Introduction video
Dorin in numbers

- **4 companies**
- **150 employees**
- To date: **65,000** manufactured compressors yearly (over **300,000** pieces totally manufactured in Europe)
- Go to market through local partnerships
Revenue distribution
A long way to excellence since 1918

First compressor in 1932

Leader in open type range

Special Range for R22 Inverter Technology
Prototypes in CO₂

1930

1950 CFC

1990 HCFC

2010 HFC

NOW ???

Hydrocarbons
CO₂ Inverter
HFOs
CO₂ Compressor Evolution

1st Generation

1930

2nd Generation

1990

3rd Generation

2000

CD600

2010

2018
1° transcritical compressor built for SINTEF (Norway)

1° prototype of 2 stage transcritical CO₂ compressor

- New CD600 range for transcritical application
- Up to 160 HP and 81,95 m³/h – 6 cylinders
- Largest refrigeration capacity range of compressor on the market
CO₂ 2019 – NEW subcritical 8 cylinders compressors

m³/h @ 50 Hz

CDS6001B
CDS7001B
CDS8001B
CDS9001B
F-GAS REGULATION
EU F-Gas regulation

Heat pumps

Commercial Heat pump: CO₂

Below 40 kW: R404A

Above 40 kW:
- CO₂ (< 2 MW)
- NH₃ (> 2 MW)

Refrigeration

Air conditioning

Commercial system:
- HFOs (?)
- Hydrocarbons (with ATEX)
## EU F-Gas regulation

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>R404A</th>
<th>R410A</th>
<th>R407A</th>
<th>R407F</th>
<th>R407C</th>
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<td>2107</td>
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<td>-</td>
<td>1.20</td>
<td>1.22</td>
<td>OUT</td>
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<tr>
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<td>-</td>
<td>2.48</td>
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<td>2.63</td>
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<table>
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<th>R134a</th>
<th>R32</th>
<th>R513A</th>
<th>R1234ze</th>
<th>R1234yf</th>
<th>R290</th>
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<th>CO₂</th>
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<td>no</td>
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<tr>
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<td>yes</td>
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<td>A3</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>COP (-35/45°C)</td>
<td>1.22</td>
<td>OUT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.31</td>
<td>1.19</td>
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<tr>
<td>COP (-5/45°C)</td>
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<td>2.76</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.88</td>
<td>2.87</td>
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</tbody>
</table>

JUST FOR CASCADE SYSTEM
CO₂ Stores

CO₂ stores in global perspective

- **Europe**: 8,732 stores
  - **Europe**
  - **Canada**: 163 stores
  - **United States**: 118 stores
  - **Brazil**: 2 stores
  - **Argentina**: 3 stores
  - **South Africa**: 63 stores
  - **Australia**: 5 stores
  - **Indonesia**: 13 stores
  - **Japan**: 1,800+ stores

**Key Legend**:
- 0: 0-99
- 1: 100+ 1,000+
Case 1: COMMERCIAL REFRIGERATION
Refrigerant and Refrigeration systems comparison

Supermarket specs:
- condensation: 45°C
- evaporation: -10°C (MT), -35°C (LT)
- MT: 150 Kw
- LT: 50 Kw

Ing. Mauro Bonfanti
MT System

- R134a
- 4 compressors H2400EP
Evap: -10°C
Cond: 45°C

COP: 2.43
Power consumption: 62.12 KW

LT System

- R404a
- 3 compressors H4000CS
Evap: -35°C
Cond: 45°C

COP: 1.14
Power consumption: 46.44 KW

MT/LT SYSTEMS

COP: 1.84 kW
Power consumption: 108.56 KW

Ing. Mauro Bonfanti
CASCADE SYSTEM – R290/R744 (CO2)

Cascade System

First stage:
- R290
- 4 compressors HEX4000CS

Second stage:
- R744 (CO2)
- 2 compressors CD1500B

COP: 1.93
Power consumption: 103 KW
-5% energy
**BOOSTER Flash gas by-pass – CO2**

**Booster System – flash gas by-pass**

**MT:**
- gas cooler pressure: 90 bar
- receiver pressure: 35 bar
- 4 compressors CD3500H

**LT:**
- 3 compressors CD1300M

**COP:** 1.72
**Power consumption:** 116 KW

Ing. Mauro Bonfanti
BOOSTER parallel compression – CO2

Booster System – parallel compression

MT:
- gas cooler pressure: 90 bar
- receiver pressure: 35 bar
- 4 compressors CD2500M

Parallel Comp. CD3000H

LT:
- 3 compressors CDS501B

COP: **1.90**

Power consumption: **105 KW**

-3% energy

Ing. Mauro Bonfanti
**BOOSTER overfeeding ejector – CO2**

**Booster System – overfeeding ejector**

**MT:**
- gas cooler pressure: 90 bar
- receiver pressure: 35 bar
- 4 compressors CD3000M

**LT:**
- 3 compressors CDS401B

**COP:** 2.08
**Power consumption:** 96.11 KW
**-12% energy**
BOOSTER Pre-compression ejector

**Booster System**

**Pre-compression ejector**

**MT:**
- gas cooler pressure: 90 bar
- receiver pressure: 35 bar
- 4 compressors CD2000M
- Parallel Comp. CD4000H

**LT:**
- 3 compressors CD1300M

**COP:** 1.98

**Power consumption:** 101 KW

-7% energy

Ing. Mauro Bonfanti
BOOSTER Overfeeding/Pre-compression ejector

Booster System – overfeeding/pre-compression ejector

MT:
- gas cooler pressure: 90 bar
- receiver pressure: 35 bar
- 4 compressors CD1400M

Parallel Comp. CD4000H

LT: 3 compressors CDS401B

COP: 2.15

Power consumption: 93 KW

14% less energy!
Case 2:

INDUSTRIAL REFRIGERATION (>500kWr)

Refrigerant and Refrigeration systems comparison
CO$_2$ vs NH$_3$

- Energy consumption comparison - CO$_2$ and NH$_3$ – system features
  - 250 kW LT capacity
  - 500 kW MT capacity
  - No heat reclaim to be conservative

- SYSTEM A: CO$_2$ cascaded with NH$_3$
- SYSTEM B: full CO$_2$ Booster – flash gas bypass (FGB)
- SYSTEM C: full CO$_2$ Booster – parallel compression (PC)

- NH$_3$: minimum $T_{\text{cond}}$ according to Bitzer OSKA range envelope
- CO$_2$: minimum $T_{\text{cond}}$ according to Dorin CD range envelope
**CO₂ vs NH₃**

- **A**: CO₂ CASCaded WITH NH₃
- **B**: CO₂ – FLASH GAS BYPASS (FGB)
- **C**: CO₂ – PARALLEL COMPRESSION (PC)
CO₂ vs NH₃

- CO₂ (FGP: -22575 €)
- CO₂ (FGP: -15547 €)
- CO₂ (FGP: -15502 €)
- CO₂ (PC: -625 €)
- CO₂ (PC: -598 €)
- CO₂ (PC: -307 €)
### CO₂ vs NH₃

#### Yearly Energy & Cost Comparison: Europe

<table>
<thead>
<tr>
<th>Location</th>
<th>NH₃</th>
<th>CO₂ FGP</th>
<th>CO₂ PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockholm - Sweden</td>
<td>REF</td>
<td>-22575 €</td>
<td>-25782 €</td>
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<tr>
<td>Berlin - Germany</td>
<td>REF</td>
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<td>Munich - Germany</td>
<td>REF</td>
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<td>Barcelona - Spain</td>
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<td>Florence - Italy</td>
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<td>Athens - Greece</td>
<td>REF</td>
<td>+7819 €</td>
<td>-307 €</td>
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</table>

- 0.06 € per kWh -
CO₂ vs NH₃

- **TOTAL MT CAPACITY:** 850 kW
- **COMPETITION CO₂ COMPRESSORS**
- (30–38) m³/h: 10–15 PIECES NEEDED
- N.2 RACKS – EXPENSIVE SOLUTION
- **DORIN 6 CYL CO₂ RANGE – 60 m³/h**
- 6 PIECES ONLY ARE NEEDED
- N.1 RACK ONLY – SIMPLER SOLUTION

**DISPLACEMENTS m³/h**
- **DORIN**
- **COMPETITION**

Future developments bringing solutions up to 100m³/h
CO₂ vs NH₃

F-gas REGULATION:

STRONG INFLUENCE IN THE EUROPEAN REFRIGERATION INDUSTRY

NATURAL REFRIGERANTS:

THE BEST ALTERNATIVE FOR ALMOST ALL THE APPLICATIONS

INDUSTRIAL APPLICATIONS

- CO₂ IS APPROACHING THIS FIELD AGAINST AMMONIA
- CO₂ PROVIDES SOME TECHNICAL & SAFETY ADVANTAGES
- CO₂ CAN ALSO PROVIDE COST SAVINGS
- DORIN 6 CYLINDERS TRANSCRITICAL COMPRESSORS UP TO 60 m³/h ALLOW CO₂ TO APPROACH THE INDUSTRIAL MARKET IN AN EFFECTIVE WAY
<table>
<thead>
<tr>
<th>System</th>
<th>Compressor Details</th>
<th>MT -8°C C [300 kW]</th>
<th>LT -28°C C [400 kW]</th>
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<tbody>
<tr>
<td>SYSTEM A</td>
<td><strong>NH3 DX</strong></td>
<td>N.2 OSKA8591</td>
<td>N.2 M series</td>
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<tr>
<td></td>
<td><strong>Bitzer screw</strong></td>
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<td>Mayekawa</td>
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<tr>
<td>SYSTEM B</td>
<td><strong>CO2 FGP</strong></td>
<td>N.5 CD6 800 59 M</td>
<td>N.2 CDS 8 cyl</td>
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<td><strong>Dorin</strong></td>
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<td>Dorin</td>
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<tr>
<td>SYSTEM C</td>
<td><strong>CO2 PC</strong></td>
<td>N.4 CD6 800 53 M</td>
<td>N.2 CDS 8 cyl</td>
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<td><strong>Dorin</strong></td>
<td></td>
<td>Dorin</td>
</tr>
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**SYSTEM A:** R717 - Two stage closed intercooler

**SYSTEM B:** R744 – Booster Flash gas bypass

**SYSTEM C:** R744 – Booster Parallel compression
- Minimum $T_{\text{cond}}$ according to compressors envelope
- Subcooling condenser MT: 2K
- Delta T condenser: 10 K [R717], 7 K [R744]
- No heat reclaim to be conservative
CO2 is an economic solution throughout the installation lifecycle, with lower capital investment and no/low concern on safety.
NEW PRODUCTS - NEW NICHES

2S-H7 RANGE: COMPETING WITH SCREW COMPRESSORS

LARGE LT APPLICATIONS

- MARKET IS DOMINATED BY SCREWS
- BRAND NEW NICHE FOR DORIN
CD series

- Pss = 100 bar - PS = 150 bar
- Wide application envelope: from 1,12 m³/h to 82,00 m³/h
- Booster applications
- HP and LP safety relief valve
- Suitable for low (B range), medium (M range) and high (H range up to +15°C) evaporation temperature
- Low vibrations, thanks to an optimized mass balance
- Low gas pulsation
- Suitable for frequency control
CD600 series

- 6 cylinder solution for transcritical application
- Largest refrigeration capacity range of compressors ever available nowadays on the market

<table>
<thead>
<tr>
<th>Range Serie</th>
<th>Model Typ</th>
<th>Displacement [m³/h]</th>
<th>Cylinders</th>
<th>Oil charge [kg]</th>
<th>Suction [SL [mm]]</th>
<th>Discharge [DL [mm]]</th>
<th>Net weight [kg]</th>
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<td>54</td>
<td>42</td>
<td>476</td>
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</table>
Dorin is the only producer of 2 stage transcritical CO$_2$ compressors from 3 HP to 35 HP

- $P_{ss} = 100$ bar, $P_s = 150$ bar
- Excellent for CO$_2$ condensing unit [1 ÷ 40 kW @-30°C / 90bar / 30°C $T_{Gout}$]
HEX series

- Displacement from 4,42 m³/h to 244,78 m³/h
- 86 models from 0,5 HP to 90 HP suitable for low, medium and high temperature
- II 3Gc Ex nA IIB T3 Gc classification
- Solutions:
  - Electric box 7J Shock proof
  - Oil sight glass 2J Shock proof
  - ATEX approved oil differential pressure switch
- Standard accessories:
  - crankcase heater
  - maximum discharge temperature sensor
Open type series

- Displacement @1450 rpm 2.37 m³/h to 250.73 m³/h for open type compressor

- Open type compressor for transport application
- Fully interchangeable with other compressor brands
- Aluminium crankcase
- Only 6 kg weight for the 2 cylinders model