POLITECNICO DI MILANO

New chiller development at Politecnico di Milano

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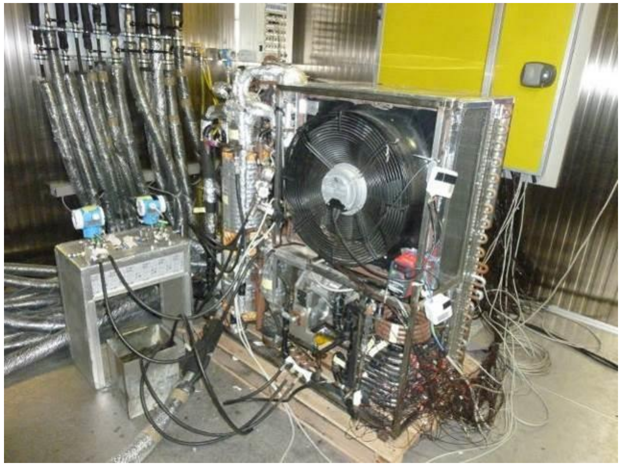
Task 48 meeting Canada, May 2014

Objectives of CASCO chiller

- Simplify chiller as much as possible (installation, maintenance)
- Avoid water based heat rejection
- Reduce auxiliary electricity consumption
- Simplify control strategy



The thermodynamic cycle is a dual lift water ammonia low temperature driven absorption cycle, in which the refrigerant flow self-adapts to the evaporator and absorber loads, making the system capable of adapting to variable loads and boundary conditions.

Thanks to self-adaptation capability, the chiller can well work without hot and cold storage, even at variable generator temperatures, which occur in solar assisted cooling.

A small storage can nevertheless be useful in order to provide the system with some inertia.

RELAB: Polimi brand new test facility

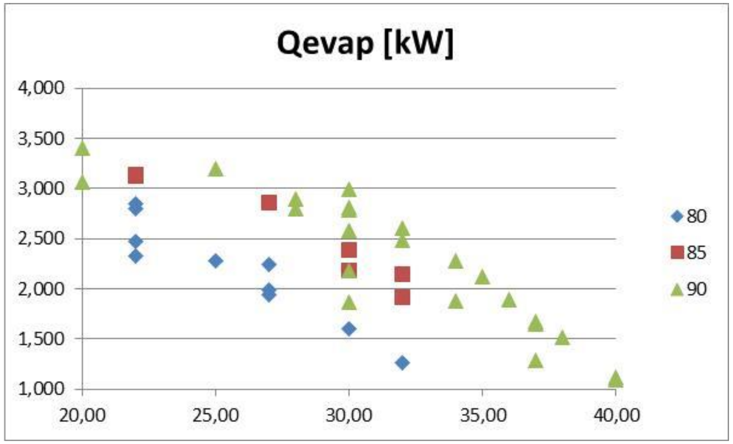
- One **Calibrated Calorimeter** for testing and developing appliances having nominal heating and cooling capacity up to **20 kW :**

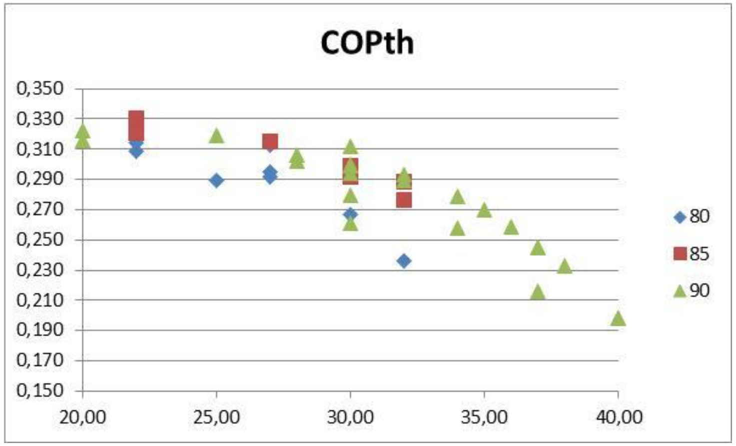
- *operative (accreditation EN 17025 expected by June 2014)*

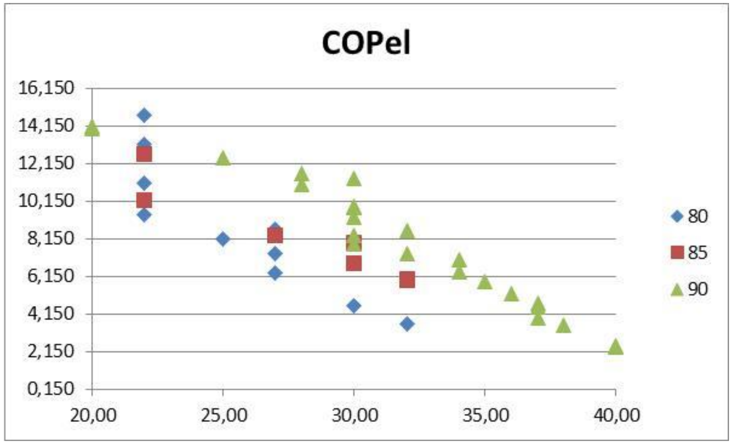
- One **Climatic Chamber** for testing appliances having nominal heating and cooling capacity **from 20kW to 100kW**:

- *currently under construction*

RELAB test lab results





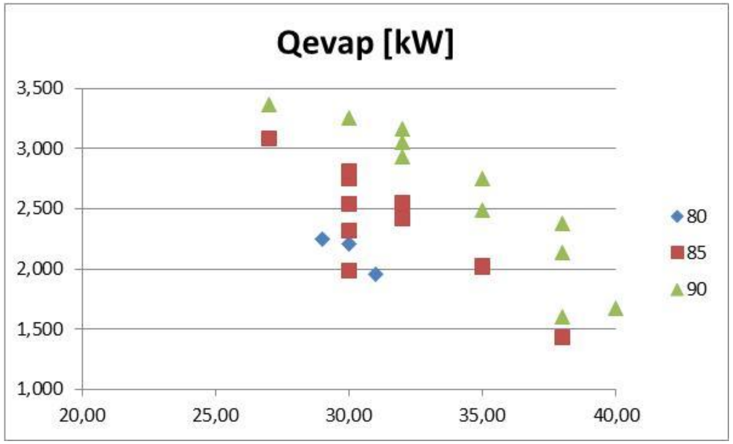


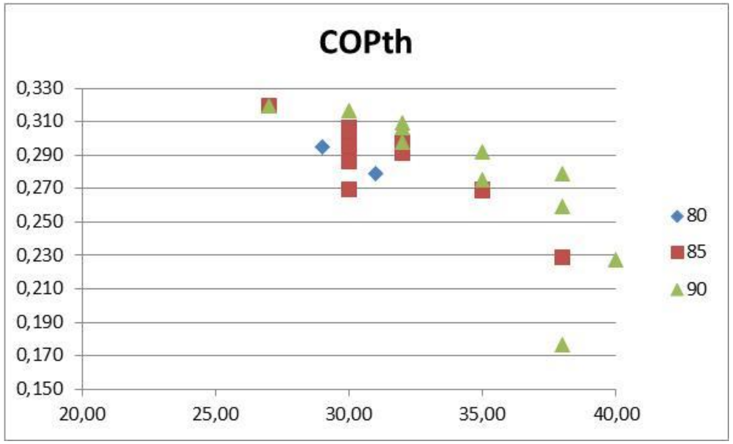
T evap= 7-12 °C

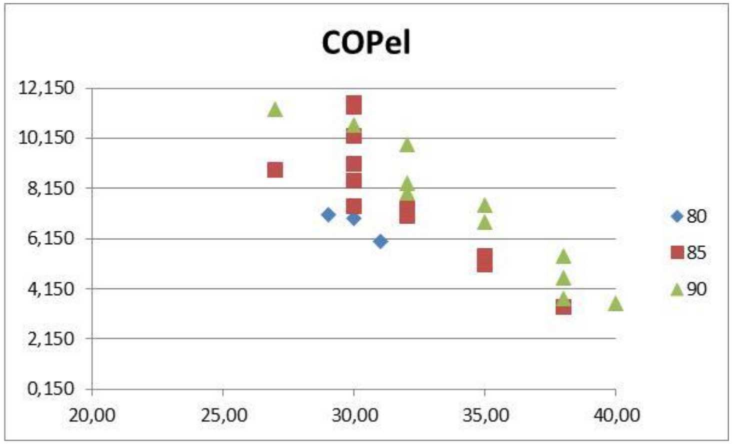
Delta T generator = 10 K

COP_{el} includes electricity consumption of fan and solution pump.

RELAB test lab results





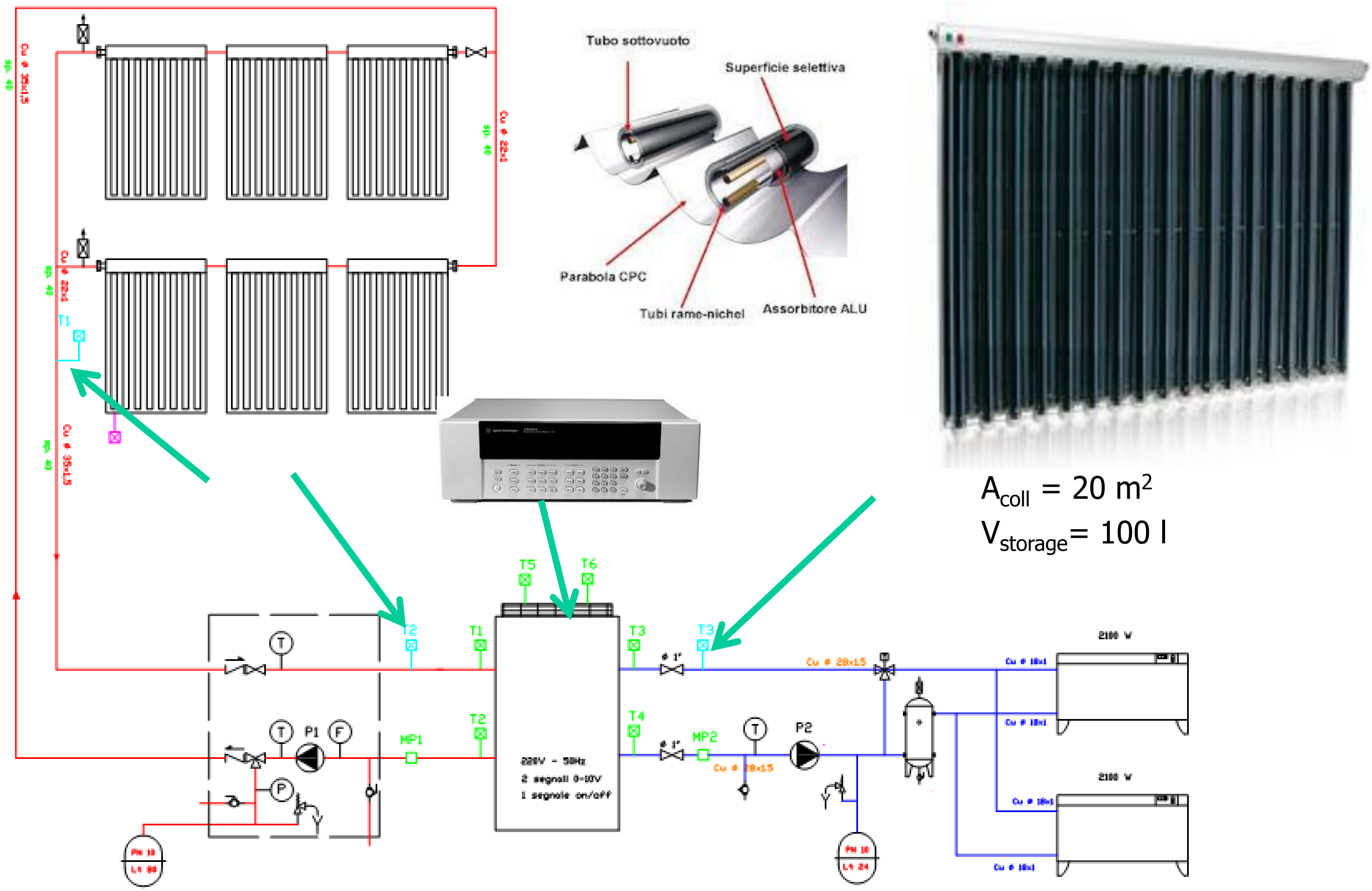


T evap= 7-12 °C

Delta T generator = 5 K

COP_{el} includes electricity consumption of fan and solution pump.

Outdoor testing



$A_{coll} = 20\ m^2$

$V_{storage} = 100\ l$

Optimization of solar loop

A. $m_{dot,sol}$ = 1.600 kg/h
- Pump consumption 125 W
- Incresed average generator temperaure
- Increased cooling power

B. $m_{dot,sol}$ = 860 kg/h
- Pump consumption 35 W
- Decresed average generator temperaure
- Decreased cooling power

Optimisation of fan control 02□012COPel

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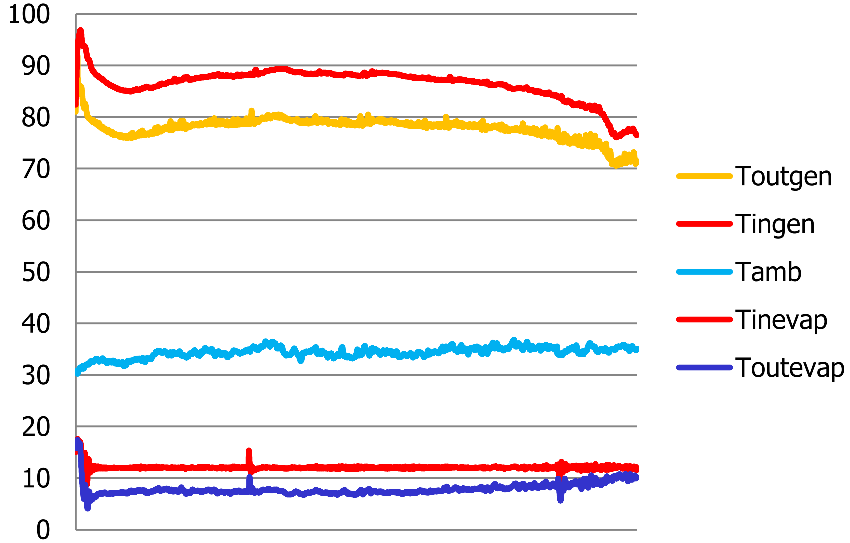
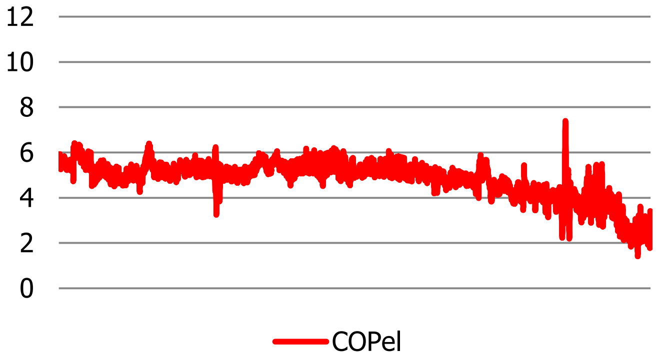
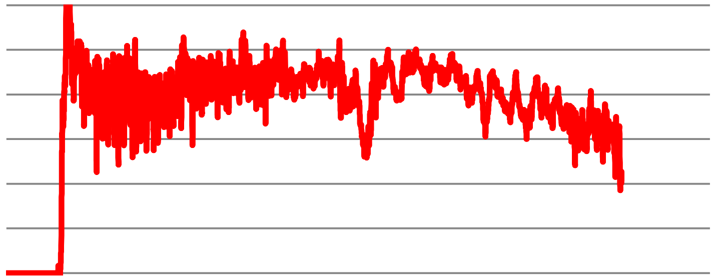




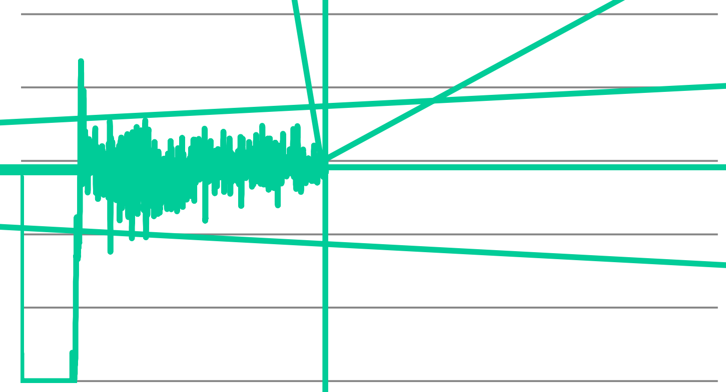


...available => DeltaTair as control parameter

Optimisation of fan control

Only T_{amb} available

T_{amb} and T_{cond} available => $DeltaT_{air}$ as control parameter



First lab test results with negative temperatures

T_{amb}	T_{gen}	$T_{out,evap}$	Q_{cold}	COP_{th}	COP_{el}
°C	°C	°C	kW	-	-
25,01	90,23	-7,18	1,783	0,243	6,73
22,00	90,13	-10,84	1,782	0,247	8,87
14,99	90,11	-14,89	1,593	0,24	10,15

Seasonal simulations with TRNSYS

$V_{storage}$	100 l	300 l
COP_{th}	0,306	0,297
COP_{el}	10,451	11,370
Q_{gen} [kWh]	7199,73	8470,586
Q_{evap} [kWh]	2351,80	2618,864
$Q_{fan\ coil}$ [kWh]	2281,11	2448,827
I_{coll} [kWh/m²]	977,25	977,249
A_{coll} [m²]	20	20
η_{coll}	36,8%	43,3%
Q_{el} [kWh]	290,107	301,580
Operation time [h]	946,50	994,50
$SCOP_{el}$	7,85	8,12
% h discomfort	7,9%	2,68%
% comfort covered	80%	86%
f_{PE}	55%	60%

Comfort: T_{in} = 26°C

Discomfort: T_{in} > 27,5°C

Location	Milano
Type of building	residential
Building surface	102 m²
Cooling period	15/04-15/10
Peak demand	3,03 kW
Energy demand	2857 kWh/year

$$PE_{sol} = \frac{Q_{backup}}{\eta_{boiler} \cdot \varepsilon_{fuel}} + \ldots$$

$$PE_{ref} = \frac{Q_{evap}\ldots}{SEER \cdot \varepsilon_{\ldots}}$$

$$SF_{cool} = 1 - \frac{Q_{ba\ldots}}{Q\ldots}$$

$$f_{PE} = 1 - \frac{PE\ldots}{PE\ldots}$$

$\varepsilon_{el,grid}$ = 0,45 e SEER=3,5

Conclusions

- A solar cooling system for small residential applications has been installed on a virtual consumer, using a prototype of H_2O/NH_3, air cooled, half effect absorption chiller;
- Through monitoring activities fan and solar pump control have been optimized in order to reduce electricity consumption. By reducing unnecessary «overventilation» cooling power output decreases slightly, but electricity consumption is significantly reduced.
- Electrical performance is higher than most existing solar cooling plants, mainly due to little auxiliaries needed and control optimization;
- A performance map of the chiller has been developed;
- Simulations show that the system could cover approx. 85% of cooling demand of a domestic user, saving 60% of primary energy;

- Further optimization of the chiller:
  - Further increase heat exchangers performance by increasing $HX_{surface}$ of better exploit available surface. Eventually experiment micro-channels HX.

- Further optimization of the system:
  - Build a solar cooling kit with commercial products (collectors, storage etc);
  - Optimize system’s control.

More information

- "Self adaptive refrigerant flow low temperature driven dual lift absorption cycle", M. Guerra, 10th IIR Gustav Lorentzen Conference on Natural Refrigerants, Delft, The Netherlands, 2012
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Thank you for your attention!

RELAB - Lab Facilities

Calibrated Calorimeter 20 kW
Appliances that can be tested:

EN14511 & EN14825 - **Air Conditioners, Heat Pumps and Chillers (***Air to Air – Air to Water– Water to Water (B/W) – Split & Packaged units***)**

EN 16147 - **Heat Pumps for Domestic Hot water production**

EN 1397 - **Hydronic terminals (** *fan coils – dry coolers)*

EN 12309 - **Gas Fired heat pumps**

EN 308 - **Air and flue gases heat recovery devices** ()

RELAB - Lab Facilities

Calibrated Calorimeter 20 kW

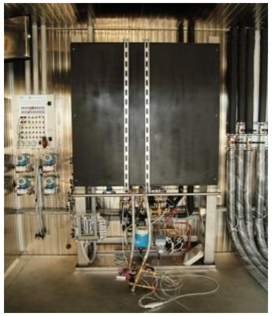
Operating Ranges :

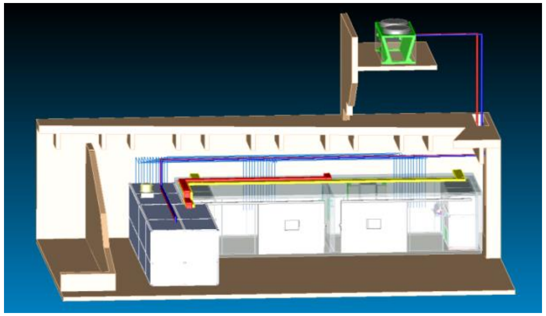
Outdoor Chamber

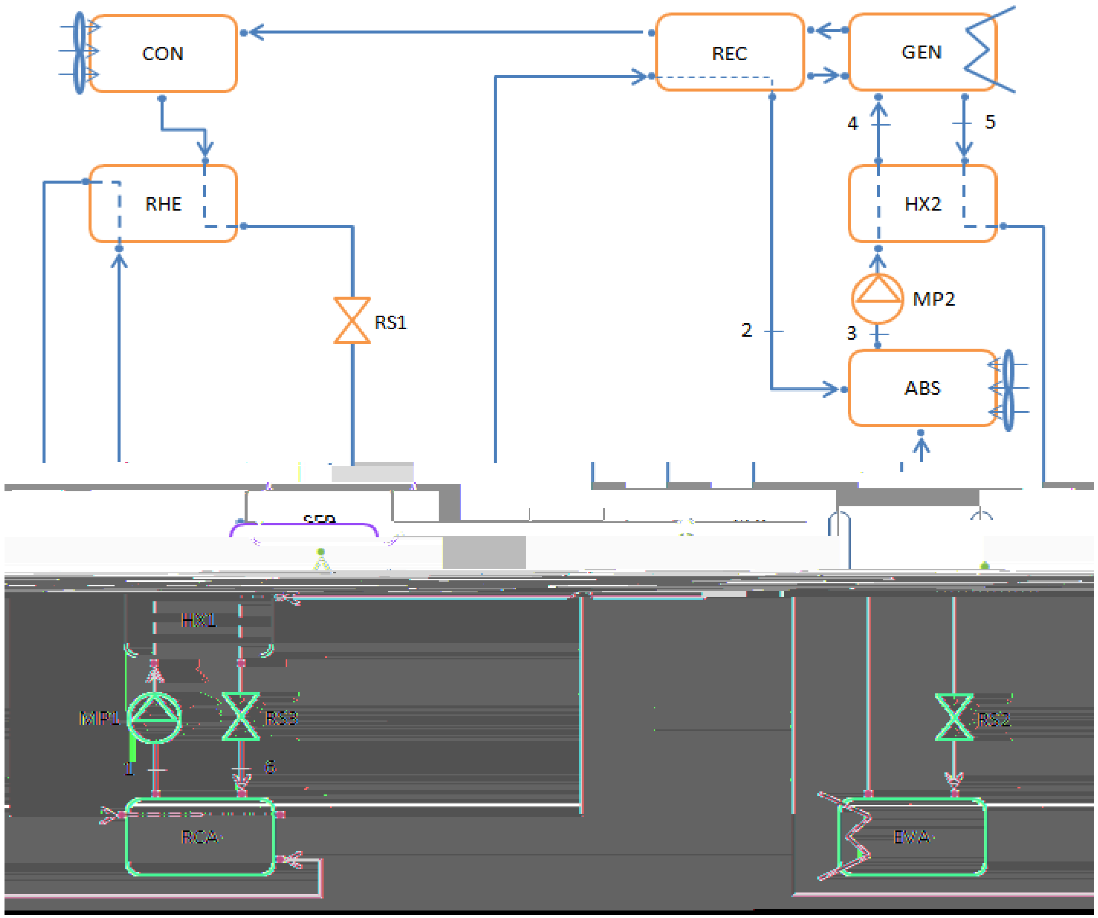
- Temperature range: -30 °C ÷ +60 °C
- Relative Humidity Range: 20% ÷ 95%
- Temperature range in which the humidity is controlled: -16 °C ÷ +46

Indoor Chamber

- Temperature range: +0°C ÷ +60°C
- Relative Humidity Range: 20% ÷ 95%
- Temperature range in which the humidity is controlled: +5°C ÷ +46°C







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