Maturing and dissemination of new Refrigeration technologies with CO_2 as refrigerant

Århus
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About ADVANSOR

- The Worlds largest producer of transcritical booster-systems
- Production of 4-6 systems per week
- Uses CO_2 to fight the global CO_2 problem (Global warming)
- Production area: 2000 m^2
- Employees: 25 (+20 at sub contractors)
- Production 2010: 200 systems
- Production capacity max. 400 systems per year
- Reference list: 250 systems operating in 7 countries
- Turnover 10/11: €10 mill.

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About ADVANSOR - history

- 2006 — 2 engineers from Danish Technological Institute founds Advansor
- 2006/07 — Development and testing in laboratories
  Establishment of production
- 2007 — Prototypes of supermarket rack, chiller and HP put into operation
- 2008 — Series production of supermarket racks
  Series of 3 racks (1 rack per week)
- 2009 — Company growth to 12 employees and moving into new production facilities
- 2010 — Scaling up production, volume based production
  4-6 racks per week, cost reduction
- 2011 — Capacity: 8 rack's per week
  Production in 2 other European countries

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Another 6 system on it’s way to England

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Products

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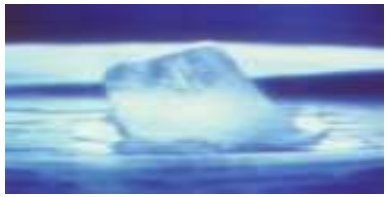
ADVANSOR's products

compSUPER: Refrigeration applications
Advansor offers refrigeration systems (compressor rack's) for supermarkets and other commercial/ industrial applications. The units work with as the only refrigerant. Main focus are placed on reliability, ease of service and low energy consumption.

compHEAT: CHP – combined heat and power
Advansor develops heat pump solutions dedicated to power plants operated by either gas motor or gas turbines.
The heat pump produces hot water up to 90°C which enables direct pipe connection to the external pipe work with no interference with the motor and piping.

compBINE: Combined heating and cooling
Combined heating and cooling - produce hot water up to 100°C and get ice water for free or counter wise. Advansor's product line is highly suitable in connection with pasteurisation, CIP systems and other application in food industry where coinciding demands for heating and cooling exist. Combined heating and cooling saves both capital investment and energy cost.



compFORT: Chiller applications and AC systems
Advansor offers highly compact air cooled chillers and AC systemsin the range from 100 to 400 kW. With natural refrigerant, no toxic risk and no flammability this is a safe and economical feasible choice.

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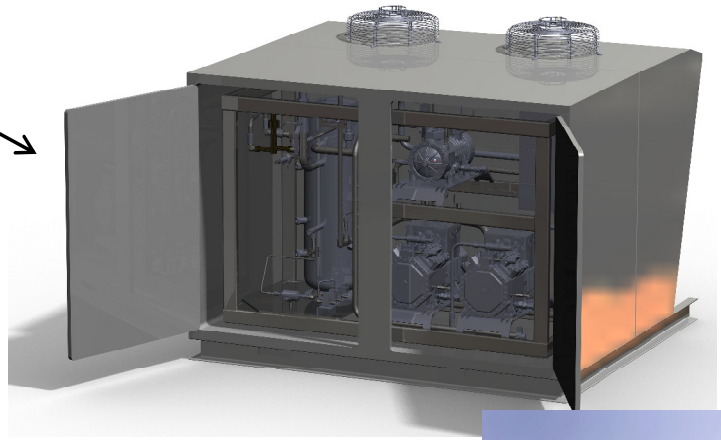
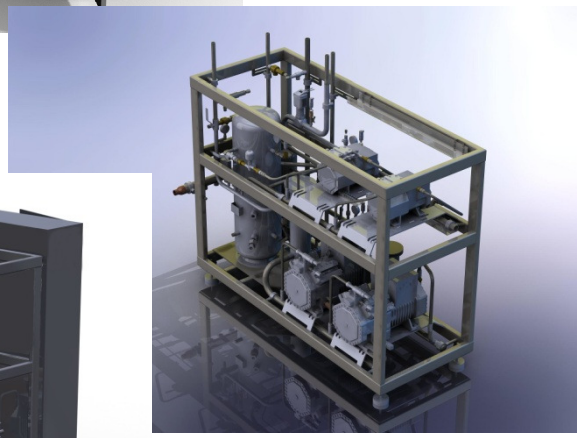
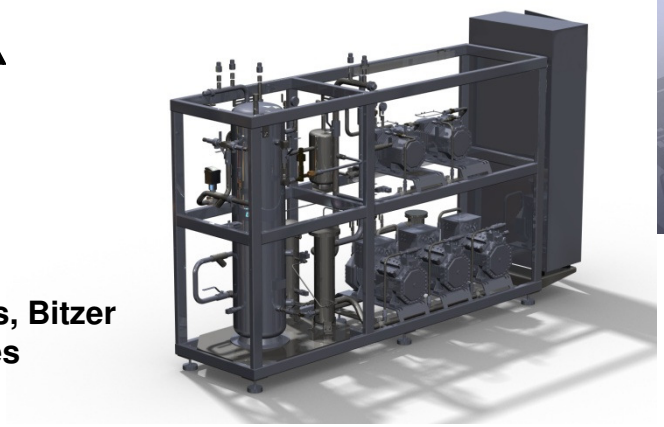
compSUPER – supermarket models

XS 2x0B CC (35 kW)
XS 2x1B CC (35/5 kW)
XS 2x0B (35 kW)
XS 2x1B (35/5 kW)
S 2x2B 1x 70 liter (42/8 kW)
S 2x2B 1x 140 liter (55/10 kW)
S 3x2B - 1x 140 liter (61/14 kW)
S 3x2B - 1x 140 liter (90/20 kW)
S 4x3B 2x140 litres (120/30 kW)
S 5x3B 2x140 litres (140/40 kW)



Indoor/
outdoor





Standard: Elec.panel, AKD, Danfoss controllers, Bitzer
Options: Gascooler, EC Fans, service switches
Heat recovery system
40/ 60 bar

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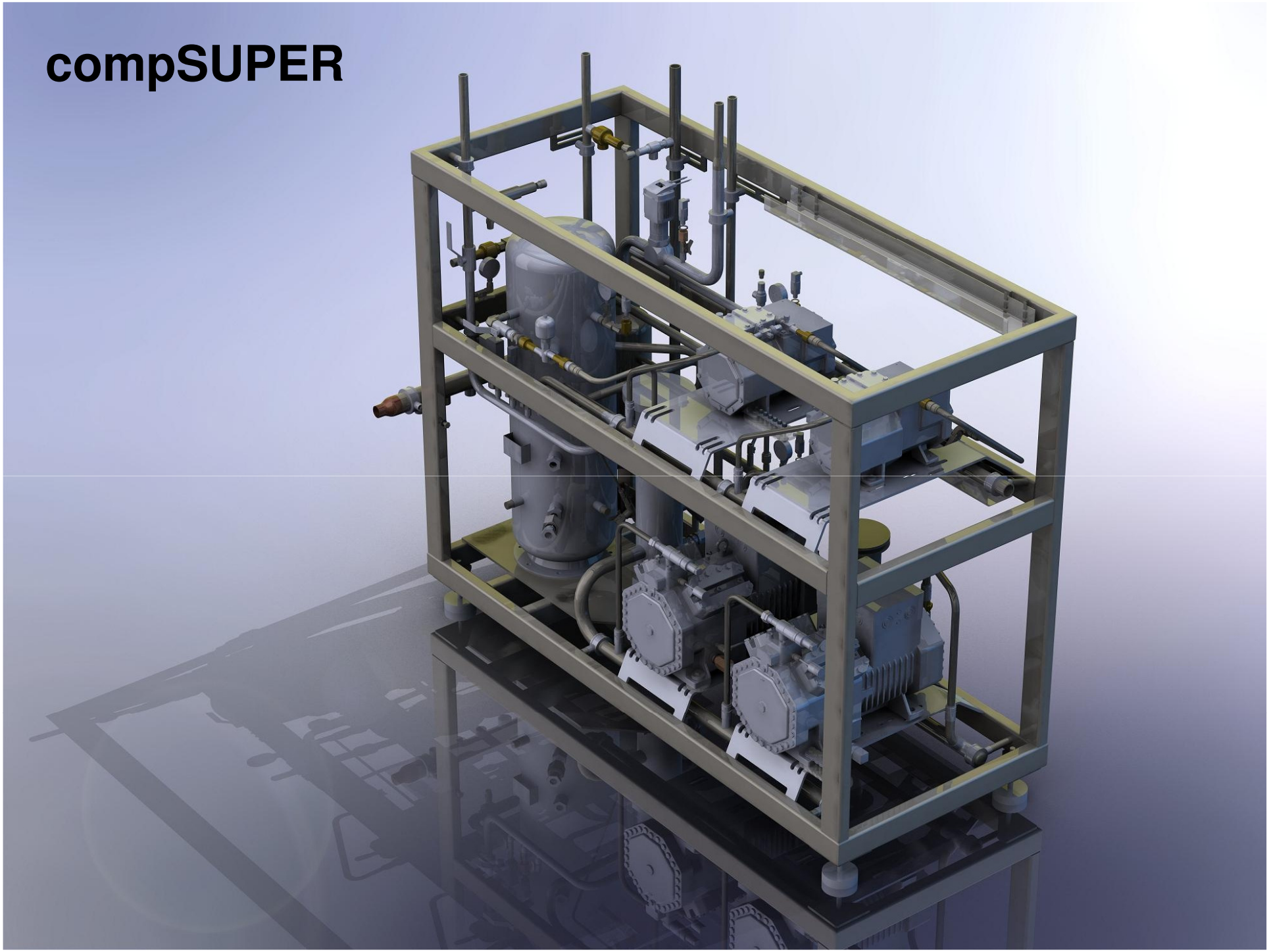
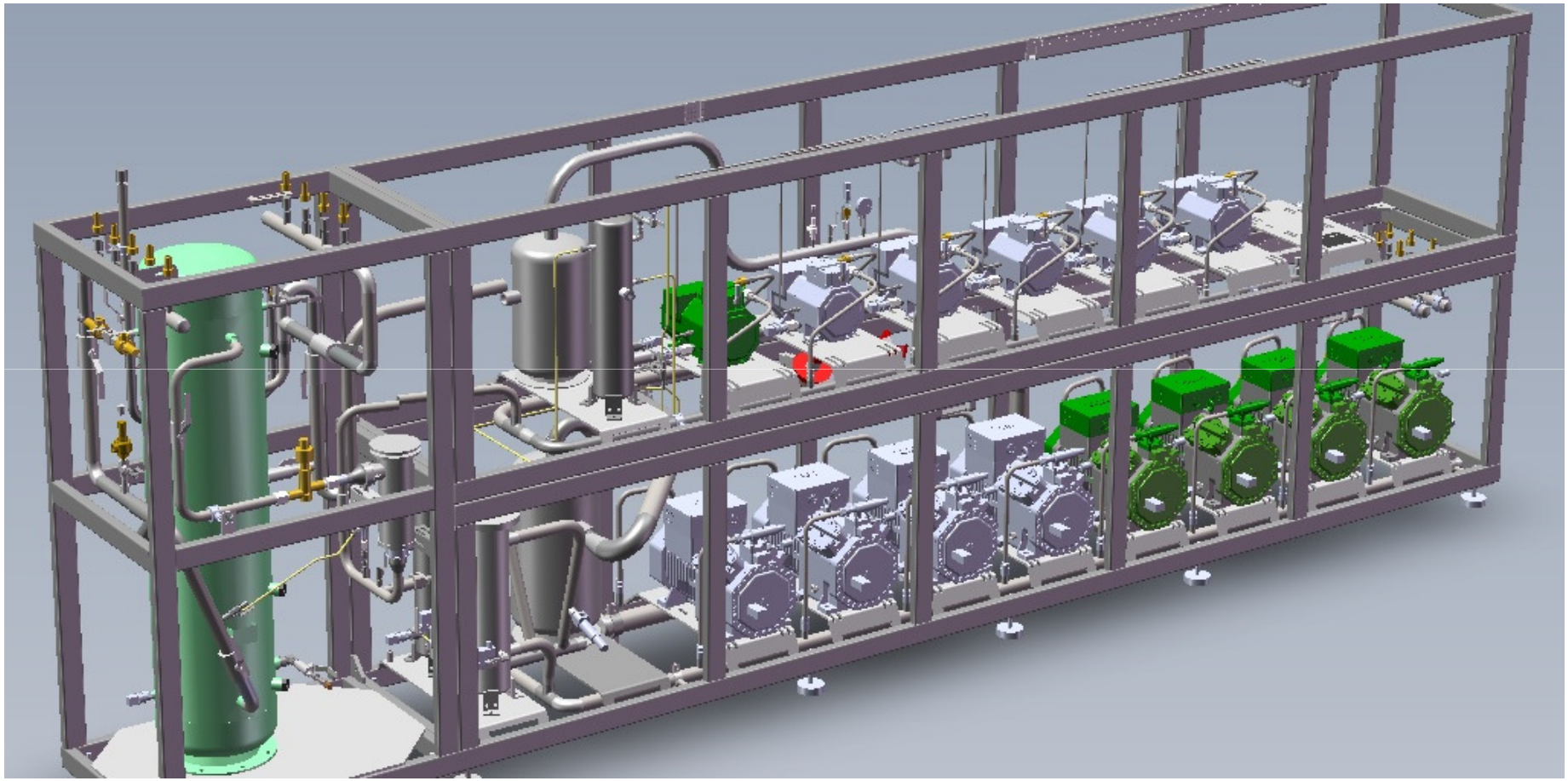
compSUPER



compSUPER XL 8x6B (180+70 kW)



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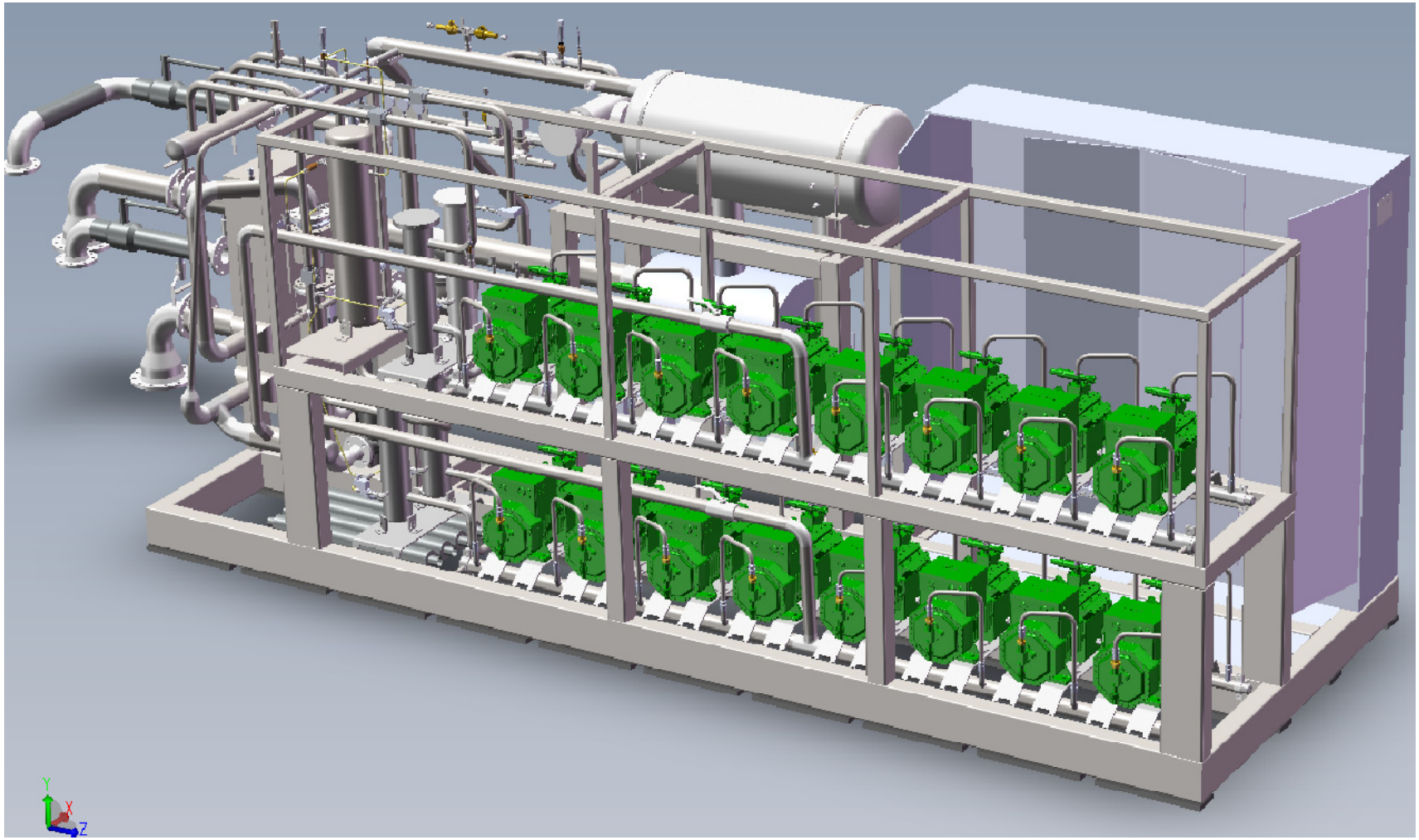
compHEAT 4-IKV
1.000 kW heat production



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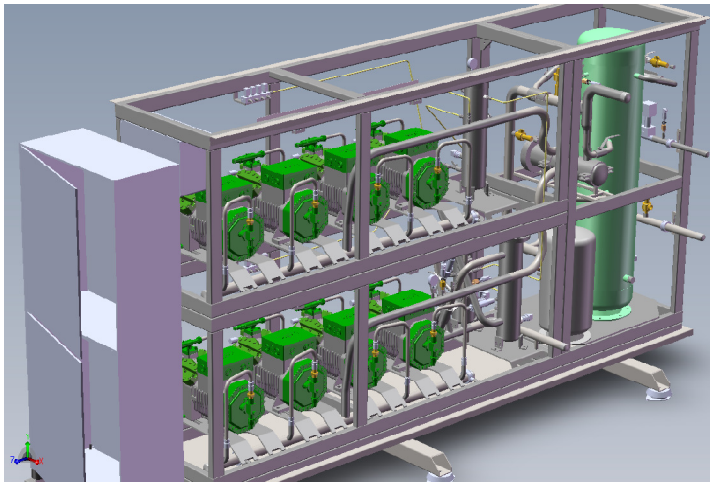
compFORT 8x0B
National arena in Copenhagen – AC with CO2

Luftkonditionering: 3xcompFORT S 8x0
Anlægstype: Gas-by-pass, DX
Kapacitet: 3 x 300 kW
Fordampertemperatur: 7-8ºC
Lufttemperatur: 15ºC
Økonomi: 20% besparelse på installationen
Energibesparelse: ca. 15% sammenlignet med de bedste HFC-chillere



			DRY		Energiforbrug		
Udeluft °C	COP HFC luft/vand	COP CO_2 luft/luft	antal timer T>udeluft	Kuldeydelse kW	HFC kWh	CO_2 kWh	
32	3,10	3,10	1	360	116	116	
28	3,50	3,46	10	360	1.029	1.040	
25	3,80	4,00	49	360	4.642	4.410	
20	4,20	5,40	351	360	30.086	23.400	
15	5,00	6,90	1.490	360	107.280	77.739	
12	5,70	9,10	2.723	360	171.979	107.723	
ESEER	3,77	4,12			315.131	214.429	kWh/år
European Seasonal Energy Efficiency Rating – Eurovent Certification Programme							

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Market Development

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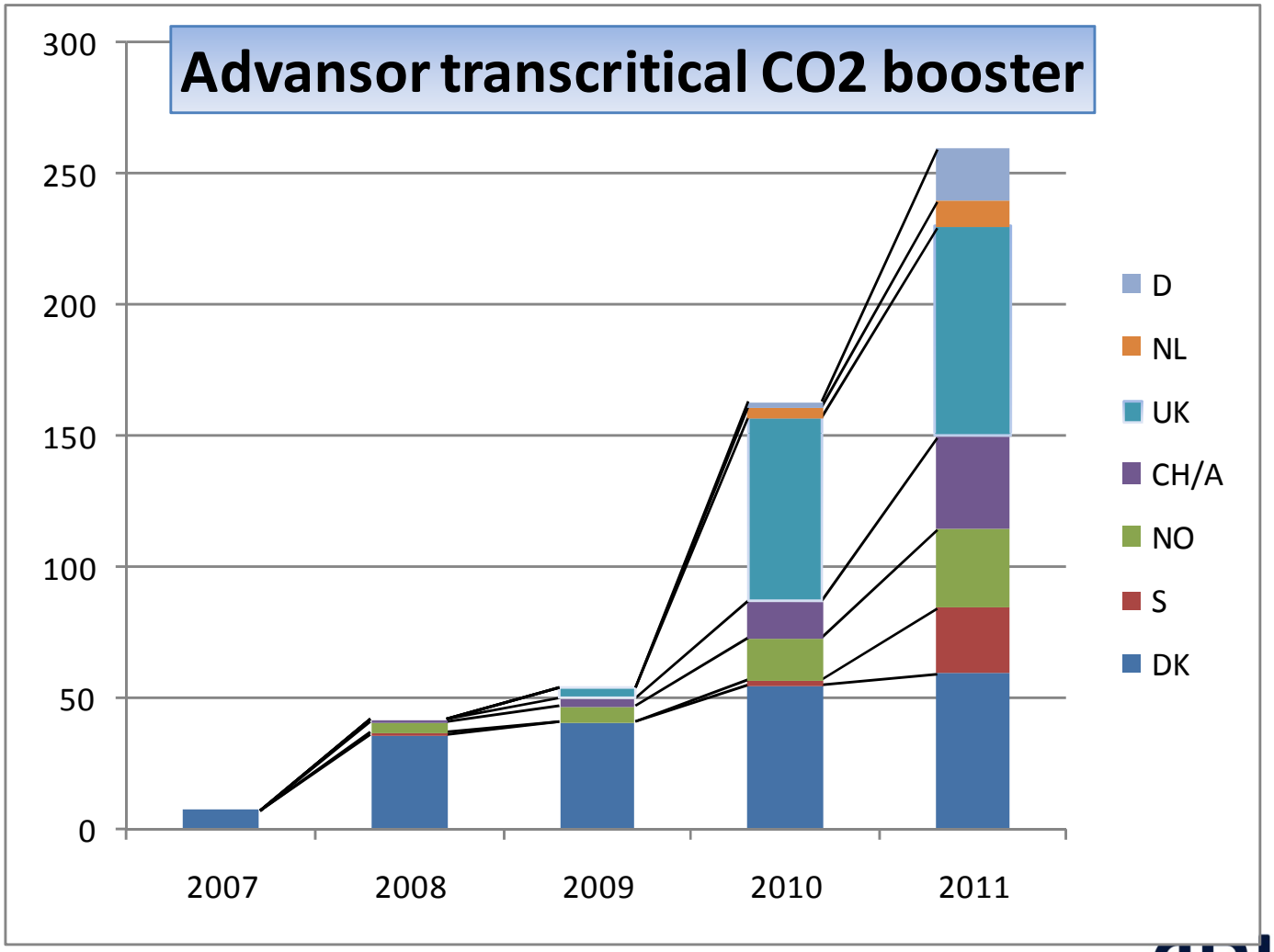
Market growth - compSUPER



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Business Strategy and Partners

- **Advansor cooperates with few but large leading companies**

Norway: 2 partners

Sweden: 2 partners

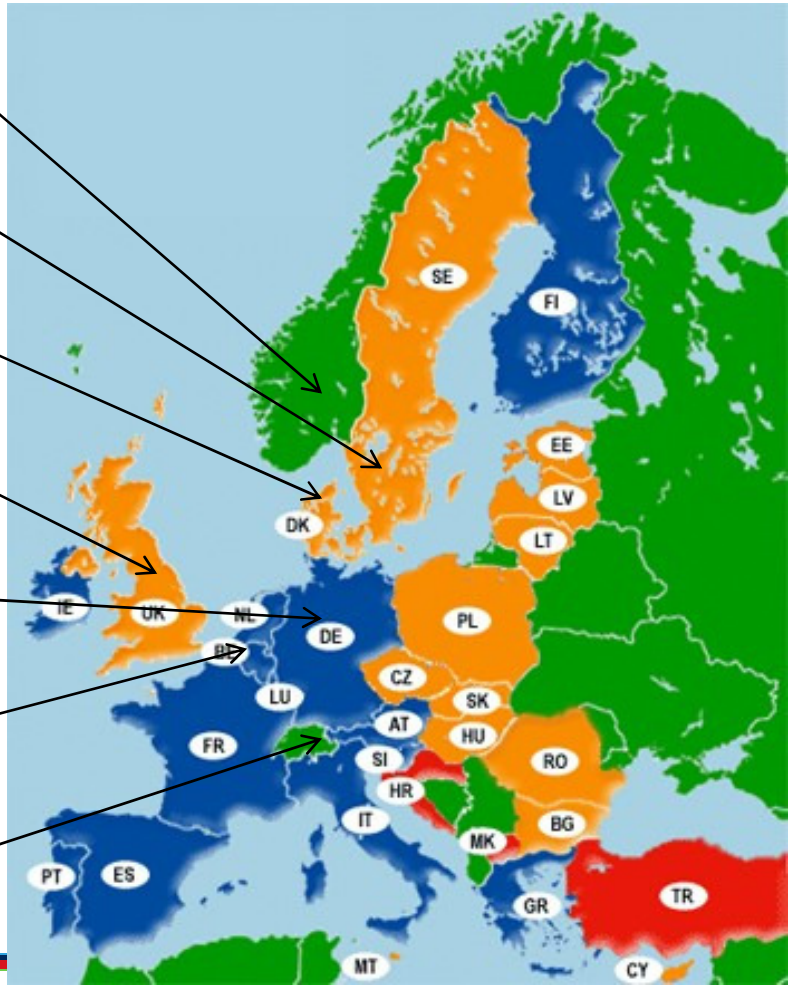
Denmark: 3 partners

United Kingdom: 1 partner

Germany: 1 partner

Bennelux: 2 partners

Switzerland/Austria: 3 partners



Market Strategy

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Business Strategy and Partners

- **Advansor is specialized in producing systems but not in installing systems**
  - **Advansor needs the strongest possible partner in each country**
- **Advansor cooperates with few but leading installers**
  - **Interested in working with 1-3 partners in the Top 5 of each country**
  - **Requirement of education in the CO_2 technology**

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What does Advansor Offer our Partners?

- **The Worlds best transcritical CO_2-systems**
  - Highest quality at the best price
  - Sales support (why should the end-user by green technology)
  - Influence ”the decision makers” and end users directly
- **Consulting**
  - Design of supermarket systems
  - Practical experience regarding installation
  - Calculation of the energy consumption
- **Education**
  - Training seminars at Advansor
  - Sales/ technical seminars
- **After-sales**
  - Start up help
  - On-line support
  - Spare parts

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Test and training system at Advansor

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Why CO_2 and why Advansor?

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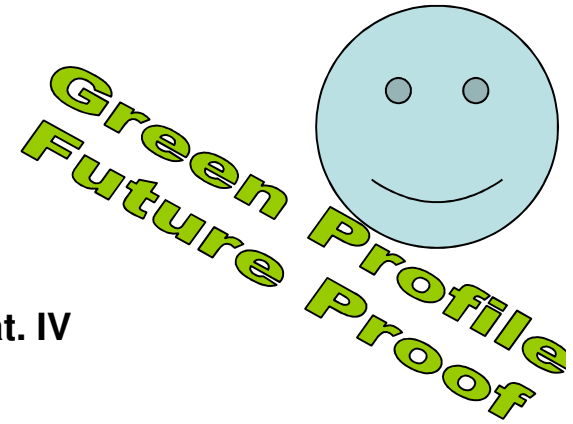
Advantages of CO_2 as refrigerant



- **High level of security**
  - Safety valves and switches
  - Production and assembly approved
  - CE-labelled in accordance to PED cat. IV
  - High level of documentation
- **Reliable operation**
  - Well known tested components (compressors, exchanger, control)
  - Optimal and easy controls and monitoring
  - Resistant against compressor failure (oil handling, IHX, accu)
  - Secure handling of stand still pressure
  - High safety at service (pump-down, easy access)
- **Easy installation**
  - Only one refrigerant – CO_2 / DX and copper piping
  - Optimized design: cobber, small pipes, hoses , and oil handling
  - No brine nor water pipes
  - Can be installed anywhere, no limits to the loc. of the condenser
- **Low installation and operating costs**
  - Low energy consumption
  - Low cost refrigerant
  - Easy and quick service
  - Availability of all components (standard)
  - 200% extra heat recovery
  - cooling with termosyfon
  - Stabile temperatures

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Point of Sale (CO2 vs. HFC) pros./ cons.

- **Pros.:**
+ **No global warming effect**
+ **CO_2 is safe and non-toxic – no restriction against the use of CO_2**
+ **Tax on HFC (CO_2 is an insurance against big refrigerant loses)**
+ **Pressure from NGO's on bigger supermarket chains**
+ **Low average outside temperatures => low energy consumption**
+ **Better possibilities of heat recovery with CO_2**
+ **Only one refrigerant, simple system, few components**
+ **Low maintenance costs**
- **Cons.:**
÷ **No legislation against HFC and no taxes**
÷ **Long experience with cascade systems and indirect systems**
÷ **The transcritical CO_2 systems are more expansive than HFC systems**

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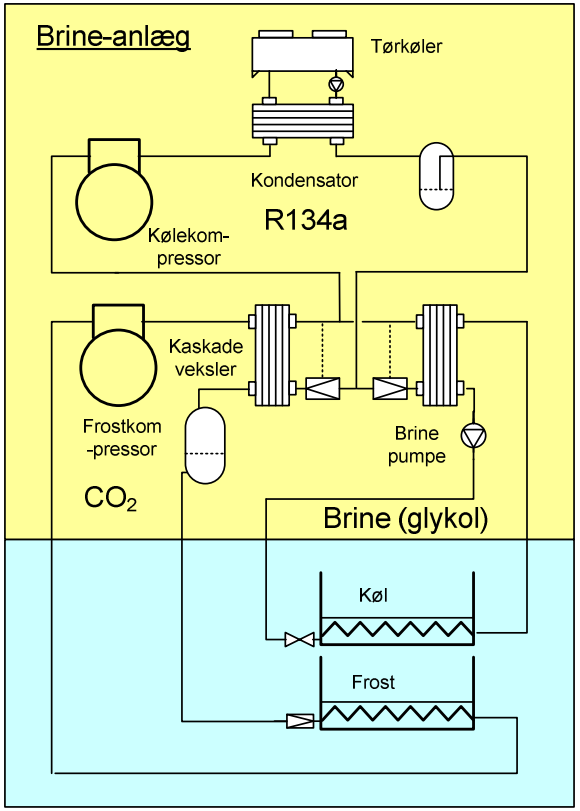
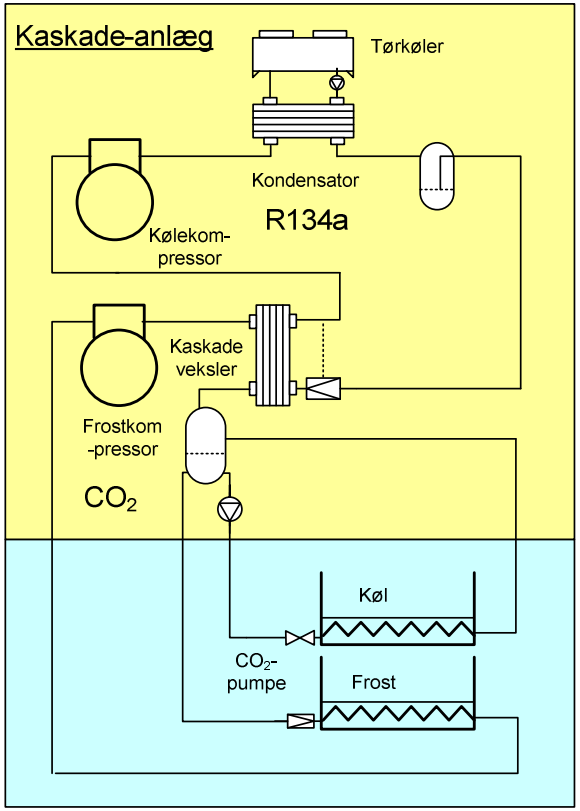
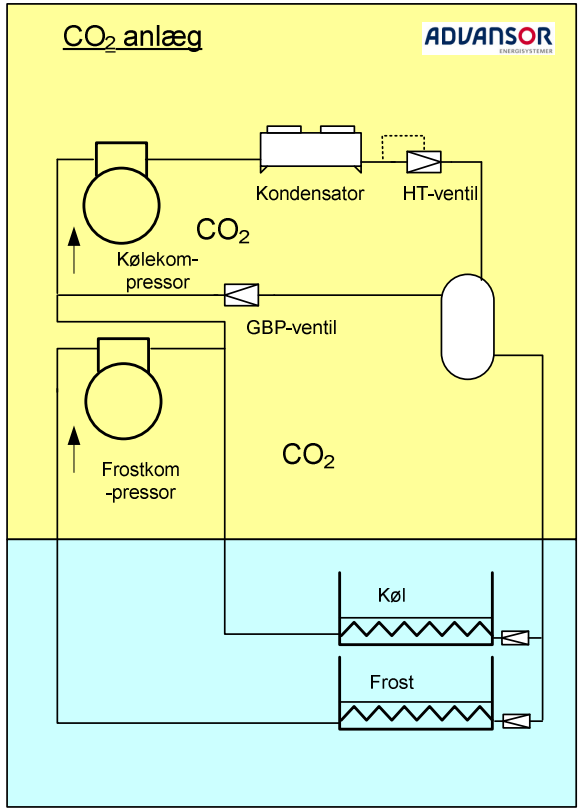
Systems Available for Supermarkets – transcritical vs. cascade







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Systems from Advansor

- Reliable systems (250 systems operating in 7 countries)
  - Optimal and robust design and thoroughly tested components
  - Oil management and protection against liquid
  - Optimal controls and monitoring easy to access and operate
  - Well known and readily available components
- Better handling of stand still pressure
  - UPS – secure shutdown in case of power failure
  - 90 bar receiver for application during maintenance and controlled shutdown
  - Strategic controlling during power failure
- Low operating costs
  - Low energy consumption (optimized components and controlling)
  - Low maintenance costs (easier to perform maintenance)
  - Optimal heat recovery
- Better documentation and training
  - User's and maintenance manual
  - Training seminar at Advansor

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Properties of CO_2 as Refrigerant

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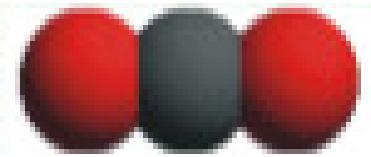
Characteristics of CO_2

Properties in general:

- **Level II (L1) with ODP = 0 + GWP = 1 (NH_3 = L2, R290 = L3)**
- **No imitations in terms of location or application**
- **Temperature and pressure: -55 -> +31 °C (5.5 -> 73 Bar)**
- **Heavier than air, is a dense gas**

CO_2

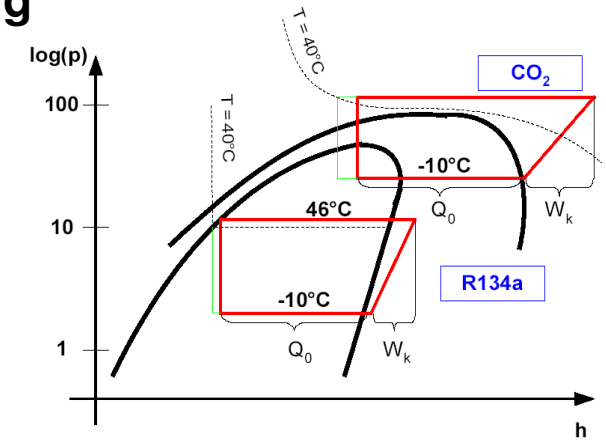


Advantages:

- **Small piping dimensions and minor pressure losses**
- **Improved efficiency of compressors high volumetric cooling capacity**
- **Improved heat transfer – especially by "pool-boiling"**

Challenges:

- **Higher working pressure (up to 130 bar)**
- **Higher stationary pressure**
- **Application of safety valves**
- **Separation of oil/liquid drops from the CO_2-gas**
- **System COP security at high temperatures**
- **Price of components**



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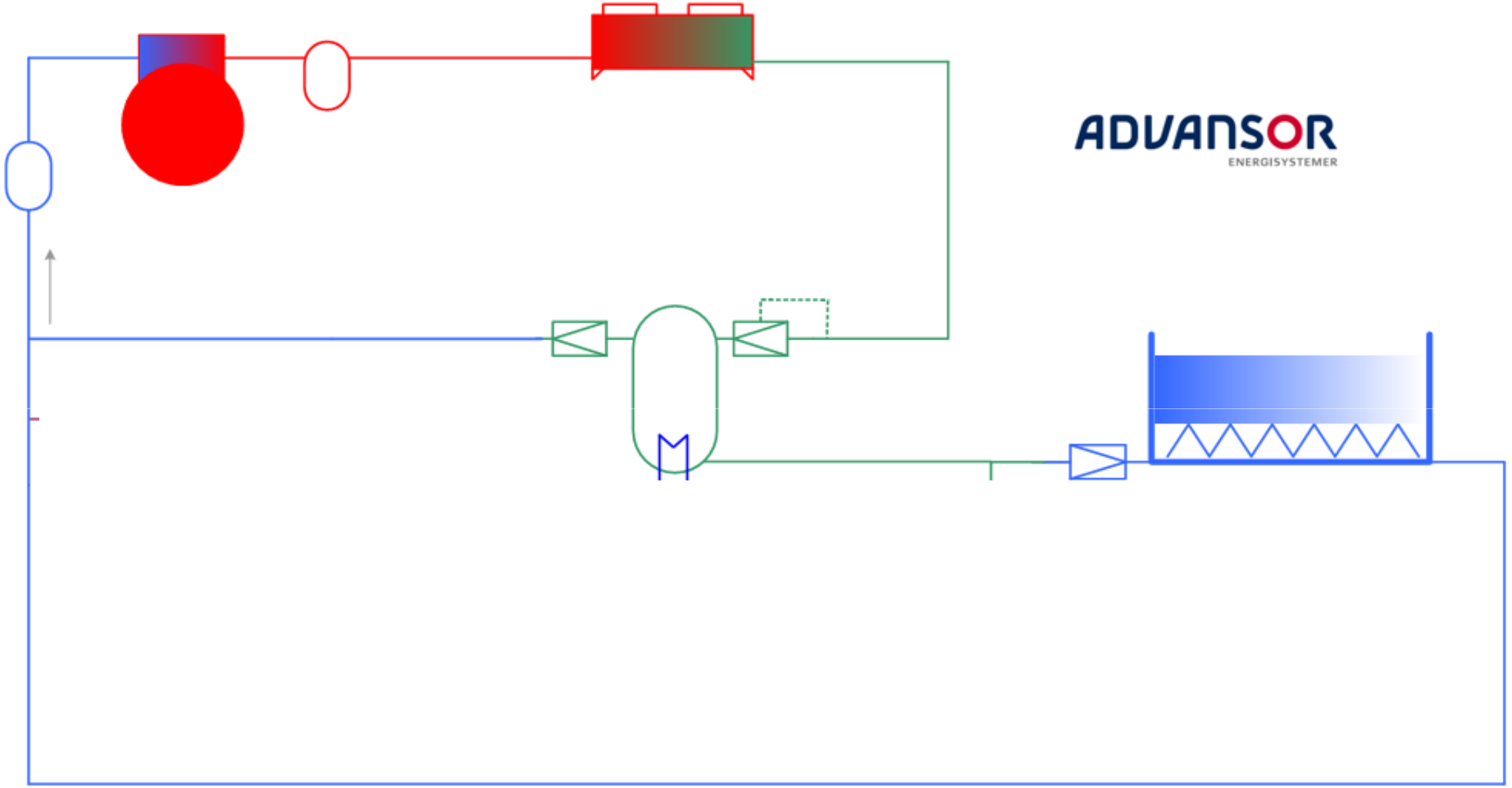
Principles of the cycle – booster + gas-by-pass



Log(p)-h diagram

Technical Properties

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System Design

- **Transcritical booster system with CO_2 as refrigerant**
  - Medium pressure receiver with gas-by-pass
  - Highest level of safety
- **Materials and assembly**
  - Sturdy welded frames
  - Welded piping system - P235GH steel
  - Conical threaded – proof against leaks
- **Noise and vibrations**
  - Balanced solution with heavy frame results in low level of vibrations
  - Low level of noise with Bitzer compressors
  - Low gas pulsation and no electrical noise
- **Reliable**
  - Oil system, dry filters and dirt filters
  - Exchanger and suction accumulator on low temperature
  - Pressure levels, pump-down, UPS

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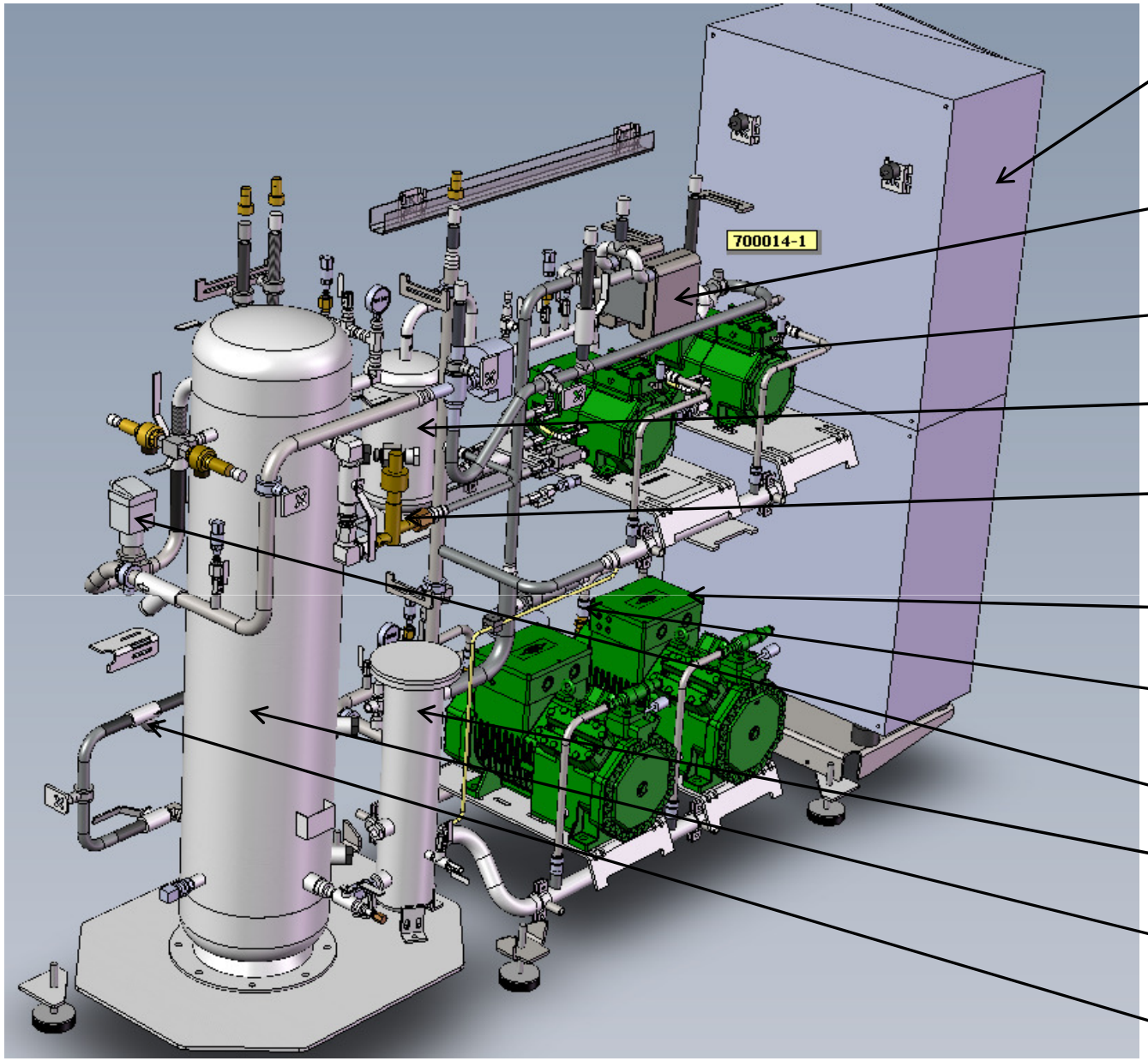
Design and layout (depth = 780 mm)



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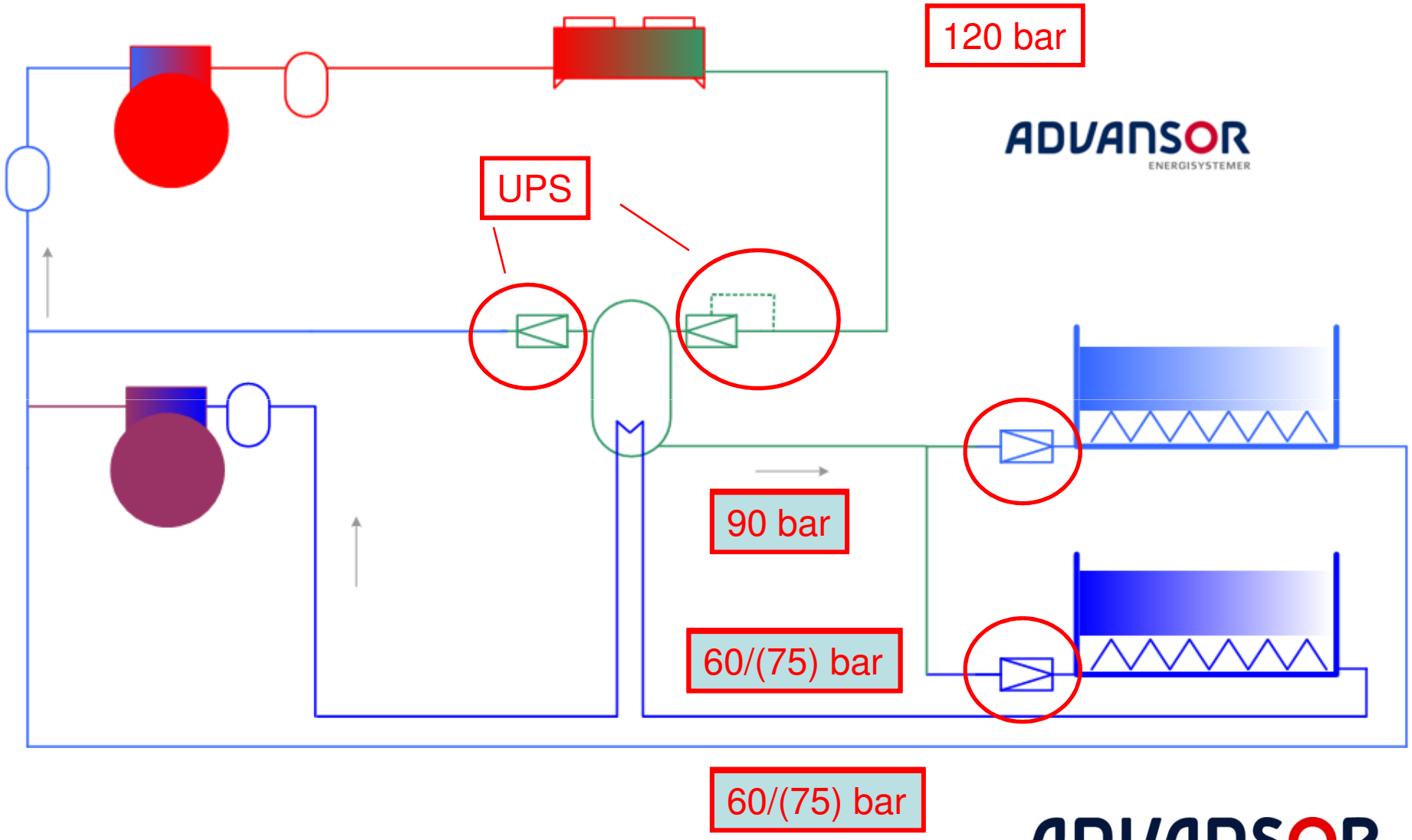
UPS – closes HT-valve + ETS-valve



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Energy Consumption and TEWI

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Why CO_2 systems are low in energy consumption

- Low average outside temperatures in Northern Europe
- No heat exchangers – no extra temperature difference
- No pumps or other aux energy consuming surplus components
- Less pressure drop and better heat transfer
- Lower condensation temperatures allowed (until +5°C)
- Much higher potential heat exchange

- ---------- and it keeps improving
- Better match of capacities of MT and LT (frequency control)
- Optimization compressors
- Optimization of control: capacity, suction pressure, condensation pressure, high pressure and receiver pressure
- Optimization of heat exchangers (gas coolers and evaporators)

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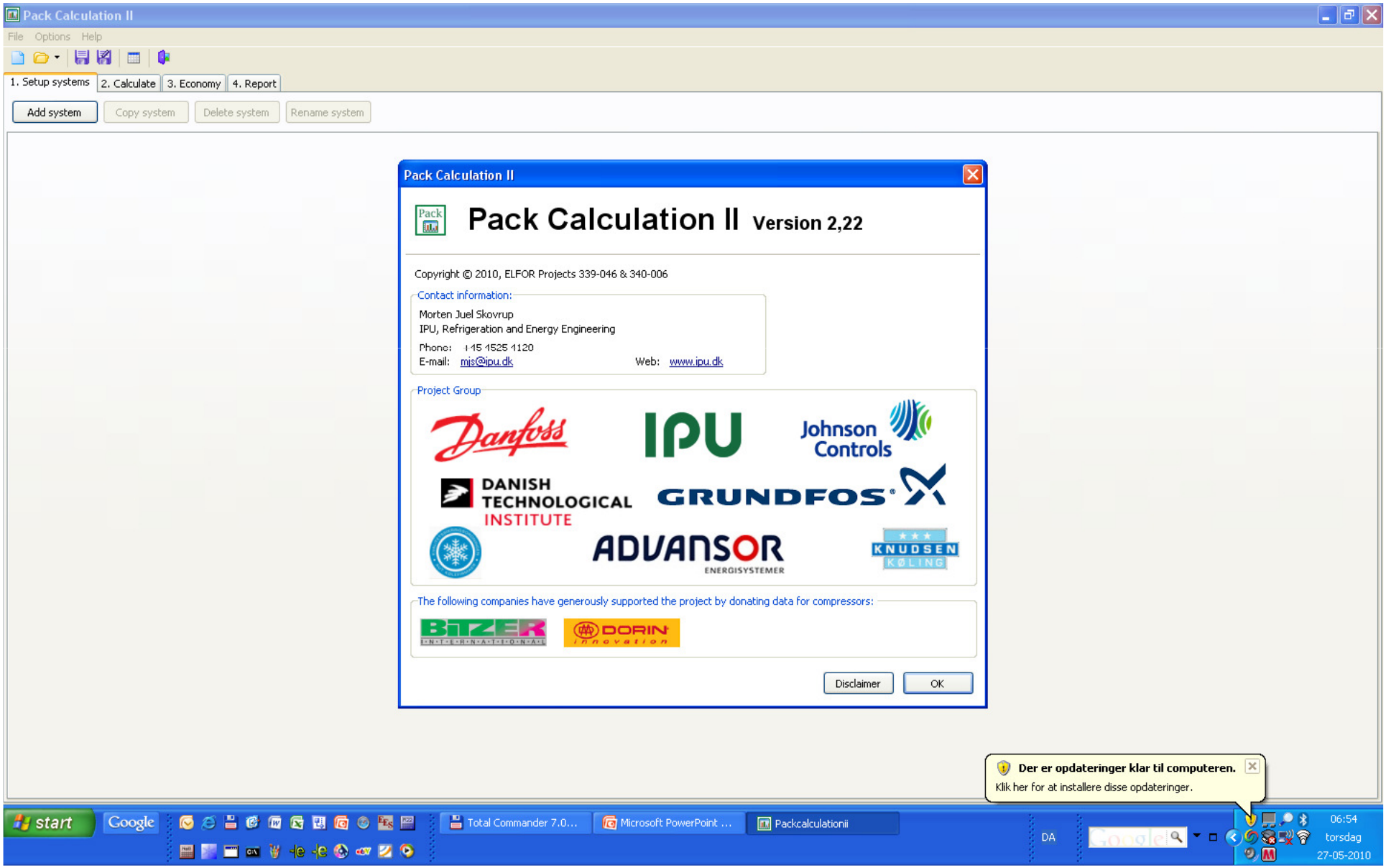
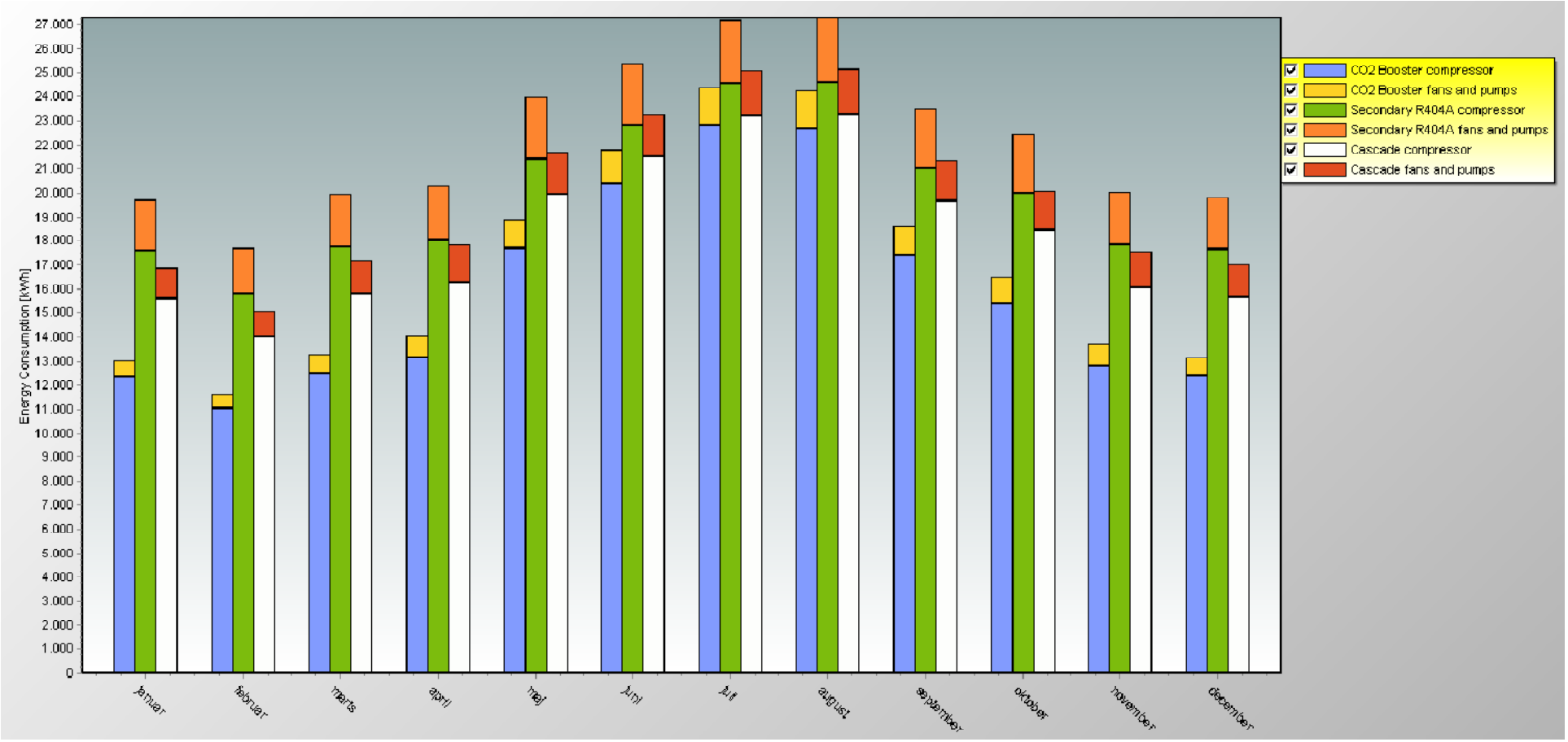
Pack Calculation



Energy consumption (booster, indirect, cascade)



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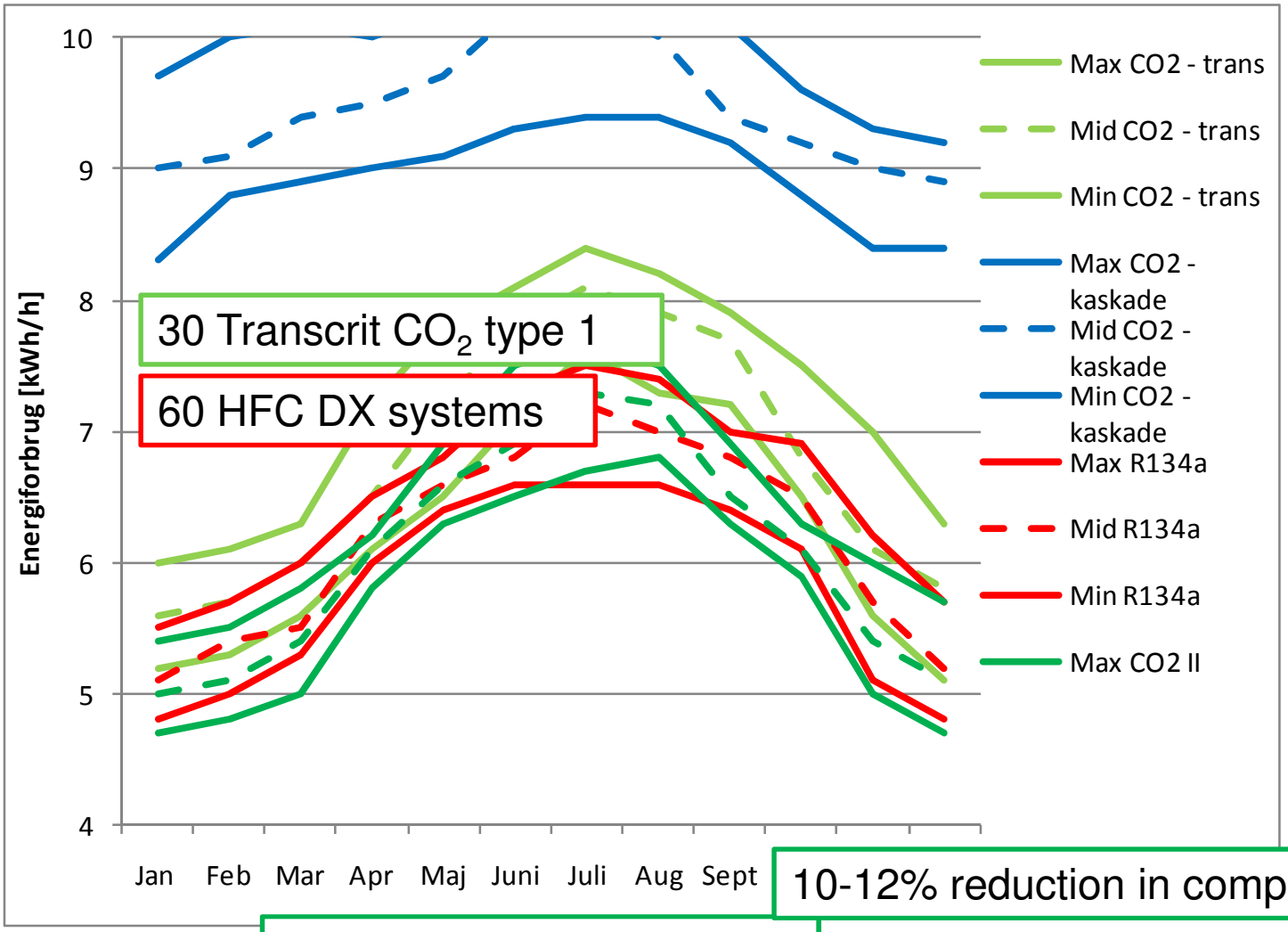
Energy consumption for CO2/ HFC indirect/ cascade

City	Transcritical [kWh]	HFC indirect [%]	Cascade (R134/CO2) [%]
Stockholm	200.272	+36	+20
Copenhagen	203.228	+36	+20
Oslo	201.309	+36	+20
Amsterdam	215.477	+34	+18
Berlin	223.761	+30	+15
Paris	233.269	+27	+13
Lyon	245.977	+23	+9
Madrid	271.159	+19	+6
Marseille	279.484	+17	+3
Barcelona	282.695	+16	+3
Rome	289.547	+14	+1

Source: DTU, Technical University of Denmark (IPU)

Measurements of energy consumption (FAKTA DK)



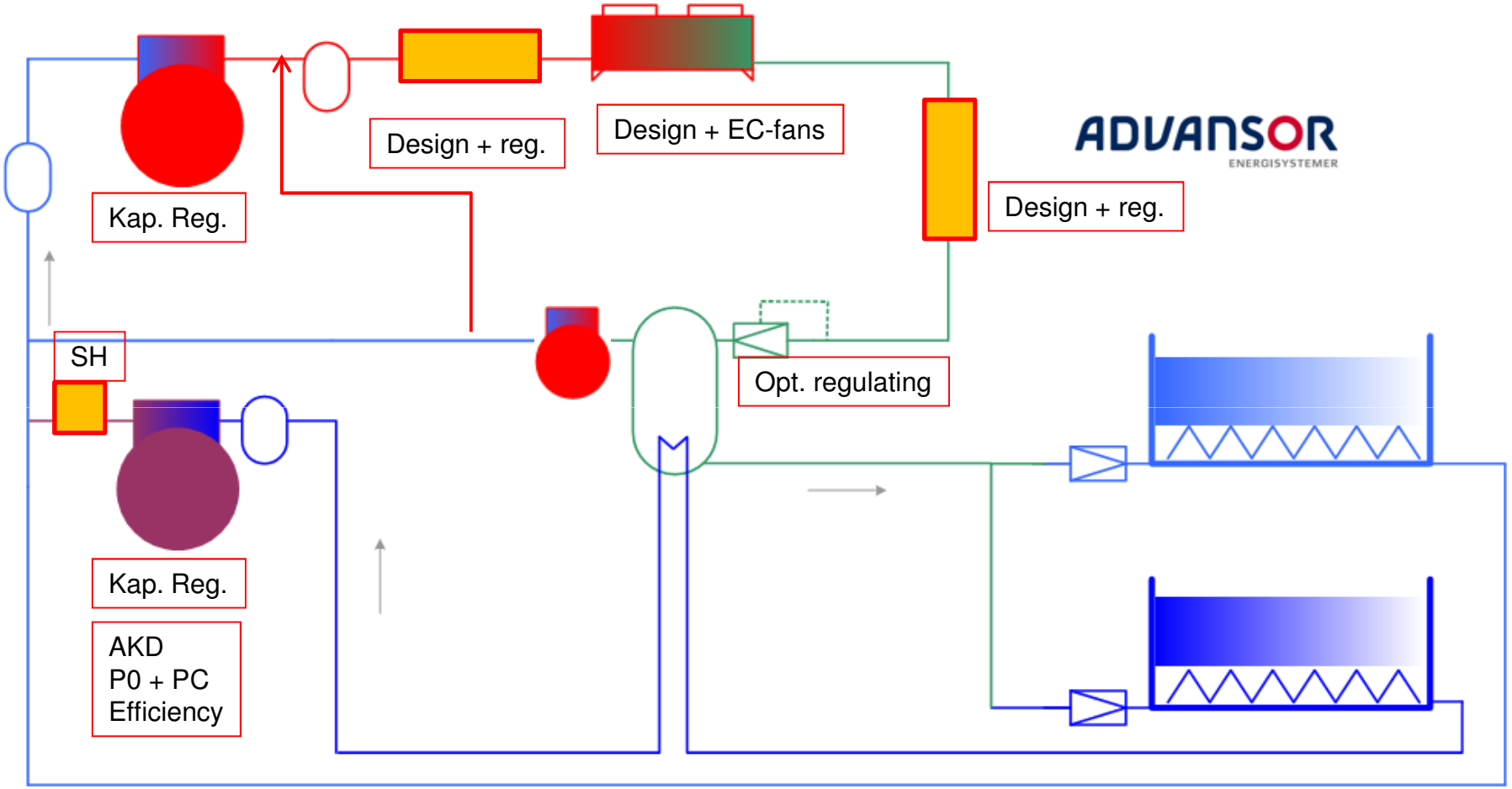
10-12% reduction in comp. to Type 1

15 Transcrit CO_2 type 2

2-5% reduction in comp. t. HFC

20-40% reduction in comparison to cascade and indirect systems

Future Energy Consumption



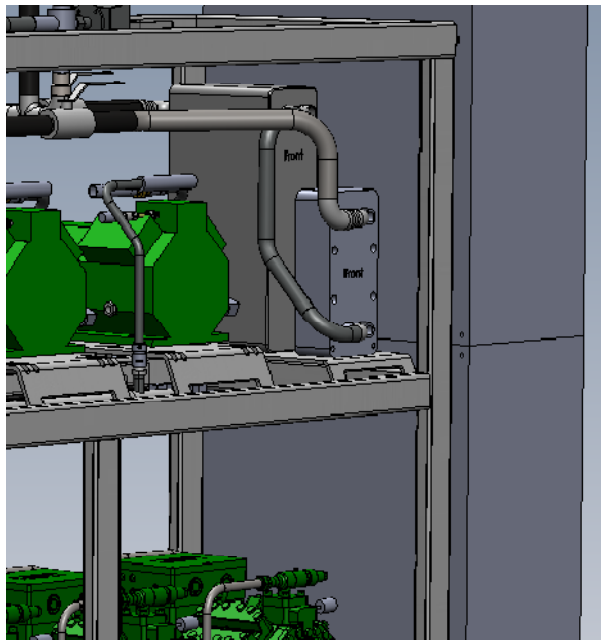
Advantages of heat exchange in CO_2 systems

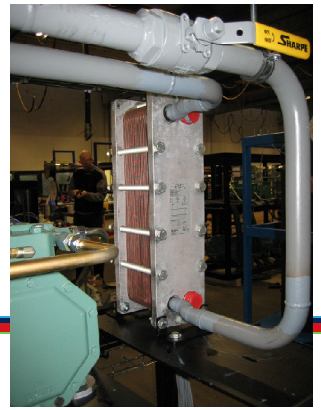
- Higher pressurized gas temperature
- Higher heat in pressurized gas

- Pinch point is situated further inside the exchanger

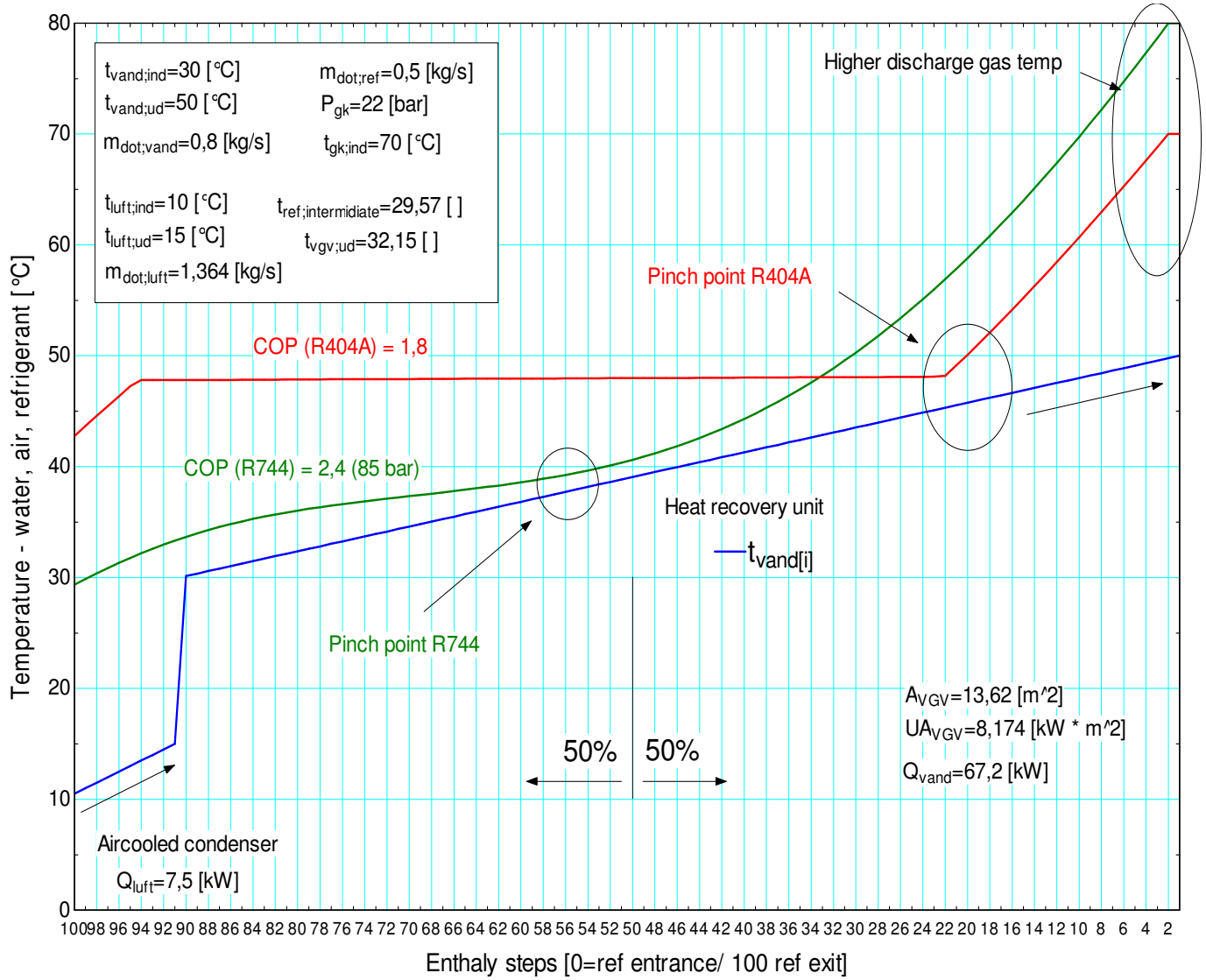
- Lower condensation pressure for the same quantity of heat
- COP during heat exchange

- Heat exchangers from ALFA LAVAL





Heat exchange from transcritical CO_2 systems



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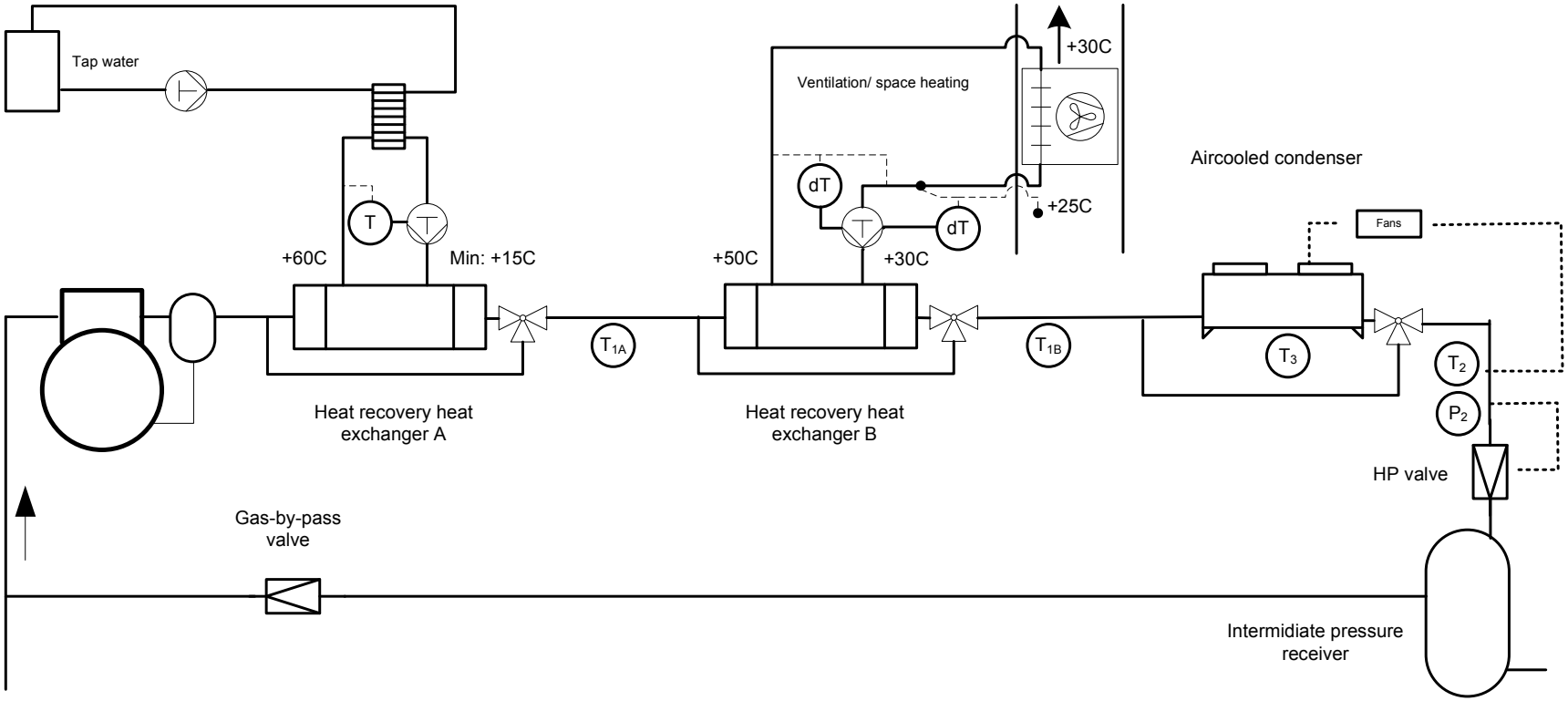
Heat recovery system



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Keywords on success with development and dissemination

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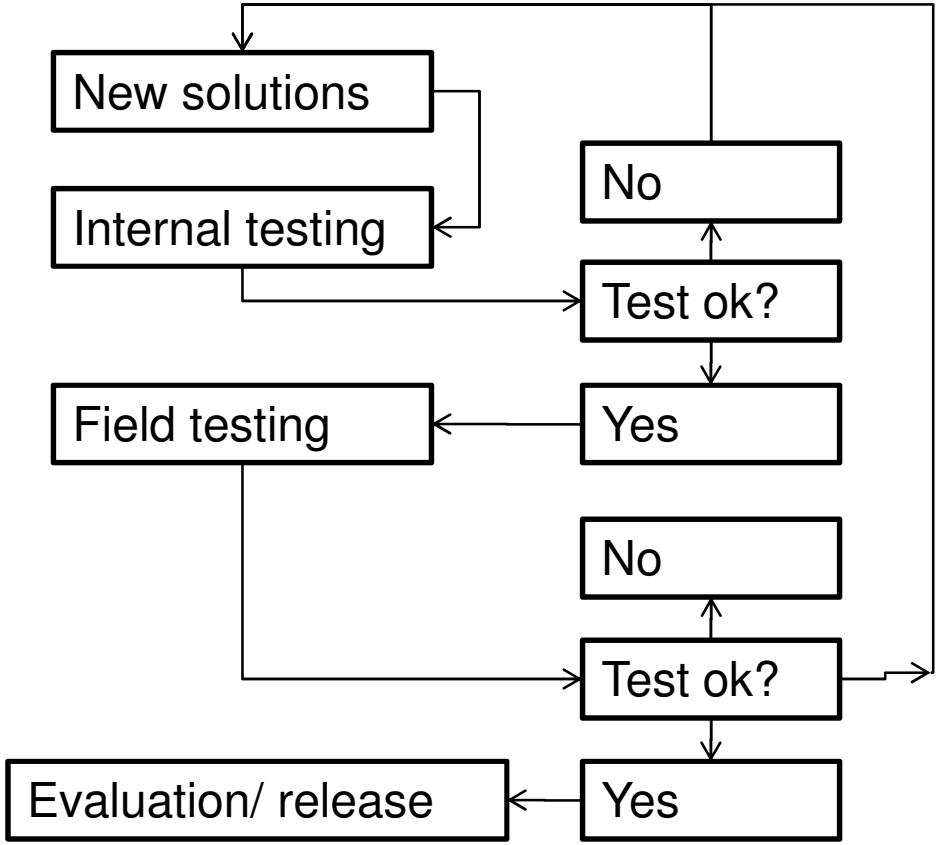
Keywords on maturing/ development

- **Work closely together with your suppliers and costumers**
- **Focus on reliability – one change give other problems**
- **Make it easy**
- **Use "home market"**
- **Do your homework**
  - **Open minded**
  - **Continuous improvement**
- **Next step: optimisation**



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Dissemination with success

- **Built up confidence!!!**
- **Have a clear strategy on each market (both to you and your customers)**

- **Use "open" and understandable components**
- **Use components that are "available" to everyone**
- **Select partners really interested**
- **Develop calculation tools for easy access to knowhow**
- **Users manuals – quick start**

- **Ease of maintenance**
- **Educate your partners (sales and technical)**

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