We built the first CO$_2$ supermarket in the Middle-East.
Our goal: promoting green refrigeration together with saving resources.
Your goal: growing your business.
Let's do it together.
By choosing green refrigeration technologies you can increase your business opportunities and gain better visibility.

Make it happen.
Do you know you can grow your business whilst improving the world? By investing in green refrigeration technologies you can help reducing the world food waste by 40% and benefiting from energy savings at the same time. Investing in our planet’s future means investing in your future.
We analyzed the state of the art of refrigeration systems. We carefully studied every single component. And we brought to life an innovative and sustainable design for the cold chain that UNIDO will bring to the Middle East, Asia, Latin America and Africa.

Unthinkable? It could be your business.
Inefficiencies are resources-wasting practices. Energy consumption can be optimized by an efficient cold chain and new refrigeration technologies that substantially reduce the need for maintenance and repair. Our vision: eliminating waste and reducing energy and management costs.

Tomorrow? Right now.
UNIDO, CCAC and the Ministry of Environment of Jordan, in partnership with innovative national and international technology providers, commissioned the first transcritical CO$_2$ supermarket in the Middle East.

MAIN PROJECT FACTS
- Donor: Climate and Clean Air Coalition (CCAC).
- GOV partner: Ministry of Environment, Jordan.
- Full replacement of HCFC-22 installation in a supermarket.
- Experiences and results disseminated throughout Jordan, other countries with high ambient temperatures and international community.
- Total budget: US$ 605,000.

PROJECT SITE & TECHNOLOGY
- Selected system: State-of-the-art CO$_2$ transcritical system with parallel compressors and multi-ejector (for higher system efficiencies in high ambient temperature operation conditions).
- Selected beneficiary: AlSalam supermarket in Amman.
- Selected technology provider: cabinets and installation 100% from Jordan, in partnership with leading European manufacturer.
PROJECT RESULTS AFTER ONE YEAR OF OPERATION

- 20% energy reduction (compared to the previous HCFC system).
- Food loss: 0 (food spoilage due to unstable refrigeration was a big problem for the supermarket before).
- Maintenance cost: 0.
- Feedback from supermarket & suppliers: extremely positive.
- Closure time in supermarket during installation: 0.

Comparison between HCFC system and newly installed transcritical CO₂ system in Amman, Jordan.
How to save energy without wasting resources? How to protect the environment and developing your business?

A more sustainable food cold chain: this is what our planet needs to light ON again.
CO₂ FEATURES
- Natural working fluid: carbon dioxide - CO₂.
- Environmental friendly > no unforeseen environmental impact in the future.
- Non-flammable.
- ODS: 0.
- GWP: 1 (CO₂ is the reference fluid = 1).
- Excellent fluid properties related to heat transfer.
- Predictable and future-proof, compliant with all future international agreement.
- Widely available in every market.
EJECTORS enable expansion work recovery & working principle: high pressure fluid enters the nozzles where pressure energy is converted to kinetic energy. Fluid at low pressures is sucked into the mixing chamber where the two streams are mixed and momentum exchange takes place. The pressure increases in the diffuser as the velocity of the stream decreases.

MULTI EJECTOR
- Fixed geometry at various capacity steps (1-2-4-8-8-8).
- Applied as high pressure control device.
- Supports operation of parallel compressor.
- Enables to operate cabinets without superheat all year.
ENERGY EFFICIENT DESIGN
• Non superheated operation of evaporators all year.
• Able to operate at high evaporation temperatures (LT @ -25 °C; MT @ -2 °C).
• Glazed doors.
• Efficient defrost.
R744 COMPRESSOR PACK

**CO₂ BOOSTER TECHNOLOGY**
One refrigeration unit (and single working fluid = CO₂) for both the freezing (LT) and chilling (MT) part of the system.

**HIGH ENERGY EFFICIENCY**
- Parallel compression.
- Inter-cooling after LT compressors.
- Integration of Multi-Ejector.

Maximum reliability and maintainability.
ENERGY EFFICIENT GAS COOLERS

- Heat recovery to produce domestic hot water (up to 90 °C water temperature).
- De-superheating after low temp. compressors.
- Power adapted main gas cooler, able to achieve a 2K temperature difference at the refrigerant outlet side.
Adjusts the parameters to operate the unit at high energy efficiency.
Safe mode operation under all circumstances.

**MONITORY SYSTEM**
- Enable energy efficient operation modes.
- Outputs are key performance indicators (energy demand, pressure levels and stability of cabinet temperatures).
INTEGRATION OF AIR CONDITIONING

- Reduces service and maintenance costs.
- One refrigerant for the entire heating and cooling system.
- Efficient utilization of parallel compressors.
- Option A: new installation > direct air cooling devices inside the shop.
- Option B (as shown): > chilled water production.

AC SYSTEM

Kindly provided by Enex
### TECHNICAL FACTSHEETS

**DIFFERENCES OF A CO₂ SYSTEM TO A STANDARD SYSTEM**

| **HIGH PRESSURE WORKING FLUID** | Low critical temperature: 31.1 °C  
High critical pressure: 73.8 bar  
Triple point at 5.18 bar & -56.6 °C  
Evaporation: 10-40 bar  
Heat release: 65-130 bar |
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| **HIGH PRESSURE, HIGH DENSITY, LOW ($Δt/Δp$)** | Small dimension on pipes, valves for gas/two phase/liquid  
NO SUPERHEAT IN HEAT EXCHANGERS |
| **REFRIGERANT CO₂**           | Use special refrigerant CO₂ or CO₂ of purity class 4.5  
(max. 5 ppm of moisture) |
| **LOW PRESSURE RATIO GOOD THERMO PHYSICAL PROPERTIES** | > High compressor efficiency  
> Efficient heat transfer in heat exchangers |

Consequence: transcritical operation at elevate ambient temperatures.  
Properties of CO₂ are unique and in favour for refrigeration and heat pumping applications.

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**HEAT REJECTION AT GLIDING TEMPERATURE IN CO₂ SYSTEM**

- **1) INLET COMPRESSOR**  
- **2) INLET GAS COOLER**  
- **3) OUTLET GAS COOLER**  
- **4) INLET EVAPORATOR**

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CO\(_2\) MULTI EJECTORS FOR HOT CLIMATES

MULTI EJECTORS
- Liquid (flooded evaporators)
- Vapour (boost parallel compressors)

ALWAYS FLOODED EVAPORATORS
> +10\% in COP

PRESSURE LIFT
10-15 bar

COP INCREASE
Of up 17\%

EJECTOR EFFICIENCY
Of 30\% under optimum operational conditions.

WHY EJECTOR?
- WORKS LIKE A “JET PUMP”
- ‘FREE’ PRESSURE LIFT
- NO MOVING PARTS
  high RAM* values
- BERNOULLI’S PRINCIPLE
  *When the speed of a fluid increases its pressure decreases and vice versa.*
  High pressure fluid enters the nozzle \((A)\) where pressure energy is converted to kinetic energy. Fluid at low pressures \((B)\) is sucked into the nozzle and the two streams are mixed. The pressure increases in the diffuser as the velocity of the stream decreases.

RAM* = Reliability Availability and Maintainability

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![Diagram of CO\(_2\) Multi Ejectors](diagram.png)
MEASURED PERFORMANCE AT ALSALAM SUPERMARKET ON A HOT DAY

**PART A**

Ambient temperature and corresponding high side pressure of the CO₂ refrigeration unit. Stable pressure levels for the low temperature and medium temperature suction lines. Intermediate temperature represents suction pressure of the parallel/auxiliary compressor.

**PART B**

Air/Cabinet temperatures (1 & 8) and evaporation temperature (average value around -2 °C) for the medium temperature suction group.

**PART C**

Applied compressor capacities related to the total installed compressor capacities (auxiliary and medium temperature).
Cabinet temperatures (1 & 8) and evaporation temperature (average value around -2 °C) for the low temperature suction group.

Applied compressor capacities related to the total installed compressor capacities (low temperature).