



COOLING | HEATING SOLUTIONS

PowerCO₂OL

CO₂ TRANSCRITICAL PACK SYSTEMS





HAIER CARRIER

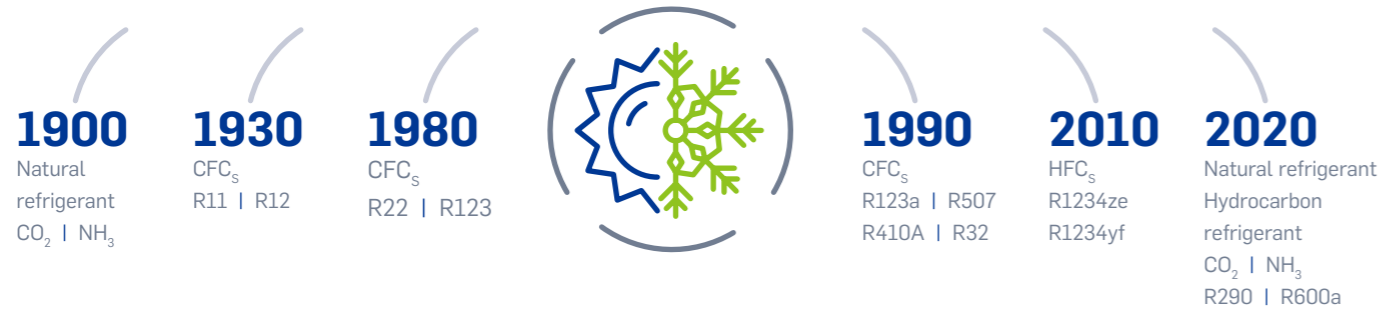
Qingdao Haier Carrier Refrigeration Equipment Co., Ltd. is a joint venture established in 2001 by Haier Group and Carrier. Its products include supermarket display cabinets (more than 1,000 specifications), compressor units (scroll, piston and screw), and heat exchangers (air-cooled condenser and air cooler). It can provide customers with whole sets of freezing and refrigerating solutions. Relying on the support of Carrier Refrigeration's R&D centers in Mainz, Germany and Shanghai, China, the company now has several laboratories. The company is committed to providing energy-saving systems, including carbon dioxide systems, for customers in the Asia Pacific region.

In the past ten years, relying on abundant resources of the parent company, Haier Carrier has become a world-class facility that owns the ISO9001 certification and the ACE certification of United Technologies (Carrier's parent). With strong R&D strength, we are able to provide world-class freezing and refrigerating integrated solutions such as D2D hot gas defrosting (national patent), Ground Water (GSHP) technology dedicated for freezing and refrigerating purposes), HybridCO₂OL (carbon dioxide cascade refrigeration technology), CO₂OLtec (carbon dioxide transcritical refrigeration technology) and POWERCO₂OL (Industrial CO₂ transcritical pack systems).

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Pros of CO₂ Refrigerant



1900
Natural refrigerant
CO₂ | NH₃

1930
CFC_s
R11 | R12

1980
CFC_s
R22 | R123

1990
CFC_s
R123a | R507
R410A | R32

2010
HFC_s
R1234ze
R1234yf

2020
Natural refrigerant
Hydrocarbon refrigerant
CO₂ | NH₃
R290 | R600a

Physical properties and specialties of CO₂ as a refrigerant

- Natural, non-hazardous
- Does not damage the ozone layer ODP=0
- Global Warming Potential GWP=1
- ASHRAE Safety Group A1
- Easy-to-produce refrigerant with cost efficiency



Excellent thermal properties of CO₂

Compressor displacement for the same refrigeration capacity
8%

- Vs. Freon
- High refrigeration capacity per unit volume (heat transfer characteristics)
 - Six-fold refrigeration capacity per unit volume compared to R404A

Suction line size
10%

- Vs. Freon
- Smaller suction line (device footprint)

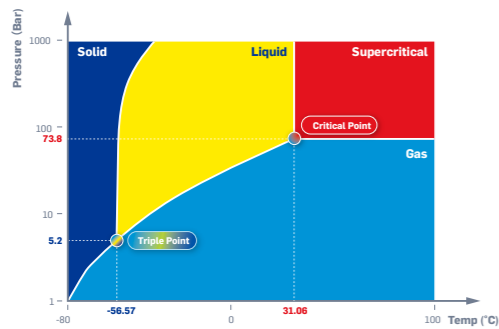
Circulator pump power
10%

- Vs. glycol pump
- Low viscosity (flow characteristics)

Purchase cost
10%

- Vs. Freon
- Low use cost (price)

Phase Diagram of CO₂ Refrigerant

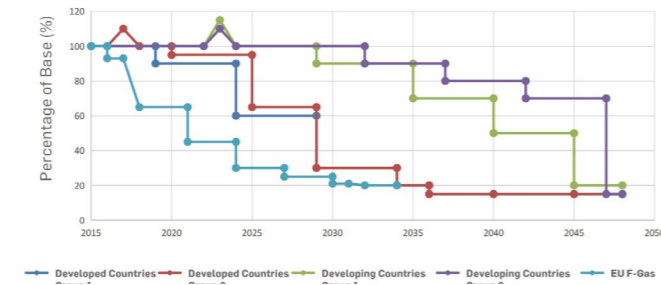


Triple Point Its three phases (gas, liquid, and solid) coexist. Below the triple point, CO ₂ becomes solid, commonly known as "dry ice".	Critical Point No gas or liquid phase. Gases cannot condense above the critical point.	Specialties of CO₂ Refrigerant Low critical temperature High critical pressure
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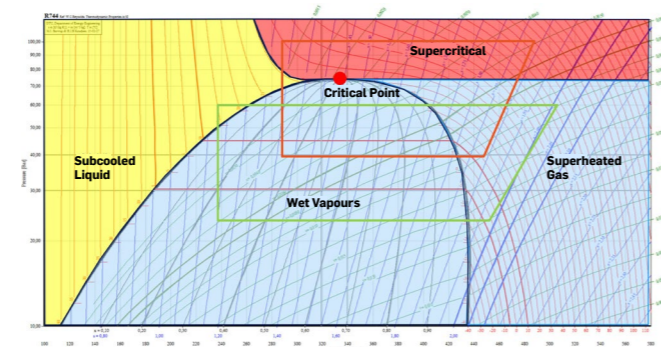
Kigali Amendment

- In 2016, the objective of Kigali Amendment to Montreal Protocol was set to cut the production and consumption of HFCs by more than **80%** over the next 30 years.
- It's the **largest, fastest, safest** short-term climate mitigation initiative in the world.
- By 2050, avoiding up to **0.1°C** of warming.
- By 2100, avoiding up to **0.4°C** of warming.

Kigali Amendment



Pressure-Enthalpy diagram of CO₂ Refrigerant



Subcritical Cycle
The CO₂ condensation temperature < 31°C

Transcritical Cycle
The CO₂ condensation temperature at air cooler outlet > 31°C

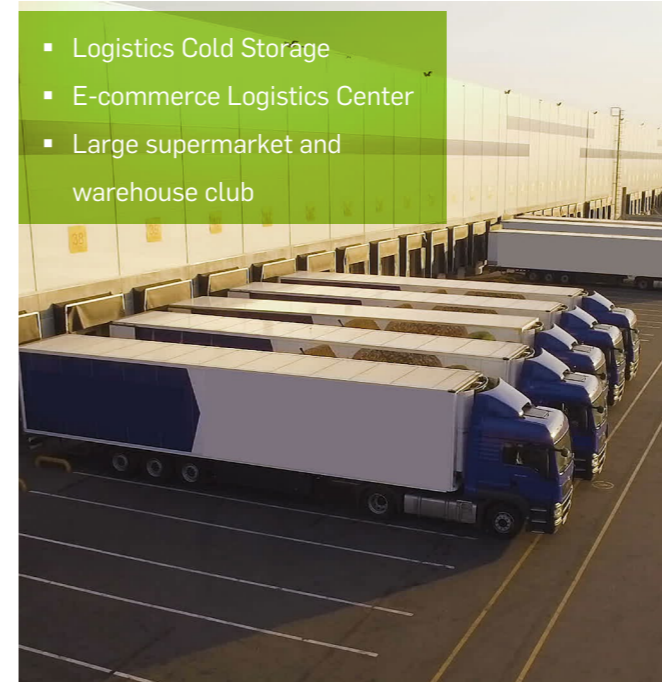
Adopting either subcritical or transcritical operation depends on outdoor gas cooling conditions and unit control.

* Note: enthalpy (the value of a state function that represents the energy of a material system in thermodynamics)

Main Applications

Warehouse & Distribution Centers

- Logistics Cold Storage
- E-commerce Logistics Center
- Large supermarket and warehouse club



Food Processing

- Food processing
- Meat processing
- Fats processing
- Dairy processing



Sport Venues

- Ice rink
- Ski arena



Other Usages

- Domestic hot water
- Distributed heating
- Industrial process heat



Configurations / Temperatures

PowerCO₂OL: a solution adapted to all your needs

MT = Medium Temperature | LT = Low Temperature | DX = Direct Expansion

Configurations	PowerCO ₂ OL MT DX	PowerCO ₂ OL MT Chiller	PowerCO ₂ OL MT+LT DX	PowerCO ₂ OL LT DX	PowerCO ₂ OL MT Chiller + LT DX	PowerCO ₂ OL MT (DX+Chiller) +LT DX	PowerCO ₂ OL Heat pump
Applications	Power 1	Power 2	Power 3	Power 4	Power 5	Power 6	Power 7
Distribution center	✓	✓	✓	✓			
Warehouse	✓	✓	✓	✓			
Hypermarket	✓	✓	✓				
Food processing	✓	✓	✓	✓	✓	✓	
Tunnel freezer			✓	✓			
Heating		✓					✓
Air conditioning		✓					✓
Sport venues	✓	✓					✓
Ice rink	✓	✓					✓
Configuration	Power 1	Power 2	Power 3	Power 4	Power 5	Power 6	Power 7
Cooling capacity MT* (kW)	350-1500	300-1250	350-1100	-	297-920	297-920	411-1172
Cooling capacity LT* (kW)	-	-	117-700	214-700	117-700	117-700	-
Heating capacity (kW)	2200	1950	1650	1350	1400	1400	2100
MT compressors	8	8	6	6	6	6	8
LT compressors	0	0	6	6	6	6	0

* @-6°C(MT)/-32°C(LT)/37°C (gas cooler outlet) for DX configuration
 @-8/-4°C(Chiller)/37°C (gas cooler outlet) for Chiller
 @+4°C(MT)/ 30-85°C Water temp for heat pump configuration

Temperature range

Ambient condition	Gascooler outlet	Evaporating temperature	PowerCO ₂ OL MT DX	PowerCO ₂ OL MT Chiller	PowerCO ₂ OL MT+LT DX	PowerCO ₂ OL LT DX	PowerCO ₂ OL MT Chiller + LT DX	PowerCO ₂ OL MT (DX+Chiller) +LT DX	PowerCO ₂ OL Heat pump	
			Power 1	Power 2	Power 3	Power 4	Power 5	Power 6	Power 7	
-35°C to +43°C	Min: +5°C/40bar Design point: +38°C/97bar Max: +45°C/102 bar	MT	Min.	-20°C	-20°C	-20°C	-20°C	-20°C	-20°C	
			Design point	-4°C	-4°C	-4°C	Optimized by control	-4°C	-4°C	+5°C
			Max.	+4°C	+4°C	+4°C	+4°C	+4°C	+9°C	
		LT	Min.			-45°C	-45°C	-45°C	-45°C	
			Design point			-32°C/-4°C	-32°C/-4°C	-32°C/-4°C	-32°C/-4°C	
			Max.			-20°C	-20°C	-20°C	-20°C	

Rack Configuration



Storage Tank

Ejector

Standard adjustable ejector, improving energy efficiency
 High-pressure power recovery to boost compressor suction pressure

Touch Screen

Compressor

CO₂ Pumps

MT Compressor **3-8** pieces
 LT Compressor Maximum **6** pieces

When the ejector cannot boost the pressure sufficiently under extremely low ambient temperatures, CO₂ pumps will be used to keep the evaporator expansion valve working normally.

Refrigeration Capacity

Maximum **1.5** MW
 Heat recovery Maximum **2.2** MW

All functions are managed through the controller, easy-to-use and flexible.

Applicable Areas

Cold | Mild | Warm | Tropical climate

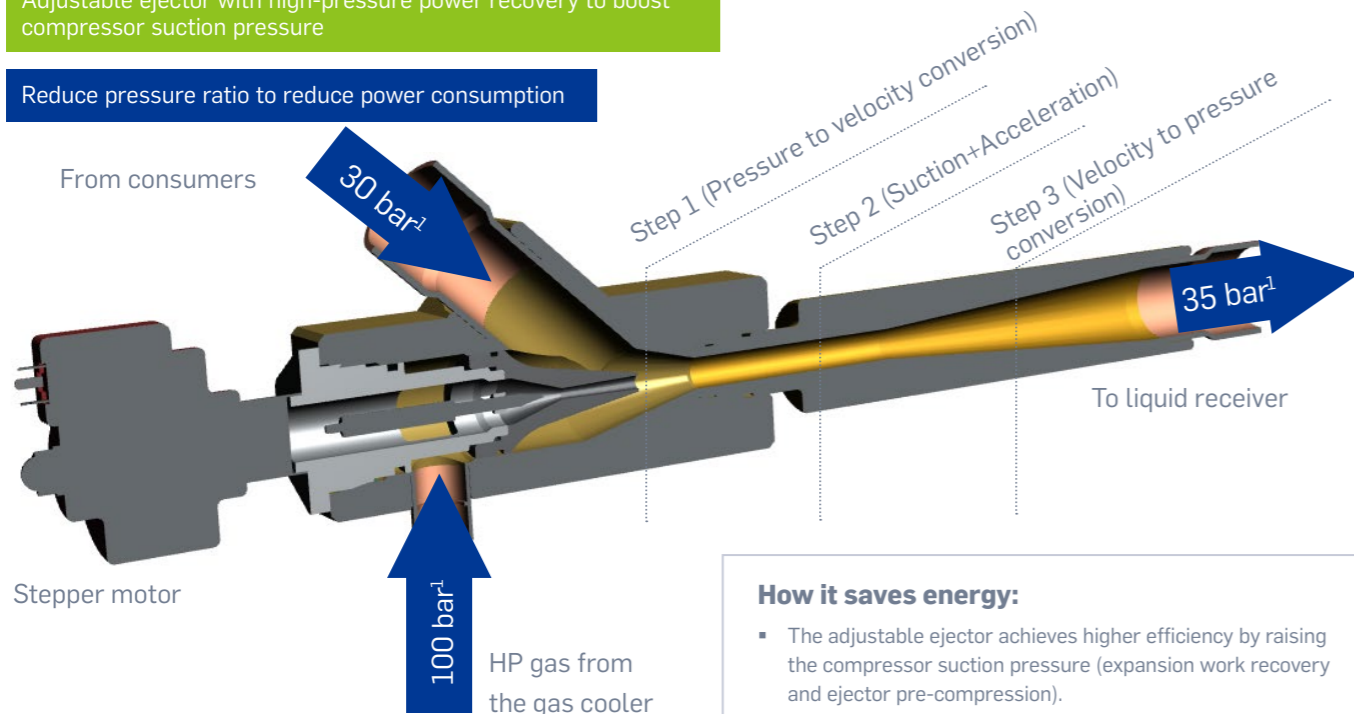
Other Features

- Air cooling or water cooling
- Active oil return management
- Used for air conditioning
- Used as chillers

Patented Vapour Ejector*

Adjustable ejector with high-pressure power recovery to boost compressor suction pressure

Reduce pressure ratio to reduce power consumption



- How it saves energy:**
- The adjustable ejector achieves higher efficiency by raising the compressor suction pressure (expansion work recovery and ejector pre-compression).
 - Integrated heat recovery module: multi-stage heat recovery for multiple application environments
 - Semi-flooded operation mode: high evaporation temperature / less frost on the evaporator
 - Pump as assistance for compensating lower injector pressure boosts in subcritical conditions
 - Controlled by PLC, using proprietary, consistently-optimized control programs

* Patent No.:ZL 2011 8 0068373.7

Customer Value

- Operating mode**
 - One machine with a large capacity
 - The low-temperature refrigeration capacity can reach 700kW, while the medium-temperature refrigeration capacity can reach 1,500kW. (Based on: medium temperature -6°C/low temperature -32°C/air cooler outlet temperature 37°C for direct expansion application)
 - The heating capacity can reach 2,100kW.
 - It can achieve higher capacities by combining units in parallel.
- Multi-level heating**
 - High temperature rise, maximum 90°C per unit
 - A same unit is capable to provide one to three levels of water temperatures.
 - It's compatible with heat sources with low temperatures.

- Improved energy efficiency**
 - The adjustable ejector achieves higher efficiency by raising the compressor suction pressure.
 - Up to a 30% improvement in energy efficiency compared with standard CO₂ systems
- User-friendly and connected control interface**
 - Latest generation of PLC (programmable logic controller) with large touchscreen
 - Embedded communication module
 - Monitoring through webserver and smartphone app
 - Included 4G router for remote commissioning and service

PLC Interface and Electrical Enclosure

Power 3 PowerCO₂ OL MT+LT DX

Power 4 PowerCO₂ OL LT DX

Compressors control

Evaporator control

Ejector control

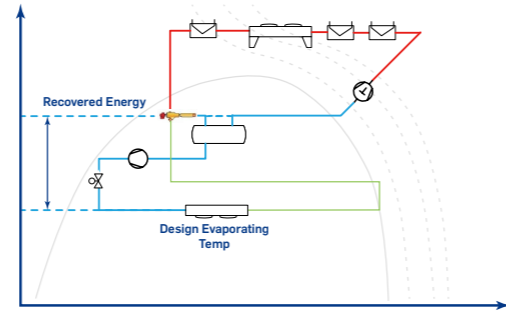
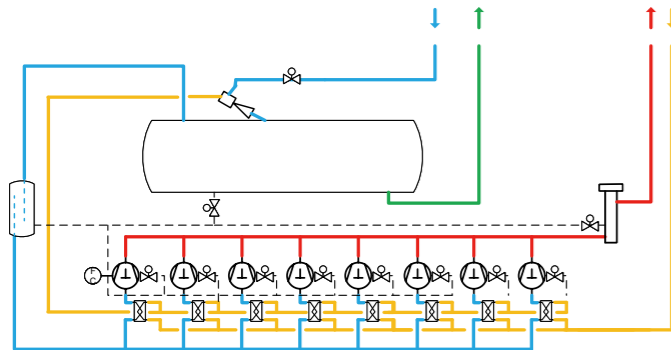
CO₂ pump control

- Electrical cabinet**
- Power supply
 - Contactors
 - Thermal protections
 - Relays
 - Terminal blocks
 - Compressor power and management.
 - Protection by adjustable thermal-magnetic circuit breaker
 - A 400V + N power supply for the gas-cooler box

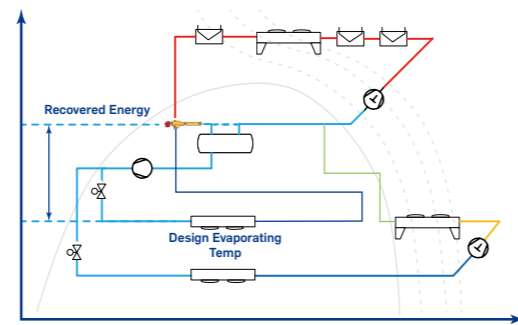
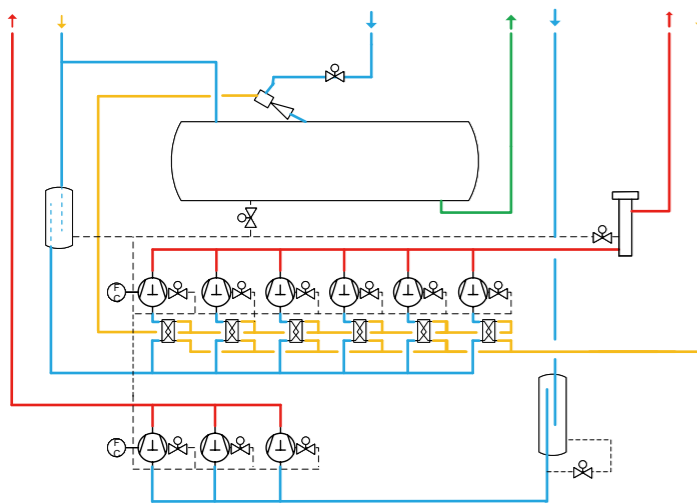
- Control**
- Control units and plant management PLCs
 - Interactive touch screen mounted on the front panel
 - Heat recovery control with control of 3-way valves and control of the pump on the water circuit
 - 0-10V or MODBUS gas cooler fan control

System Types

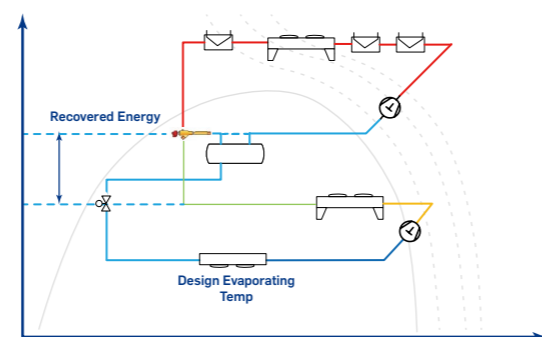
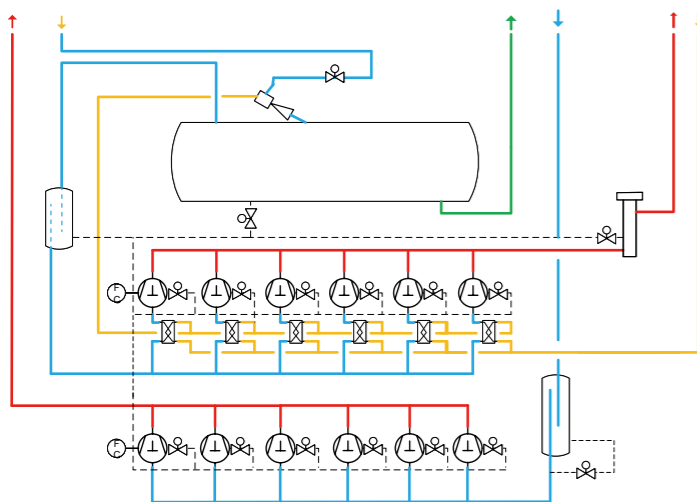
MT Single Evaporation Temperature



MT/LT Dual Evaporation Temperature



LT Single Evaporation Temperature



Heat Reclaim Possibilities

HE10

- High grade heat recovery (sanitary hot water)

HE20

- Medium grade heat recovery (Heating)

HE30

- Air cooled gas cooler

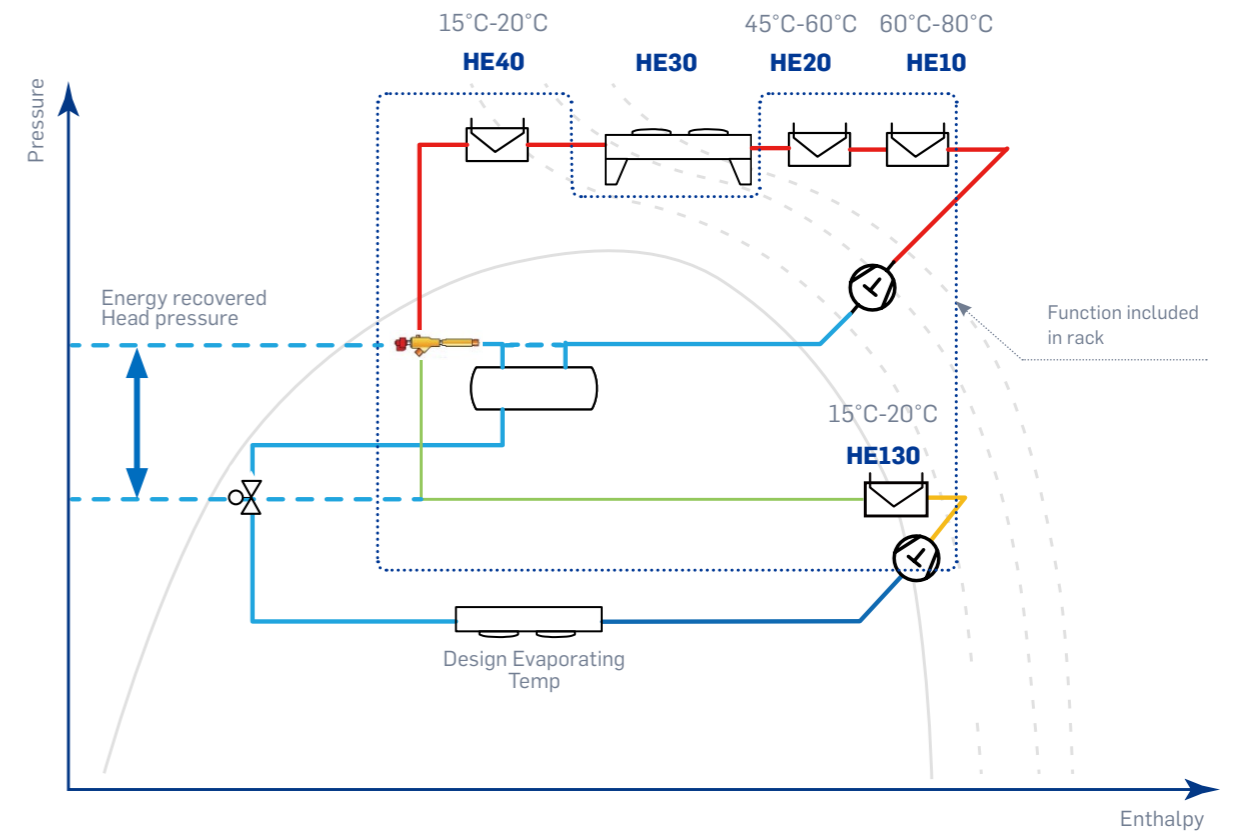
HE40

- Low grade heat recovery (floor heating)

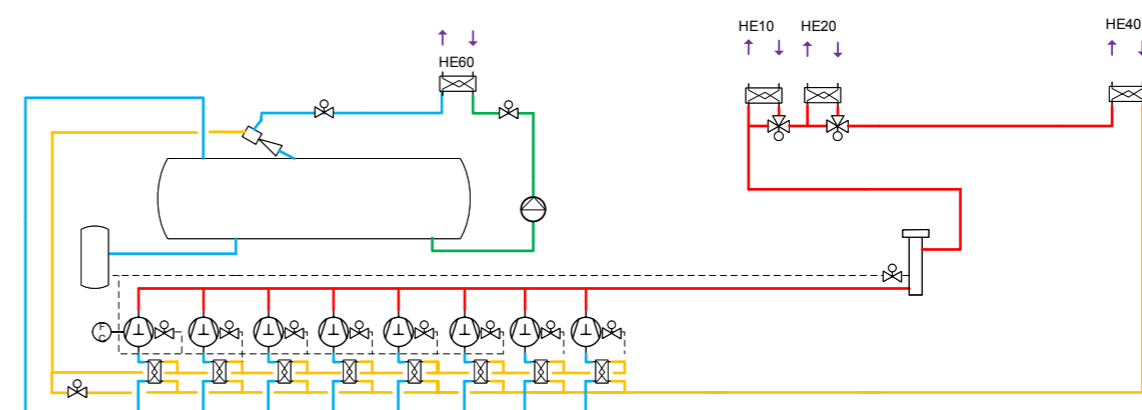
HE130

- Low grade heat recovery (floor heating)

Enthalpy diagram of a heat recovery system



PowerCO₂OL MT Heat Pump



HeatCOOL₂

Smart Heating Production

90°C hot water production

The combination of our technology and CO₂ refrigerant offers a high temperature heat pump capable of delivering hot water up to 90°C. By selecting the HeatCOOL™ system, you can now supplement traditional boilers in applications such as district heating and industrial processes and achieve your decarbonation target.

Up to 4 temperature levels

The various combination of compressors and heat exchangers allow customers to manage 3 different temperature levels simultaneously on the heating side for different applications (for example domestic hot water + floor heating + pool heating) and one level on the cooling side, from air conditioning applications to freezing process applications.

High reliability and peace of mind for our customers

Every HeatCOOL™ heatpump is factory assembled on a dedicated production line, leak-tested and electrical factory tested.

Eligible for financial incentives

Many government environmental programs provide financial incentives for heat pumps to support renewable heat production in the industry, district heating sector, multi-family buildings and natural refrigerant solutions.

Low total cost of ownership

HeatCOOL™ manufacture is based on premium quality components to guarantee an absolute reliability and peace of mind for our customers. During operation, the bearing lifetime of the compressors is 100,000 hours without expensive mechanical revision and oil renewal. In regard to preventive maintenance, the cost of the replacement of components is also limited. Only oil filter, motor expansion valves and liquid line core dryer are periodically reviewed.

Low environmental impact

HeatCOOL™ heatpumps use CO₂, a natural refrigerant, with a GWP = 1 and ODP = 0. In addition, CO₂ is not flammable and non-toxic for the environment. Furthermore, these units are highly efficient as they reach a COP of 5 or more depending on the running conditions. This results in reducing both direct and indirect emissions that contribute to global warming.

Other advantages

HeatCOOL™ have many other advantages to meet every single customer needs and project constraints. It includes:

- Compact design (from 1,000mm wide) to save space into technical rooms.
- Low water temperature on inlet side (down to 15°C) to reach a high temperature lift with one unit (up to 70K lift).
- Several units can be connected in parallel for very large applications.
- Connectivity capability to enable remote monitoring and preventive maintenance operations.



Up to 90°C



Heating & cooling



Full reliability



Financial incentives
& Low total cost of ownership



Low environmental footprint

Temperatures up to 90°C depending on return flow temperature and water quality

HeatCOOL₂

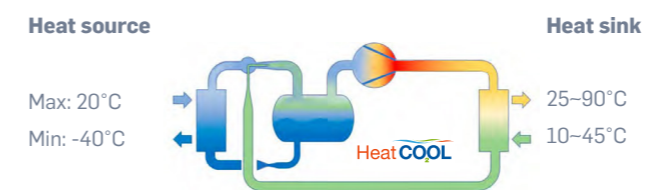
Maximizing performance

The HeatCOOL™ range covers heating capacity from 400kW to 2,2 MW. Units can be placed in parallel to reach higher capacities. The lowest is the heat sink return temperature, the better performance you can reach. To achieve this, you can connect several heating circuits on the same unit.

From 1 hot water circuits to 3

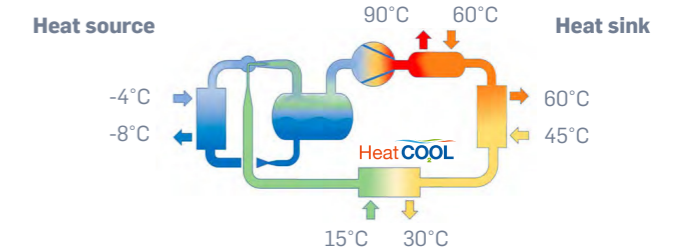
SOLUTION 1

1 heating circuit



SOLUTION 2

3 heating circuits

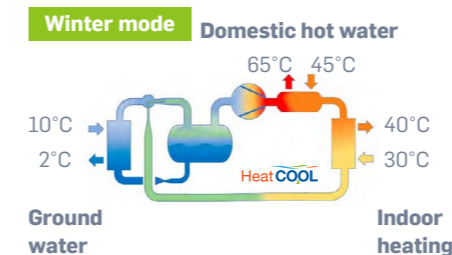


Combining heat source and usages to maximize energy savings

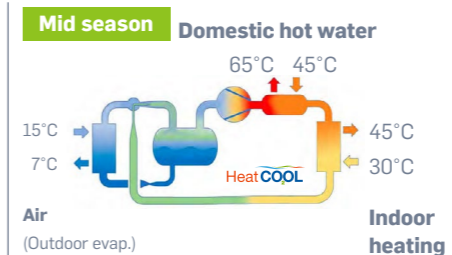
HeatCOOL™ are compatible with a wide range of heat sources and can provide water up to 90°C. Combining heat source, heat usage and cold water usage on same plant will drive annual performance at its maximum.

Example

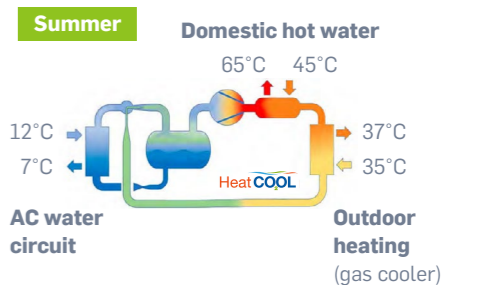
Winter mode



Mid season



Summer



National Speed Skating Oval (The Ice Ribbon)

 **LT** 10~30°C
Anti-freeze floor

 **MT** 30~60°C
Ice melting pool

 **HT** 60~80°C
Domestic hot water | ice pouring truck | high temperature dehumidification

 **CO₂ refrigeration system**
Annual energy saving

Daily Energy Saving
5,500 kW·h

Monthly Energy Saving
160,000 kW·h

Annual Energy Saving
2,000,000 kW·h

 **Project Highlights**

Largest artificial ice surface in Asia

- Ice area 12,000 m²
- Ice areas are refrigerated and controlled separately.
- Realizing "operating together for different usages"

Transcritical CO₂ direct cooling ice making technology

- Applied in Olympic Games for the very first time
- With annual energy saving of about 2 million kW·h.
- "Near-zero" carbon emissions



In 2022, the project "Key Technologies and Applications of Large-Scale CO₂ Refrigeration and its Transcritical Heat Recovery" won the first prize of the **Beijing Science and Technology Progress Award**.

Regional Distribution Center in Finland



 Total floor area
62,000 m²

Freezing and refrigerating area
29,000 m²

 Warehouse height
22 m

 Total storage capacity
1,000,000 m³

 Refrigeration load
2,446 kW @-10°C

Freezing load
810 kW @-34°C

Fast freezing load
240 kW @-48°C



Design Essentials

- The area where the distribution center is located restricts using ammonia as a refrigerant.
- A 1000 m³ water storage tank has been configured as an energy storage device for heating in winter and pre-cooling in summer.
- The design of the heating system fully leverages the heat recovery of the CO₂ system and sets the heat recovery to 2500 kW.
- The distribution center makes full use of green wind and hydroelectric energy with zero carbon emissions.

Compared with distribution centers of the same size,
It saves up to **20%** of energy.





Margarine

A renowned food processing group

Tianjin Guangzhou Shanghai



- The green and environmentally friendly CO₂ refrigerant will not cause pollution to food and processing workshops.
- The cooling capacity per unit volume of CO₂ refrigerant is 5 to 8 times that of Freon and ammonia refrigerants. So, its system pipeline size and floor space are much smaller.
- Its good heat transfer results in faster food freezing, shorter freezing time, and better product quality.



Compared with an ammonia system, the energy consumption per unit product is reduced by approximately

40%



Sam's Club

Beijing Shanghai Fuzhou Nanjing

Total floor area
18,000 m²



Project Challenges

- Huge warehouse area
- Different storage, display and sales needs for frozen, fresh and pre-made meals in different areas
- Decentralized equipment and tons of commodities
- Mostly seafood and meat with high value
- High requirements for temperature stability and energy consumption



Project Outcomes

Compared with traditional systems, this comprehensive solution for heating and cooling saves energy by **25%**

Reduces carbon emissions by **56%**

Reducing carbon emissions of **15,000** tons

CHINASHOP
Golden Wings Awards
Best Fresh Food Supply Chain
Practice List **Selected Cases**



Metro in Chongqing

Customer Value

- The first Ejector+CO₂ Pump all-climate transcritical system in China:
 - Compared with R22, the CO₂ evaporator has higher evaporation temperature.
 - Higher evaporation temperatures for the semi-flooded evaporators
 - Higher evaporation temperatures for the ejector units
- E6 Series Semi-vertical Glass Door Multidecks have higher evaporation temperatures than conventional ones.
- It's automatically controlled by heat recovery three-way electric valve and equipped with a calorimeter.
- A multi-stage frequency conversion compressor
- Energy savings of 20%, and carbon emission reduction of 28% (vs. the prior freon system)



System energy saving vs. R22

Average daily energy saving **15%**

Energy saved per unit meter of cabinets **25%**

Reduced carbon emissions **5,780 tons**
 Reduced carbon emission ratio **28%**



Lawson Store

Customer Value

- The first frost-free cold chain solution model store in China
- Smaller temperature fluctuations
- Better food quality and energy saving
- The actual energy saving of the unit is about 16% (vs. Traditional conversion system from Haier Carrier)

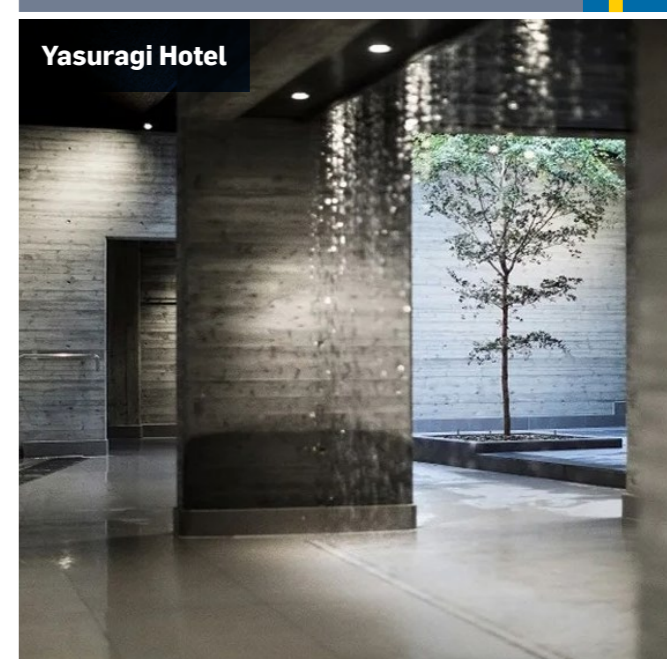


Carrier CO₂ Heat Pump Global Project | Replacement of Boilers

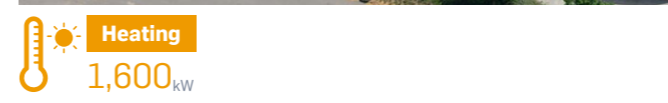
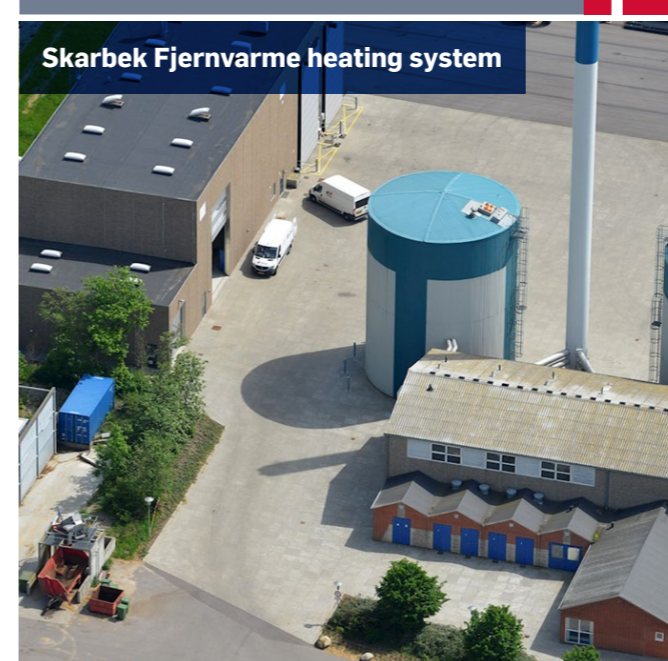
France



Sweden



Denmark

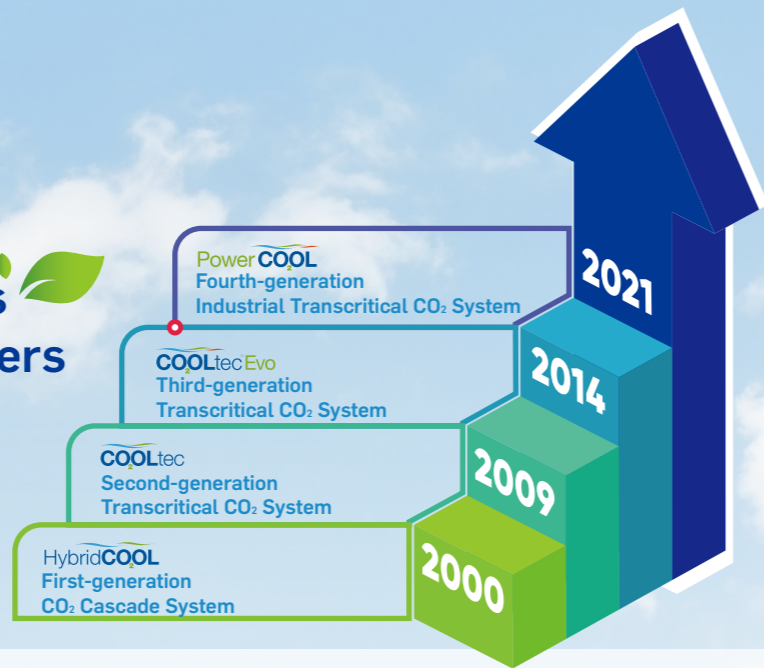


Denmark



Carrier is Committed to Reduce Greenhouse Gas Emissions for Our Customers

2030 Carrier ESG Goal
Reduce customer footprint by over **1 BILLION tons**

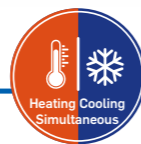
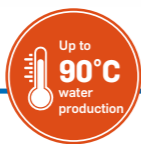


Proven Solutions. **COOLING | HEATING** Sustainable. Efficient.



1 KW~1.5 MW full cooling capacity multi-industry CO₂ total solution
More than **20,000+** successful applications worldwide

Our Solutions



Chillers, racks and heat pumps



Condensing Units



Air coolers



Gas coolers & Condensers

NOTES



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