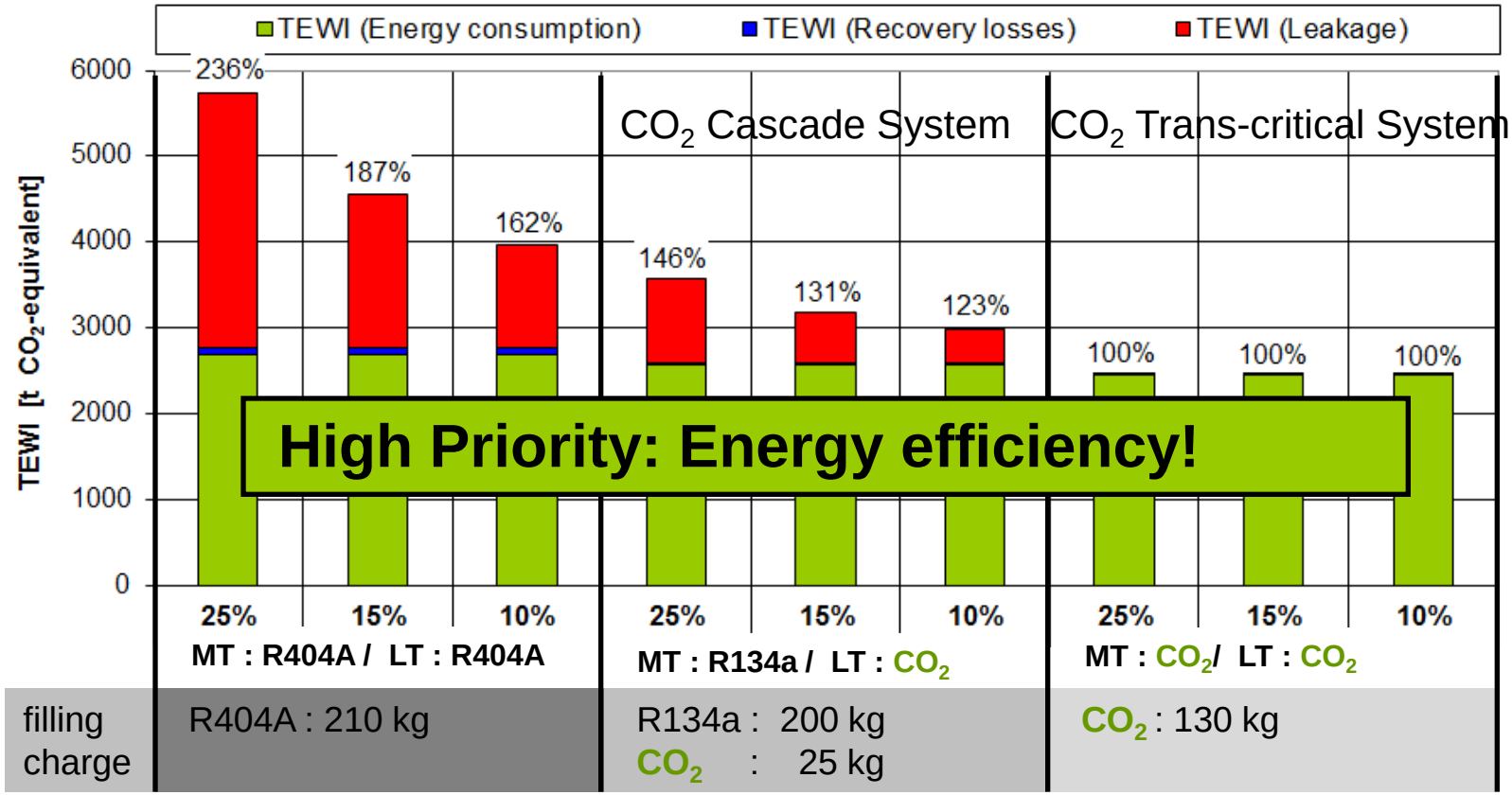


* IPCC AR 4 GWP values

CO_2 TECHNOLOGY EVOLUTION

Total Equivalent Warming Impact of CO_2

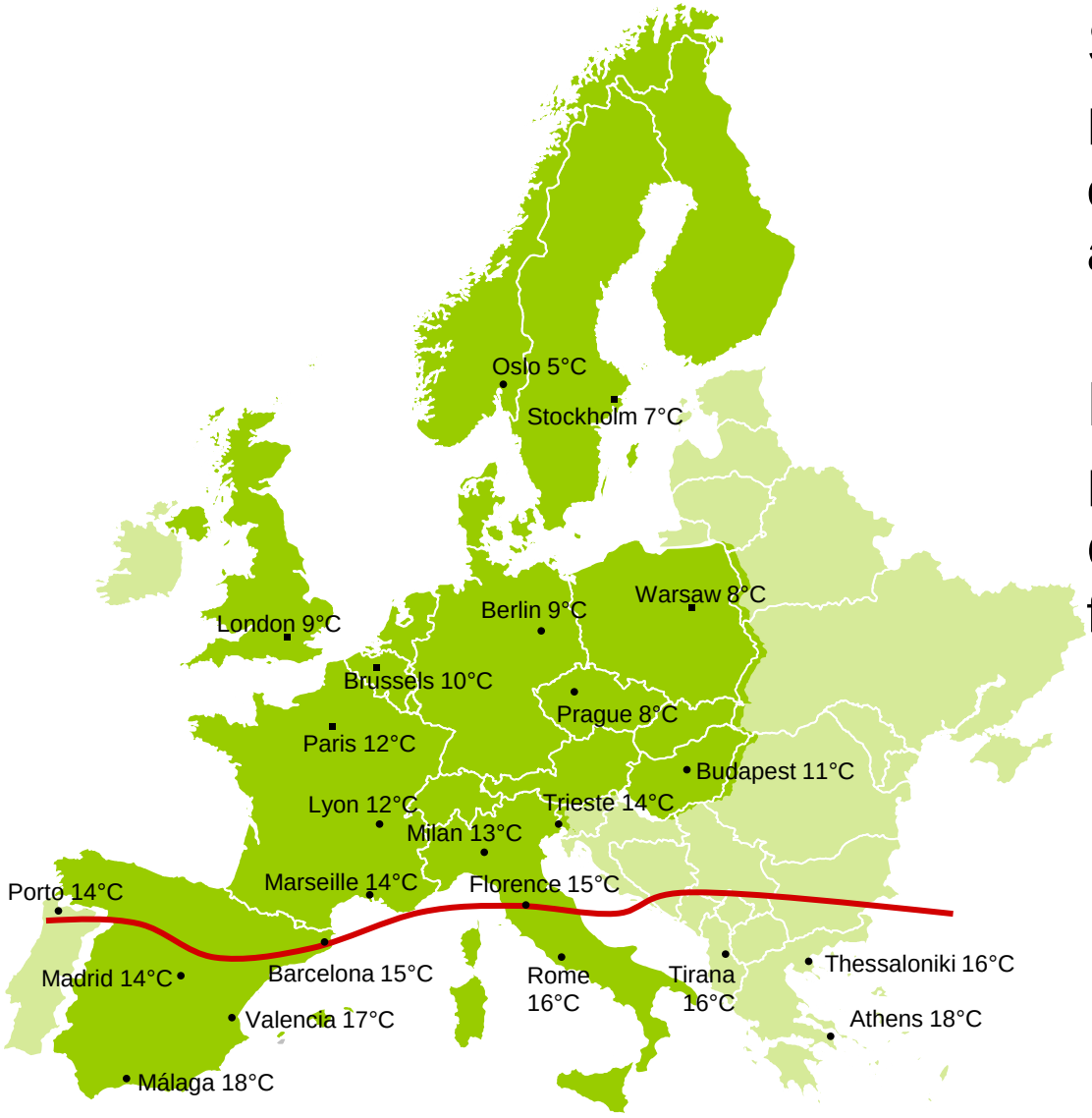
Qo_{MT}=60kW, Qo_{TK}=20kW, 15 years, 25%, 15%, 10% leakage rate
data according mild to cold climates, emission factor (China 2010: 0,77 kg CO2/kWh



Even one breakdown with a total loss of the refrigerant results in an average leakage rate of approx. 7% based on a life cycle of 15 years

CO_2 SYSTEMS FOR SOUTHERN EUROPE

CO_2 trans-critical solutions for warm climates



Standard Efficiency

Proven energy efficiency of trans-critical CO_2 DX systems in cold and moderate climates

High Efficiency Innovation

Next generation of trans-critical CO_2 DX systems developed and field tested for warm climates

Targeting attractive energy performance across all of Europe, eliminating current *"CO_2 equator"*

Source: www.eurometeo.com- yearly climate averages

CO_2 SYSTEMS INNOVATION

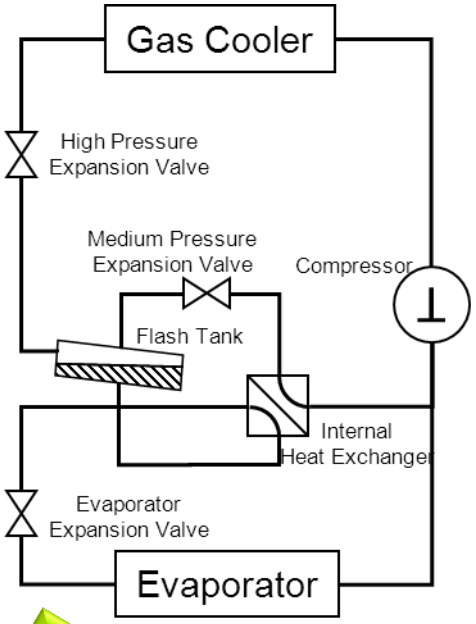
CO_2 trans-critical solutions for warm climates

Installations:

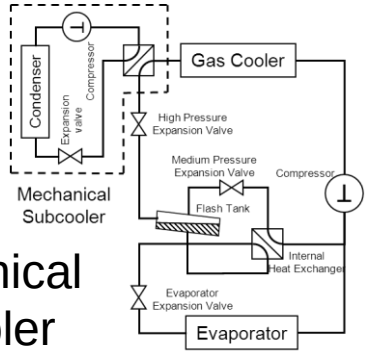
Economizer
Denmark, Germany, Netherlands, Switzerland, Italy and Spain

Mechanical Subcooler
Spain
Portugal (2015)

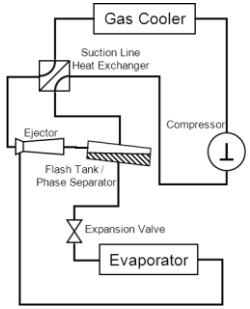
Ejector
Spain



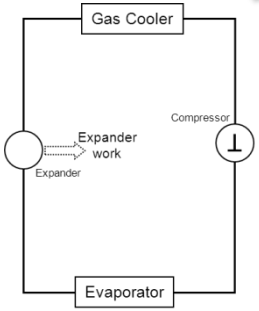
Mechanical Subcooler



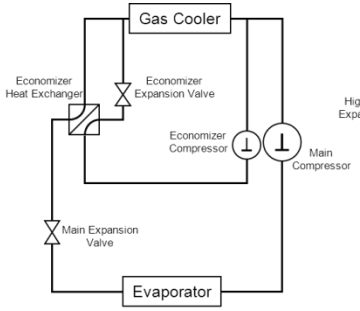
Ejector

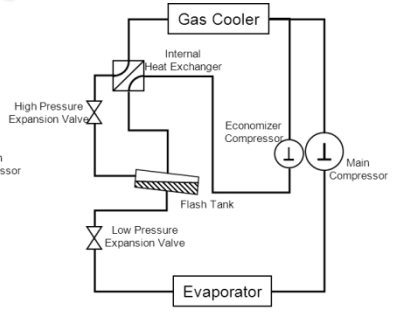


Expander



Economizer





CO_2 SYSTEMS INNOVATION

CO_2 trans-critical system with HC subcooler

Hydrocarbon subcooler add-on to CO_2 trans-critical DX system

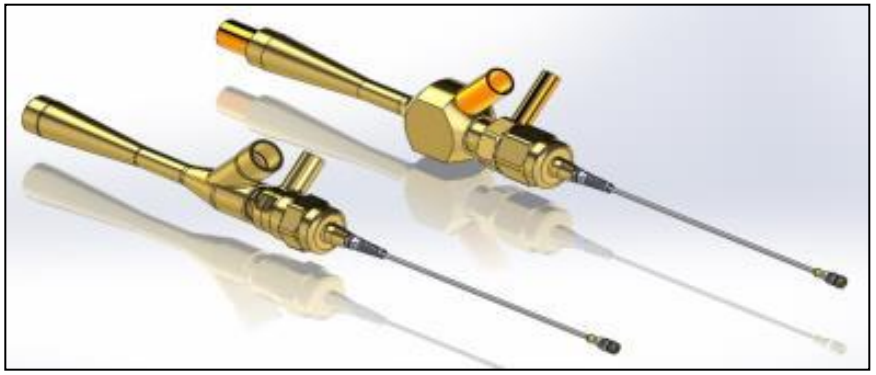
- Location : North-Western Spain
  (further projects in Madrid and South-Eastern Spain installed)
- CO_2 trans-critical booster system with add-on roof-top mounted HC subcooler for warm climates
- MT refrigeration capacity 310 kW
- Commissioning in October 2012

CO_2 SYSTEMS INNOVATION

CO_2 trans-critical system with economizer & ejector

Measuring operational performance, efficiency & reliability

Application:	Food Retail Hypermarket,
Location:	South-Eastern Spain
Total MT capacity:	222 kW
Total LT capacity:	57 kW
Controls:	Carrier PLC rack controller
Commissioned:	October 2014



CO_2 SYSTEMS INNOVATION

CO_2 trans-critical system with economizer & ejector

Preliminary Performance Results

Measurement results for daily energy consumption (24h) during summer operation

Operation with/without ejector for comparison

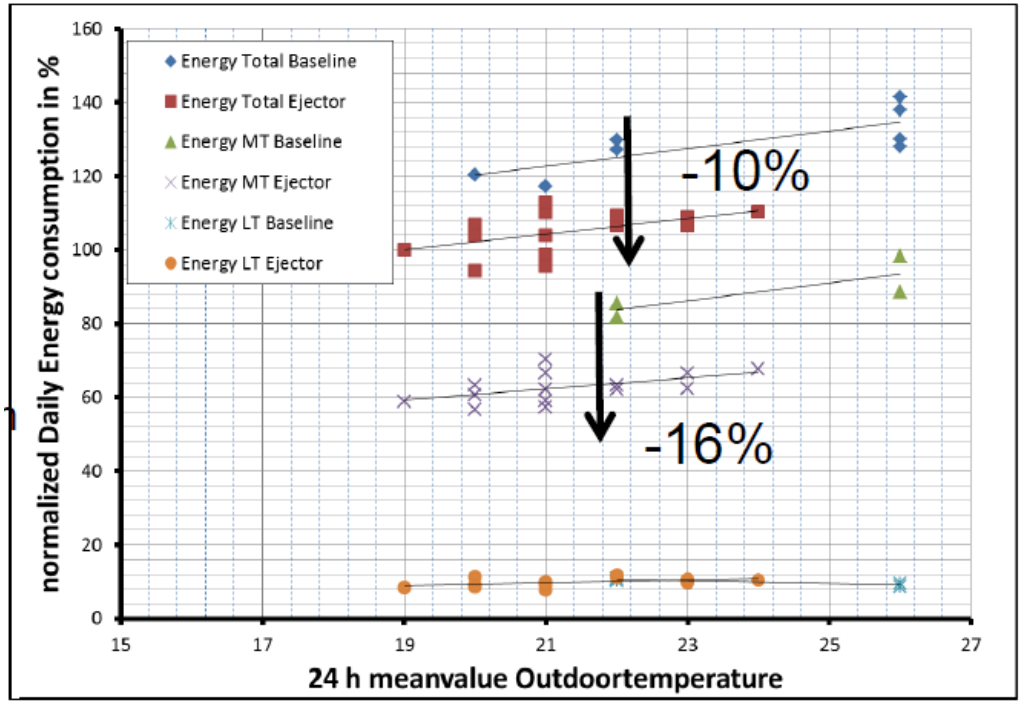
Reduced energy consumption in ejector operation mode:

-16% MT compressor rack

-10% total refrigeration system

(MT rack + LT rack + cabinets lighting/defrost)

Further optimization ongoing



y-axis normalized, Total Energyconsumption Ejector @19°C = 100%

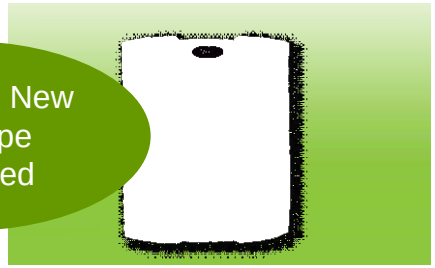
CO_2 TECHNOLOGY EVOLUTION

CO_2 in Commercial and Transport Refrigeration

Commercial Refrigeration market uptake :

1370 trans-critical and 779 sub-critical CO_2 refrigeration system installations in Europe with significant efficiency improvements

Container Refrigeration now commercially available after 2 years of intensive field trials (training, reliability, performance, efficiency)



IAA 2014 : New Prototype presented

Road Transport Refrigeration systems, field trials started in September 2013, new prototype presented at IAA 2014

CO_2 TECHNOLOGY IN EUROPE

Summary

- Natural Refrigeration systems are mainstream technology in Europe
- New EU F-Gas Regulation expected to stimulate further interest
- Market growth for CO_2 systems
- Cost-effectiveness
- Targeted elimination of the "CO_2 equator" across Europe

Xie Xie!

Thank you for your attention!

For further information please visit our website
www.carrier.com

We have the right refrigerant for every application, but every application will not have the same refrigerant solution

Back-Up

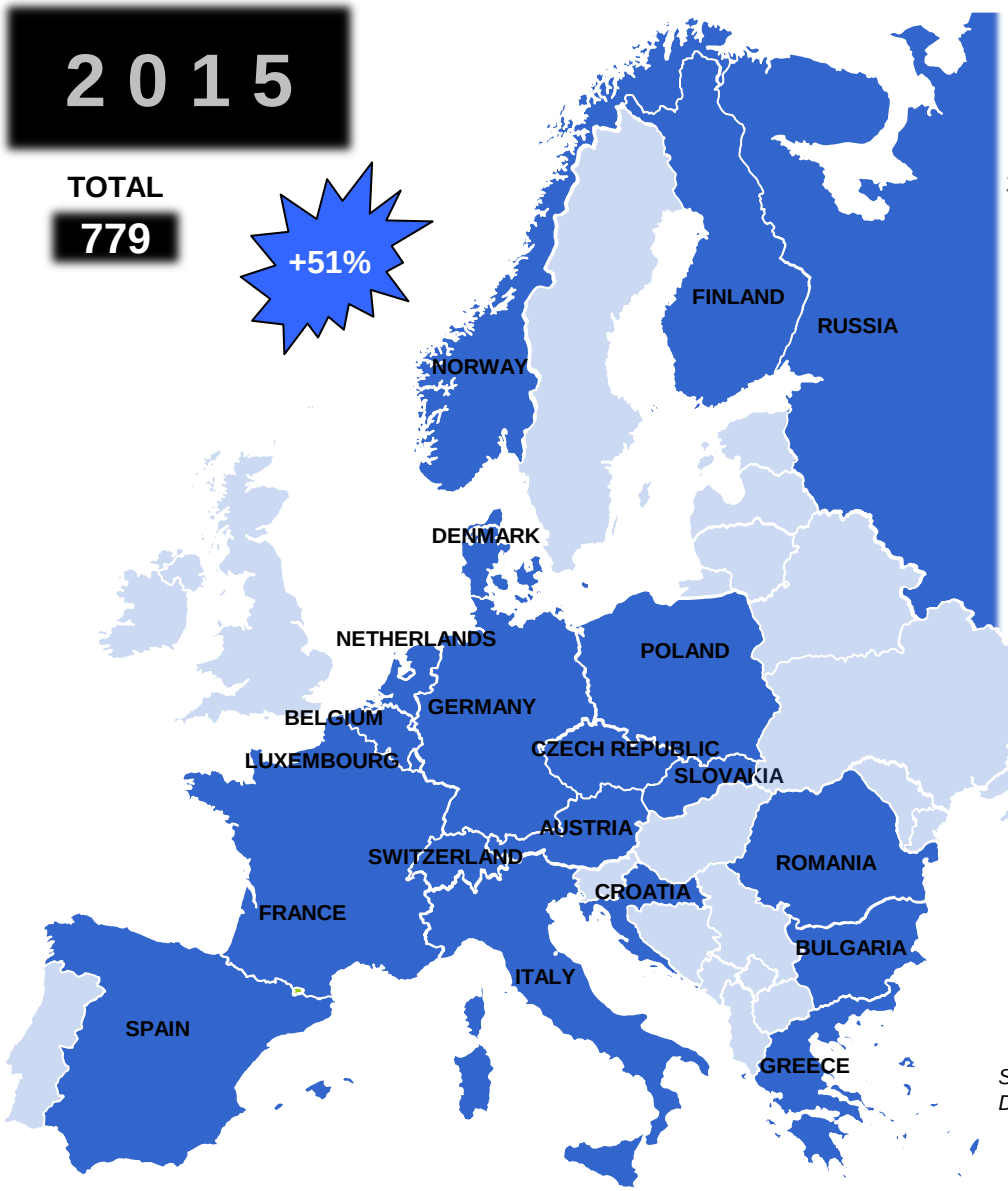
CO_2 FOOTPRINT IN EUROPE

R134a/CO_2 sub-critical installations

2015

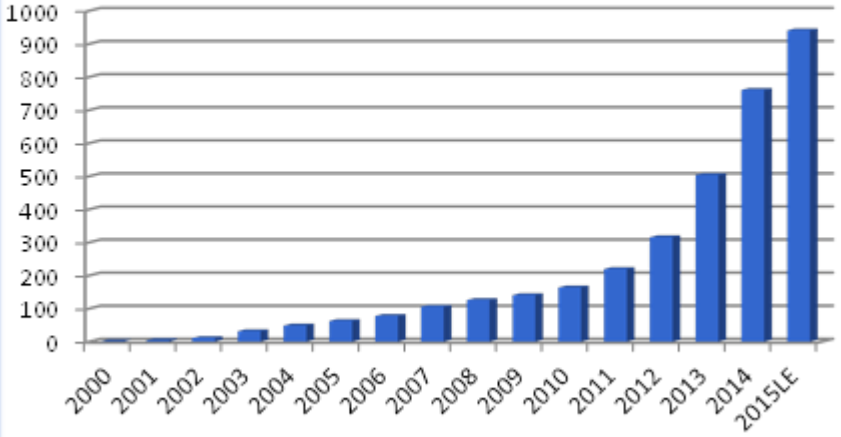
TOTAL
779

+51%



Segment uptake trend

Turnkey stores in operation



Source: Carrier Commercial Refrigeration Europe
Data end of February 2015

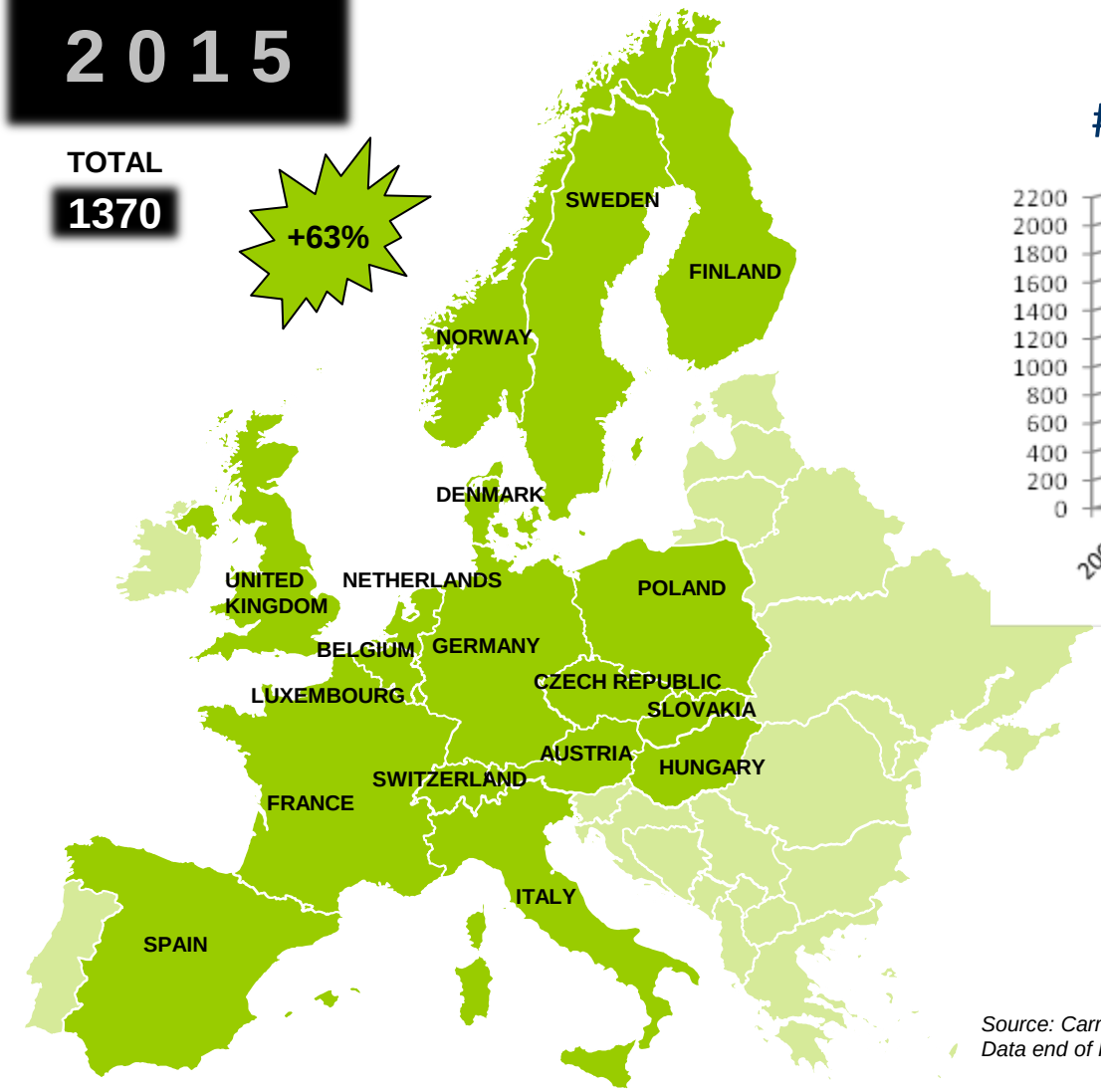
CO_2 FOOTPRINT IN EUROPE

CO_2/CO_2 trans-critical installations

2015

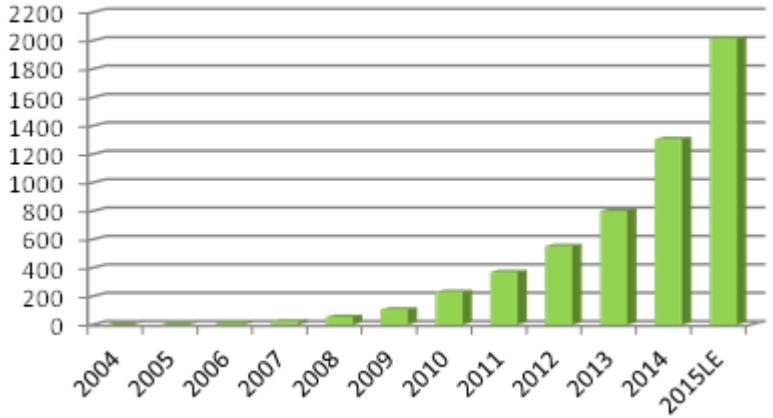
TOTAL
1370

+63%



Segment uptake trend

Turnkey stores in operation



Source: Carrier Commercial Refrigeration Europe
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EU F-GAS REGULATION EU/517/2014

HFC cap and phase-down scheme

Reduction of HFC supply (Annex V)