

High
Efficiency
Solutions.



CAREL



25 & 26 June - Atlanta, Georgia

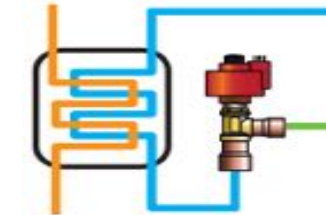
DC waterloop systems
in commercial refrigeration:
the new frontier for natural refrigerants

Tommaso Ferrarese
26th June 2015

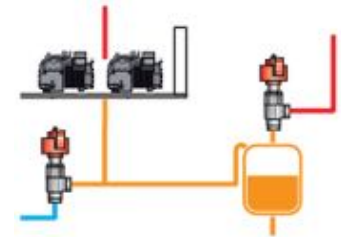
Energy efficiency in CO₂ systems



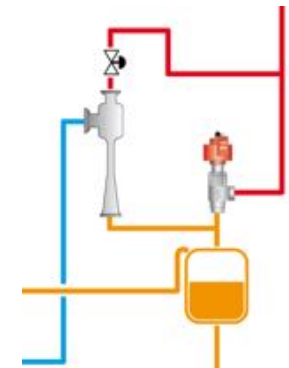
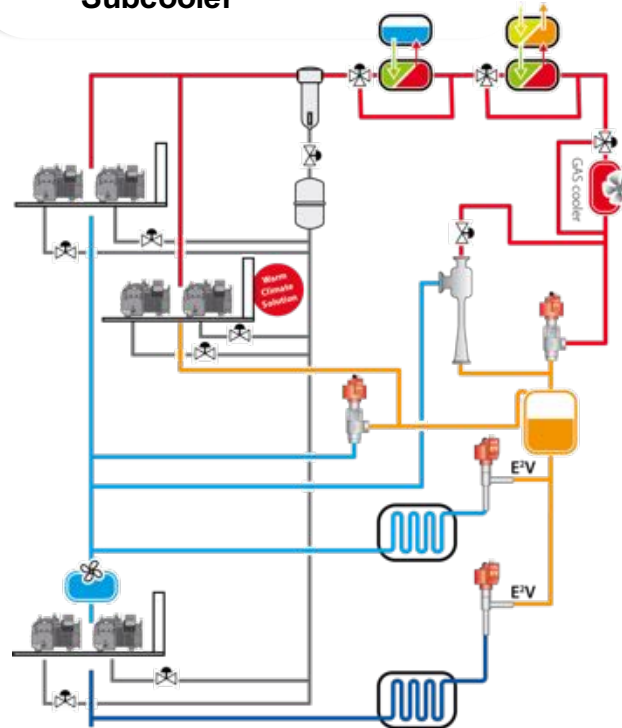
Evaporative cooling



Subcooler



Parallel compression



Ejectors



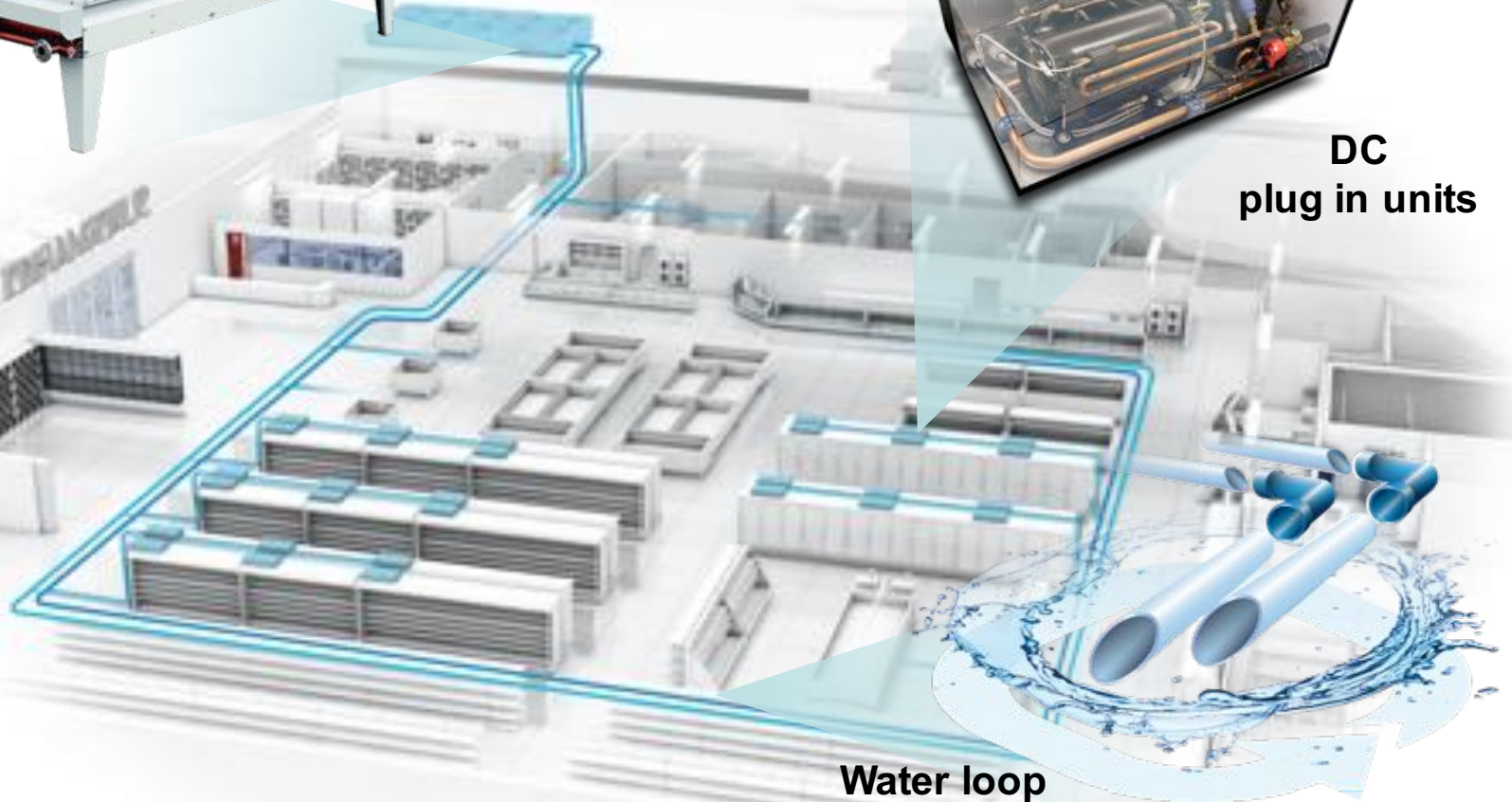
Heat Reclaim & AC integration

DC compressor waterloop systems

Dry cooler



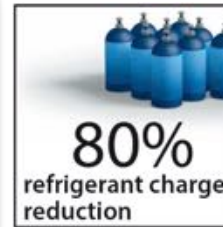
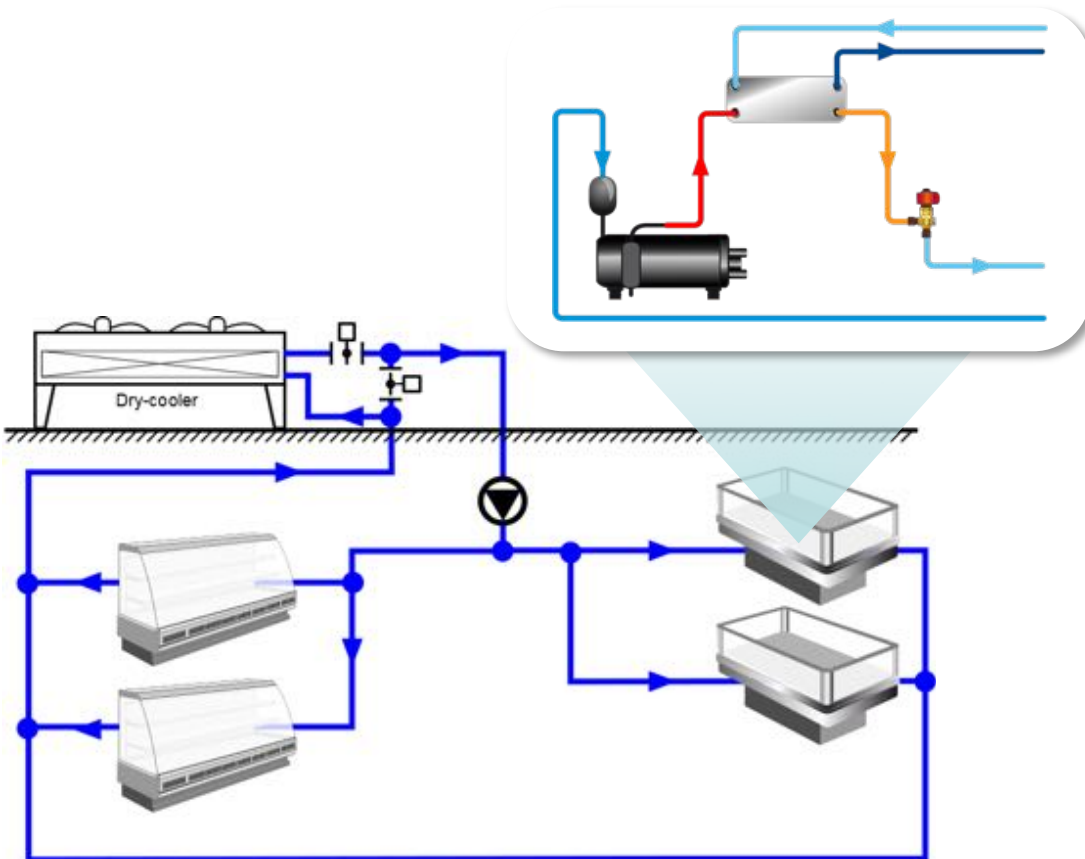
DC
plug in units



Water loop

DC compressor Waterloo systems

Plug-in units with DC inverter compressor and water condenser on-board connected with a water loop system for condenser heat management



- No long copper pipes
- No comp rack and receivers
- 1-2kg refrigerant charge for cabinets



- From «multiplexed systems» 10-15% to «integral cabinets» 1-2%
- No welding on the field
- Factory tested units

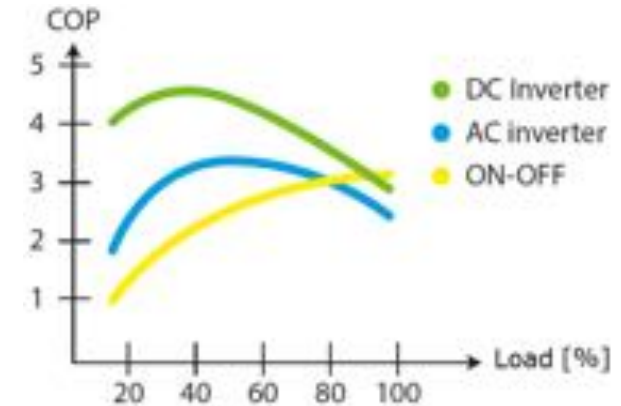


- High efficiency DC compressors
- Individual evap. temperature
- Fully controlled performances

DC compressor Waterloo systems

ENERGY EFFICIENCY

- All units always at their best working condition
- Wide modulation range and energy efficiency at part load
- Optimum food temperature control
- Full control of the units: preventive diagnostic and maintenance



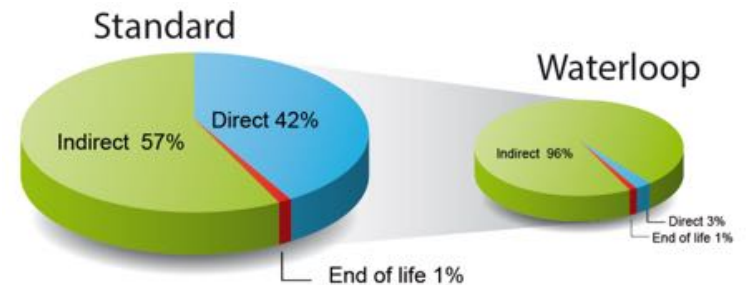
FLEXIBILITY

- Easy layout change and showcases repositioning
- Wider sales area, less space needed for machine room
- High investment recovery in store relocation
- Low installation and maintenance cost



ENVIRONMENT RESPECT

- Charge reduction **80%**
- Leaks reduction **96%**
- 96% Direct effect reduction
- Almost 50% TEWI reduction (HFC)

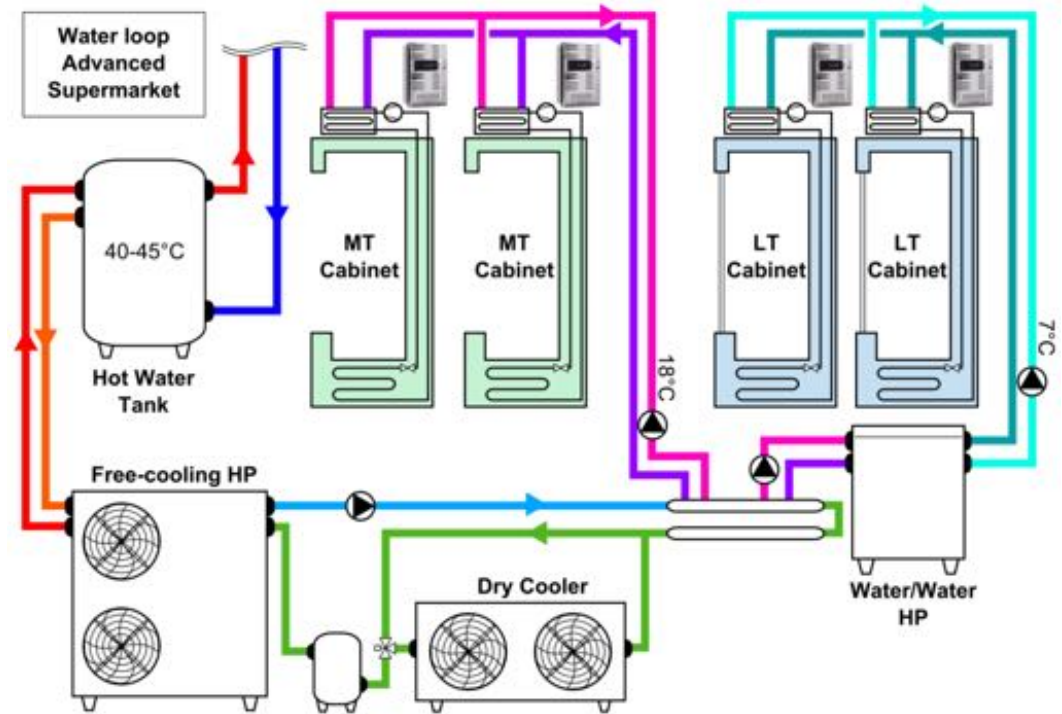


Field experiences

First trial done in 2012 – Bologna (IT)

- 10 LT cabinets (29 kW);
- 28 MT cabinets (63 kW);
- Sales area: 10.000 ft²;

R404A horizontal scroll compressors
Dry cooler, air chiller,
heat pump for heat reclaim



Results presented on

- Refrigerazione a basso effetto serra. Tendenze verso la sostenibilità (AiCARR, November 2012) - **Vicenza (IT)**
- Coolenergy.dk exhibition 2013 - **Odense (DK)**
- XV European conferenc on technological innovations in refrigeration (CS Galileo, June 2013) – **Milano (IT)**
- 3rd International conference on sustainability and cold chain (IIR, June 2014) - **London (UK)**
- Recenti sviluppi nella tecnologia dei compressori frigoriferi e loro impatto sulla efficienza stagionale delle macchine frigorifere (AiCARR, february 2015) **Vicenza (IT)**

Field experiences



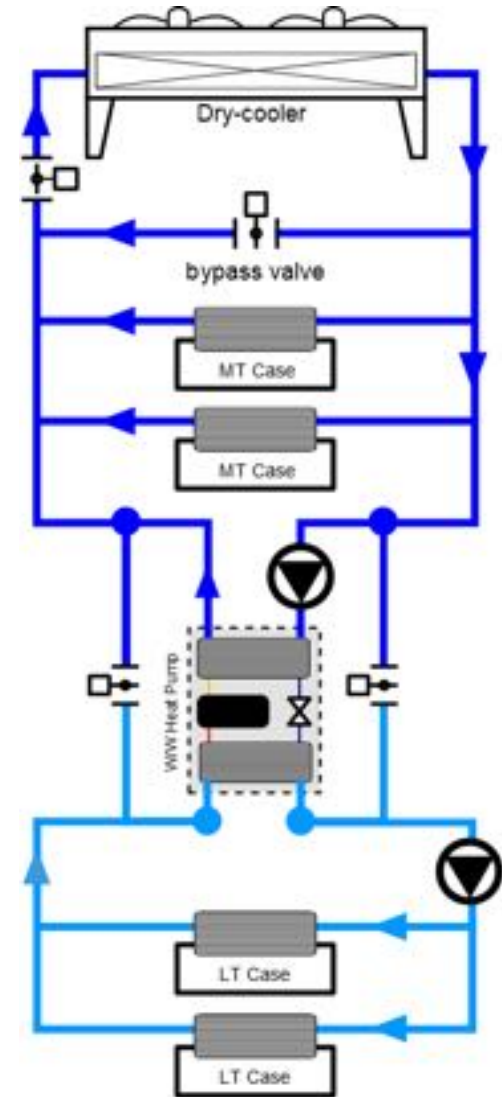
Supermarket Bologna Italy

Field experiences

2014 roll out with best in class configuration

- R410A refrigerant (GWP: 2088)
- Freecooling on MT units
- LT units
 - Freecooling with liquid injection (high discharge temperature)
 - LT loop chiller (W/W or A/W chiller)

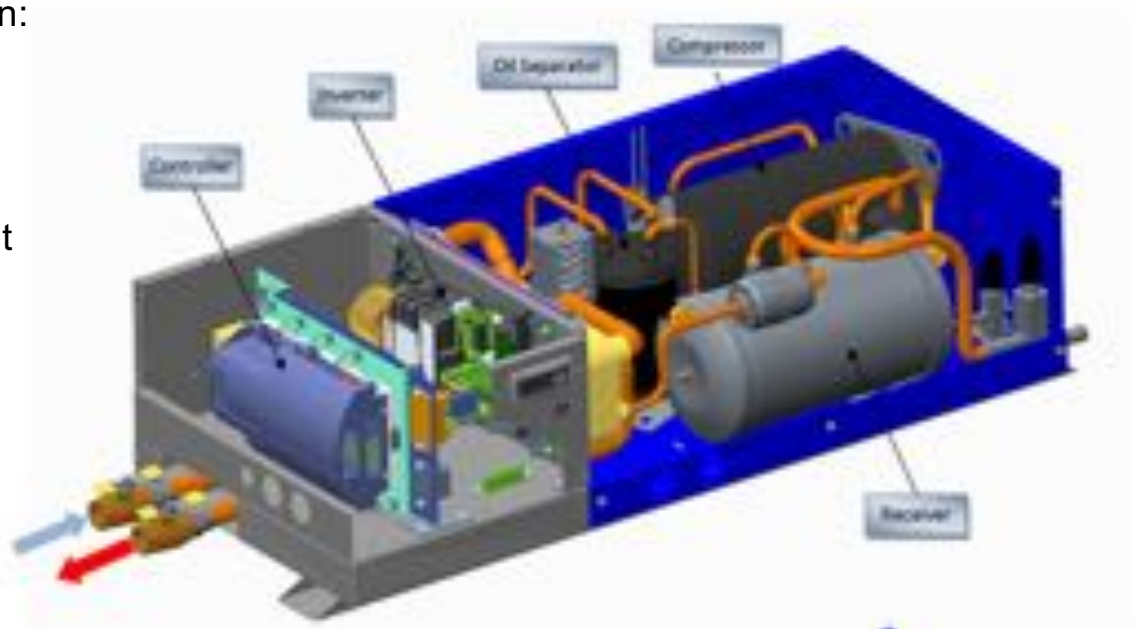
Deployment on going in Europe, USA, Australia.



USA Field Experience

First Installation Q4 2015

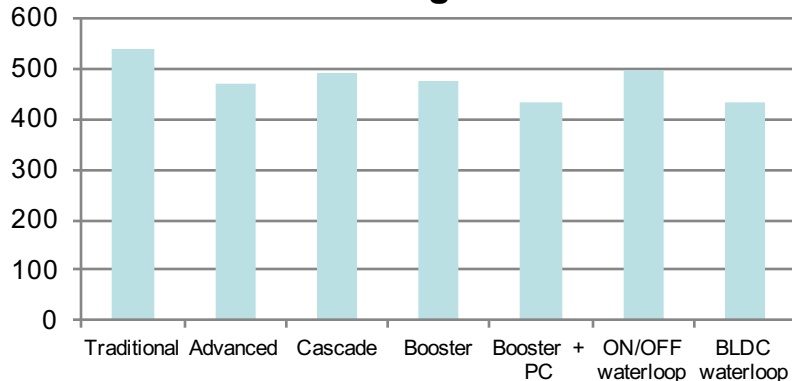
- Case manufacturer and installation:
Hillphoenix
- 77 MT cases
 - Single evaporator
 - Multievacaporator management
- 33 LT cases
 - Liquid injection
- Single waterloop circuit
 - BAC Cooling Tower
- Sales area: 90,000 ft²
- R410a Toshiba horizontal compressors



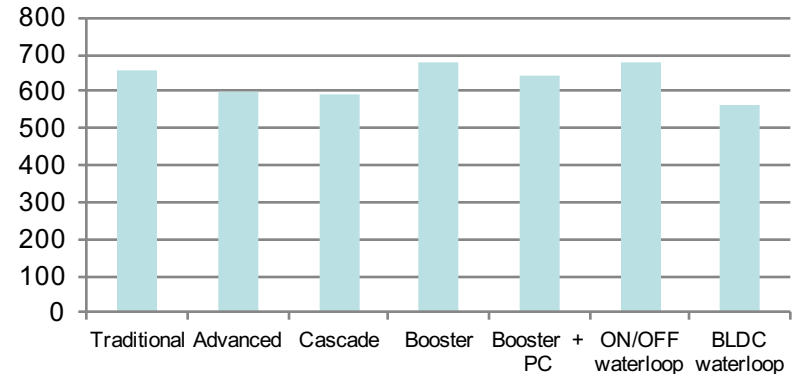
Energy consumption analysis

| Technology | Refrigerant | Chicago (IL) | | Seattle (WA) | | Atlanta (GA) | | San Antonio (TX) | |
|------------------|-------------|--------------|--------|--------------|--------|--------------|--------|------------------|--------|
| | | Energy | DC WL | Energy | DC WL | Energy | DC WL | Energy | DC WL |
| | | [MWh/yr] | saving | [MWh/yr] | saving | [MWh/yr] | saving | [MWh/yr] | saving |
| Traditional | R404A | 539 | 25% | 544 | 19% | 598 | 20% | 655 | 16% |
| Advanced | R404A | 468 | 9% | 460 | 0% | 533 | 7% | 598 | 6% |
| Cascade | R134a/CO2 | 491 | 14% | 494 | 8% | 544 | 9% | 595 | 6% |
| Booster | CO2 | 473 | 10% | 481 | -5% | 577 | 16% | 678 | 21% |
| Booster + PC | CO2 | 431 | 0% | 450 | -8% | 525 | 5% | 644 | 14% |
| ON/OFF waterloop | R410A | 496 | 15% | 544 | 19% | 583 | 17% | 675 | 20% |
| DC waterloop | R410A | 430 | | 458 | | 498 | | 563 | |

Chicago



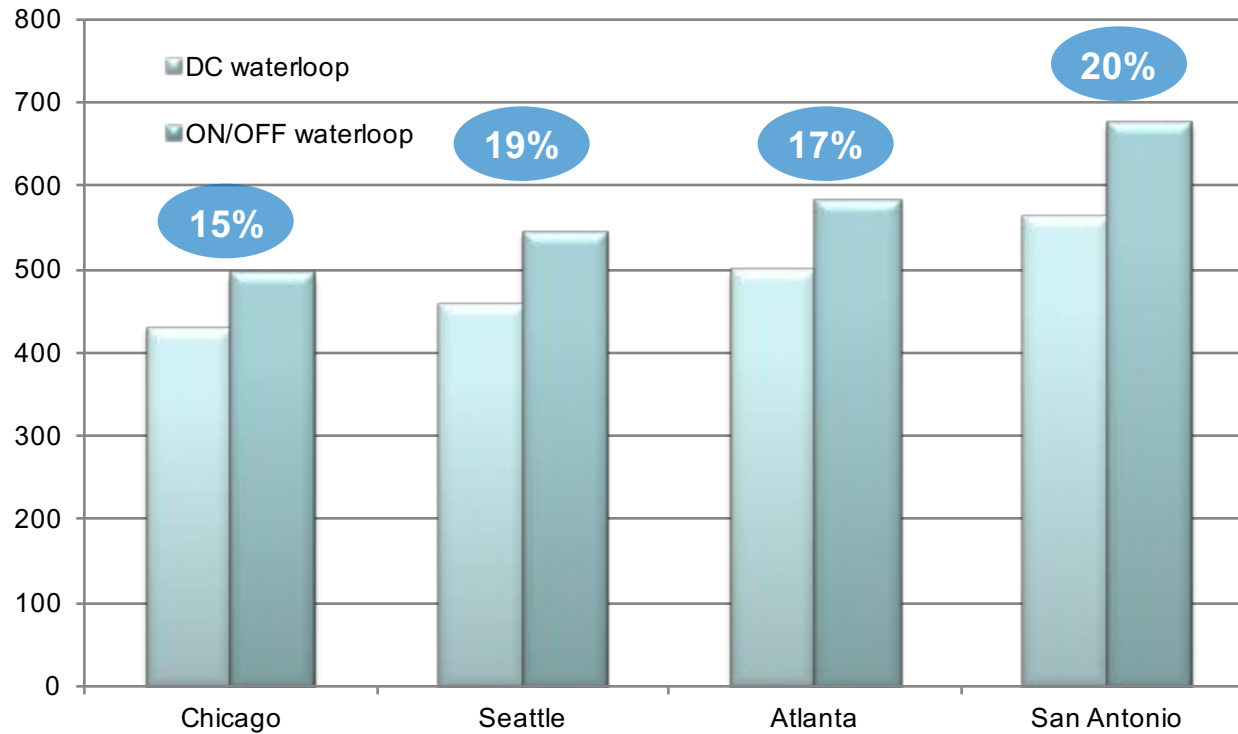
San Antonio



All data are related to 180kW MT, 50kW LT supermarket in different weather conditions

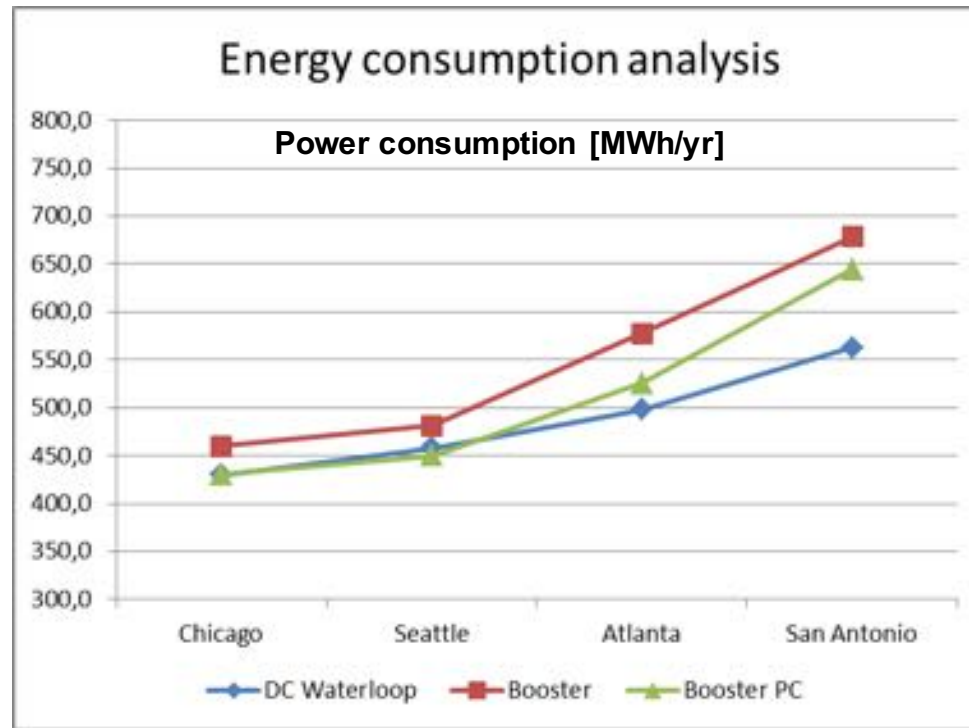
Energy consumption analysis

Power consumption [MWh/yr]



| | Chicago (IL) | Seattle (WA) | Atlanta (GA) | San Antonio (TX) |
|---------------|--------------|--------------|--------------|------------------|
| DC | 430 | 458 | 498 | 563 |
| ON/OFF | 496 | 544 | 583 | 675 |

Energy consumption analysis



| Type | Refrigerant | Chicago | Seattle | Atlanta | San Antonio |
|--------------|-------------|---------|---------|---------|-------------|
| DC waterloop | R410A | 430 | 457 | 498 | 563 |
| Booster | R744 | 460 | 481 | 577 | 678 |
| Booster PC | R744 | 431 | 450 | 525 | 644 |

Natural refrigerants in DC waterloop systems

PROPANE

PRO

- High efficiency refrigerant
- Standard working pressures
- Ideal for small units

CONS

- Flammability
- Missing legislative uniformity at EU and local level
- EN378, EN60079, ATEX EU Dir.
- 150g now enough for supermarket showcases
- High investment for units production/testing

CO₂

PRO

- Well accepted from the market
- Overcomed worries on pressures and usability
- Innovation trends ongoing

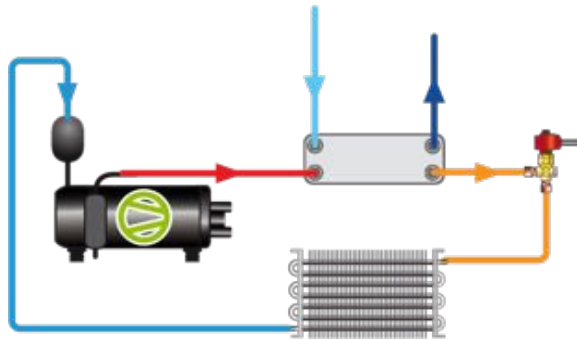
CONS

- Low efficiency in warm climates
- Expensive low capacity high pressure components
- Missing wide compressors range

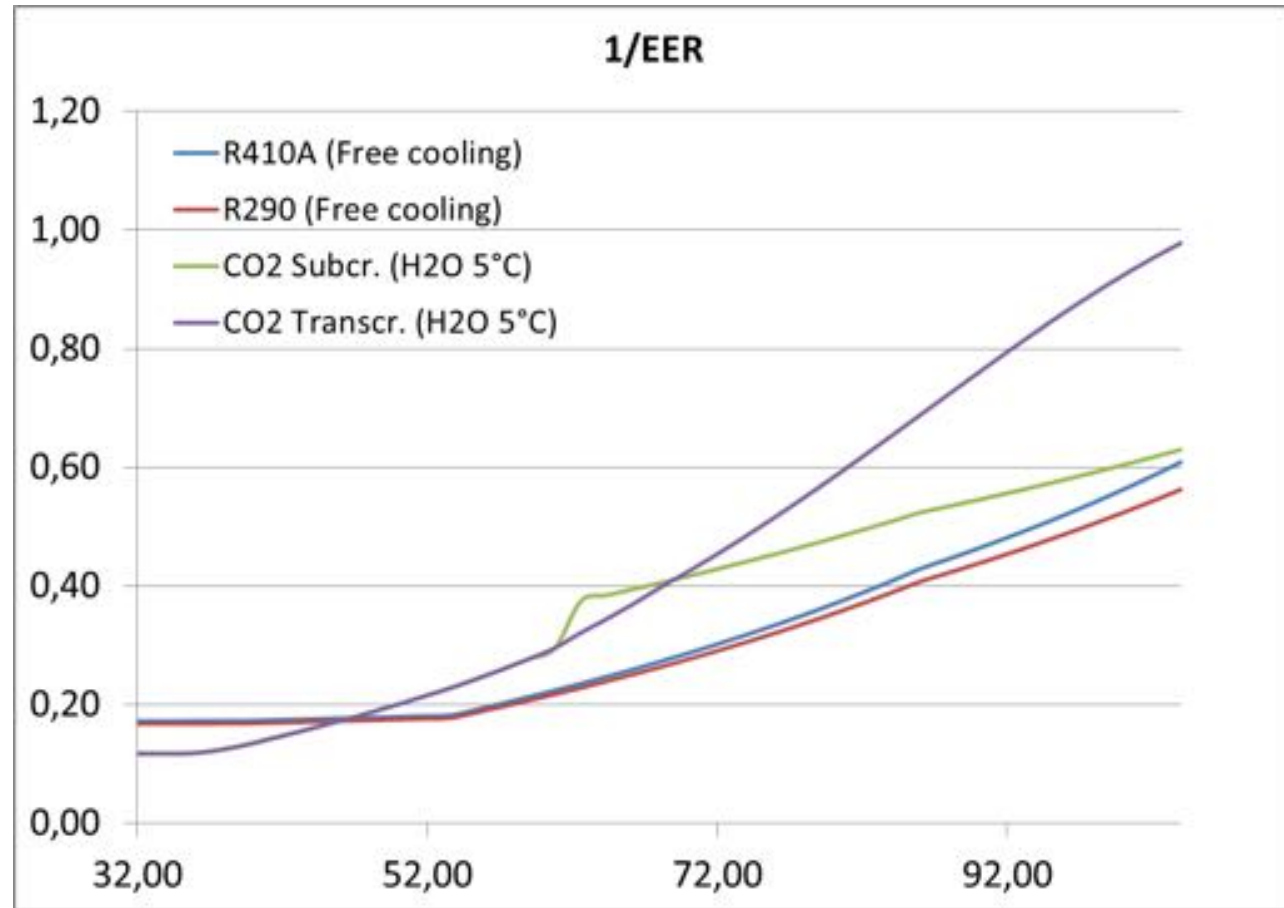
Natural refrigerants in DC waterloop systems

Test conditions

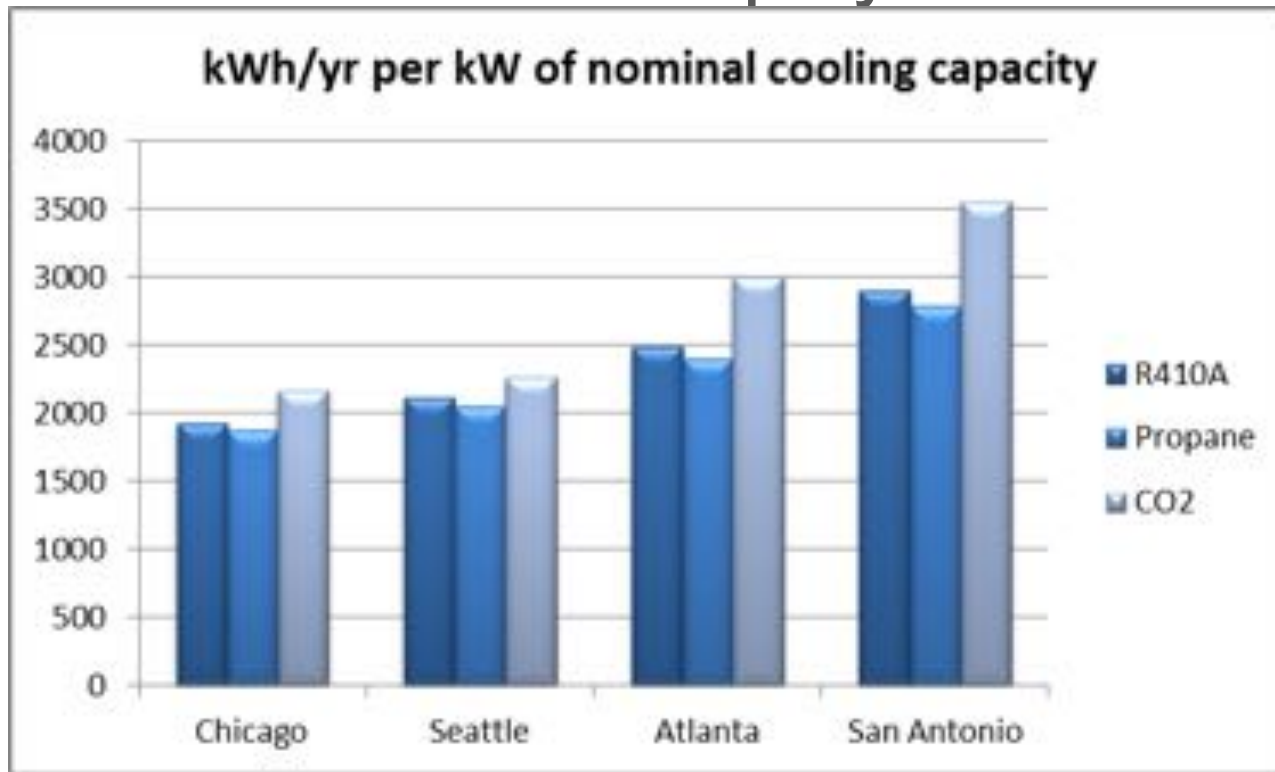
Refrigerant scheme



- MT only
- DC comps
- R410A freecooling
- R290 freecooling
- CO₂ sub, chiller activation
- T_{water} = 68° F
- CO₂ transcritical, optimum GC pressure control



Natural refrigerants in DC waterloop systems



| Refr | Tech | Chicago | Seattle | Atlanta | San Antonio |
|---------|---------------|---------|---------|---------|-------------|
| R410A | Free cooling | 2120 | 1925 | 2491 | 2900 |
| Propane | Free cooling | 2053 | 1872 | 2405 | 2789 |
| CO2 | Chiller 20° C | 2265 | 2170 | 2997 | 3556 |

Conclusions

- DC waterloop system is a real and efficient solution in industry portfolio
- Factory tested units to improve ease of installation, flexibility and energy efficiency
- Installation and maintenance cost reduction
- Suitable use with natural refrigerant: Propane and CO₂
- Propane
 - Best in class efficiency
 - Less accepted by industry for high flammability
 - Legislations under revision (EN378)...
- CO₂
 - Well accepted by the market due to intensive job already done by the industry
 - Missing complete range of compressors
 - Issue on efficiency in warm climates in small application... let's work on it!!

High Efficiency Solutions.

CAREL

HeOS sistema

The new frontier for refrigeration system design



watch it!



<https://www.youtube.com/watch?v=eholSWxFzL0>

High Efficiency Solutions.

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ATMO
sphere
business case
natural refrigerants
25 & 26 June - Atlanta, Georgia

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