Monitoring and energy performance assessment of the compact DEC HVAC system “freescoo facade” in Lampedusa (Italy)

Alexander Thür – University of Innsbruck

On behalf of:

Authors: Marco Beccali[1], Pietro Finocchiaro[2], Biagio Di Pietra[3], Mario Motta[4]

1 University of Palermo, Palermo (Italy)
2 SolarInvent, Catania (Italy)
3 ENEA, Palermo (Italy)
4 Polytechnic of Milan, Milan (Italy)

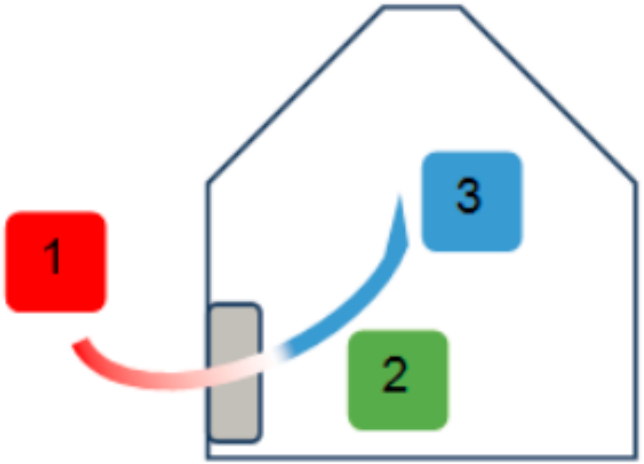
IEA SHC Task53 Workshop – Graz / Austria – Oct 3rd, 2018

What is freescoo?

Freescoo is an innovative solar DEC air conditioning concept designed for **ventilation, cooling, dehumidification** and **heating** of buildings in residential and tertiary sectors.

Schematic view of: **1** – ouside ambient air; **2** – inside room air; **3** – supply air.

Conventional split system



Freescoo system

WHAT IS FREESCOO?

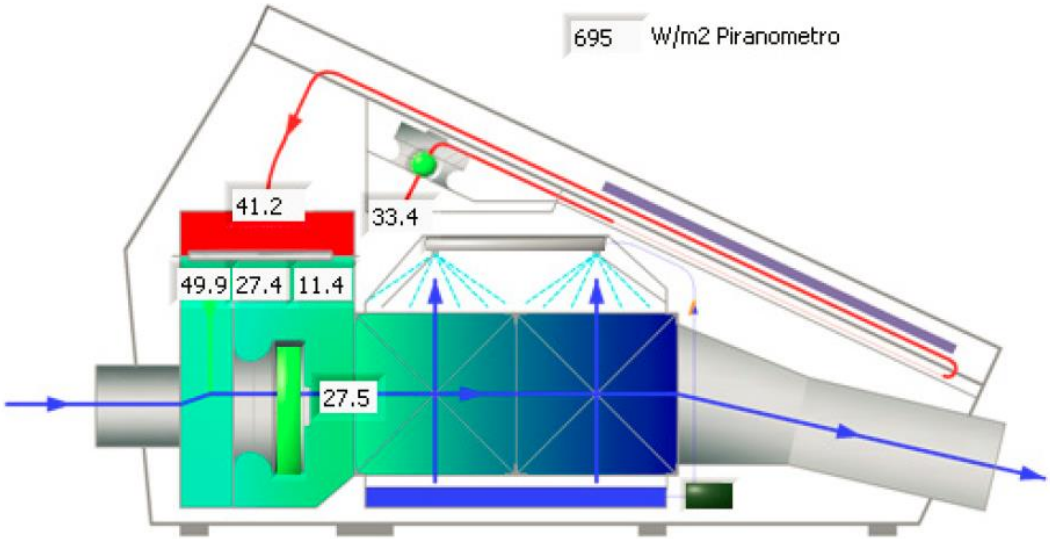
SELECTED for the EeB PPP Promising Technology Brochures 2018 by ECTP

Freescoo is an innovative solar DEC air conditioning concept designed for **ventilation**, **cooling**, **dehumidification** and **heating** of buildings in residential and tertiary sectors. Main features of the concept are:

- Use of water as refrigerant and heat as main energy input
- Use of the Cooled Packed Bed (CPB) technology and high efficiency evaporative cooling concepts
- Low grade solar heat (50-60°C) to drive the cooling process
- High global electrical efficiency (Typical EER >10)
- Preassembled and ready to be installed
- Several system configurations possible

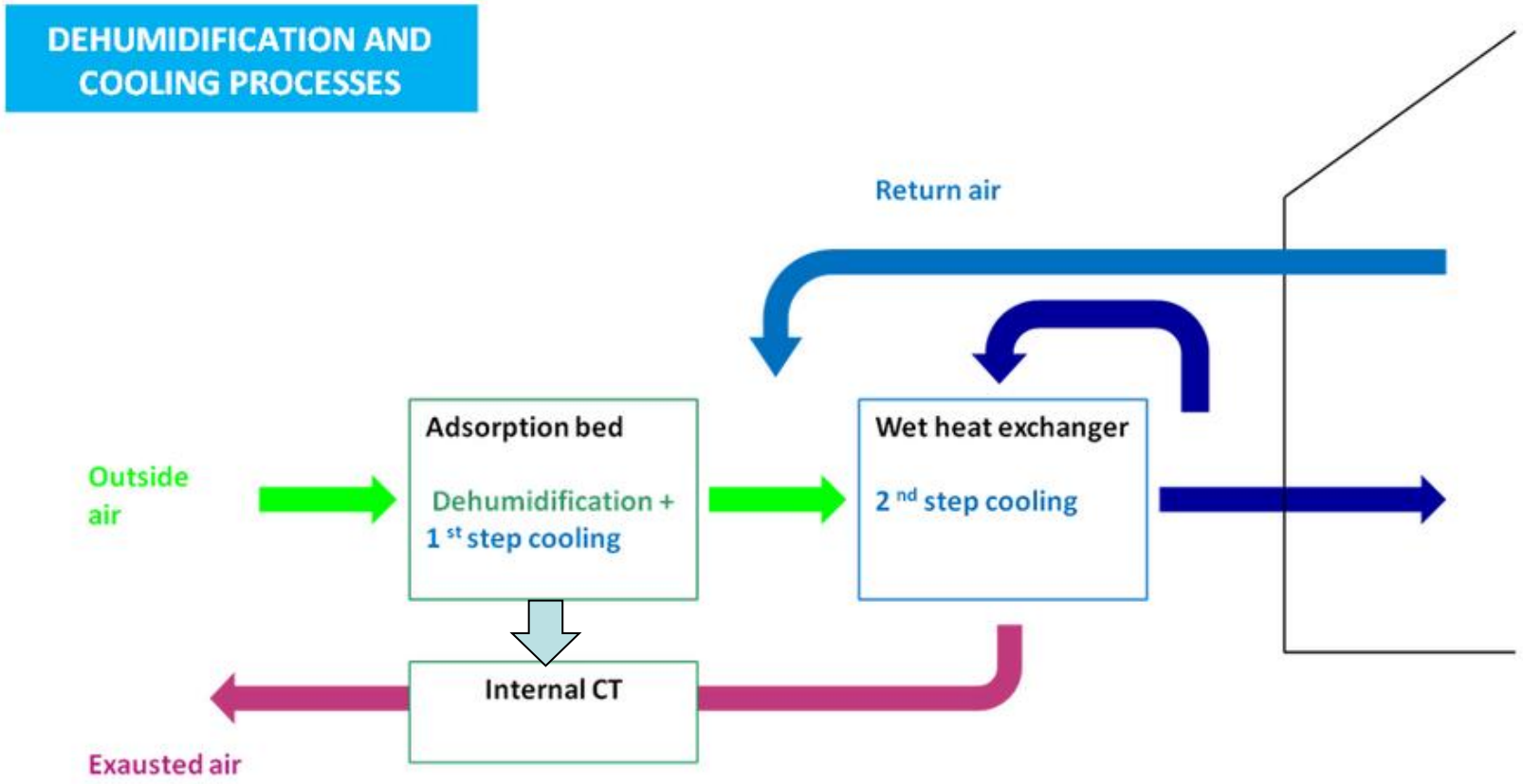
Freescoo is a patented solution by the startup company SOLARINVENT

What is freescoo?



How does freescoo work?

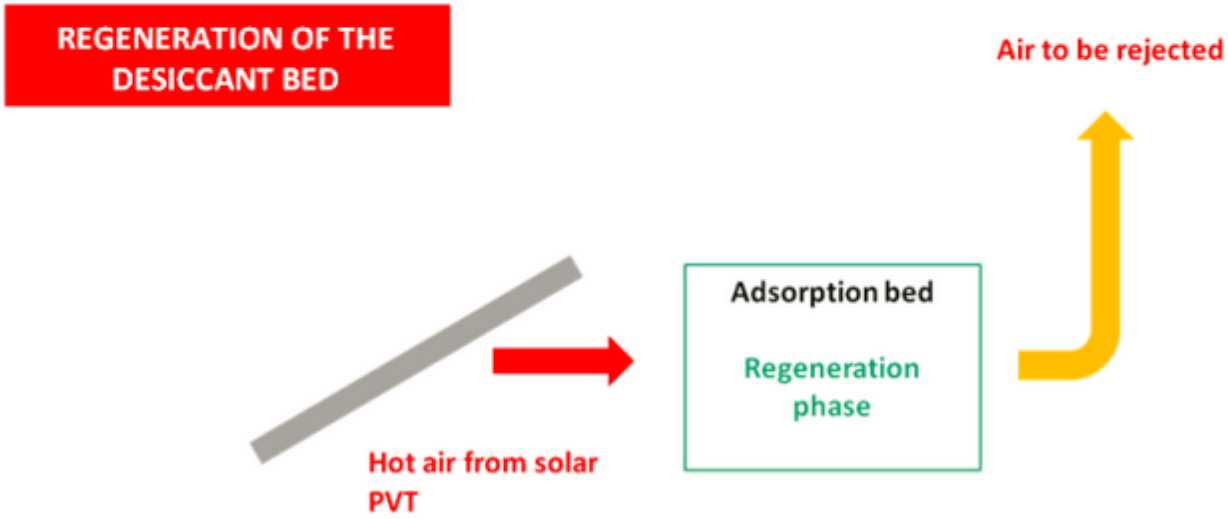
- in first phase external hot and wet air is dehumidified thanks to the passage through **CPB (Cooled Packed Bed)**; now air is dry with a similar temperature;
- in second phase air is cooled thanks to an evaporative cooling system using an air to air heat exchanger. Typical delivery temperatures of the system are 18-20°C;



How does freescoo work?

Why heat is used?

After hours of working sorbent material reach the maximum moisture content. To continue dehumidification it has to be *"regenerated"* heating and drying sorbent material with hot air. The heat, thanks to **CPB** technology does not require high temperature, so can be produced easily by commercial solar collector (**air or liquid**).



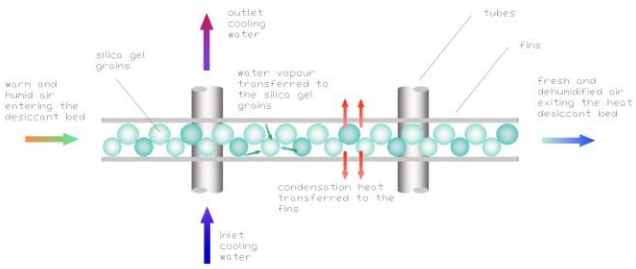
COMPARISON OF THE ADSORPTION PROCESSES

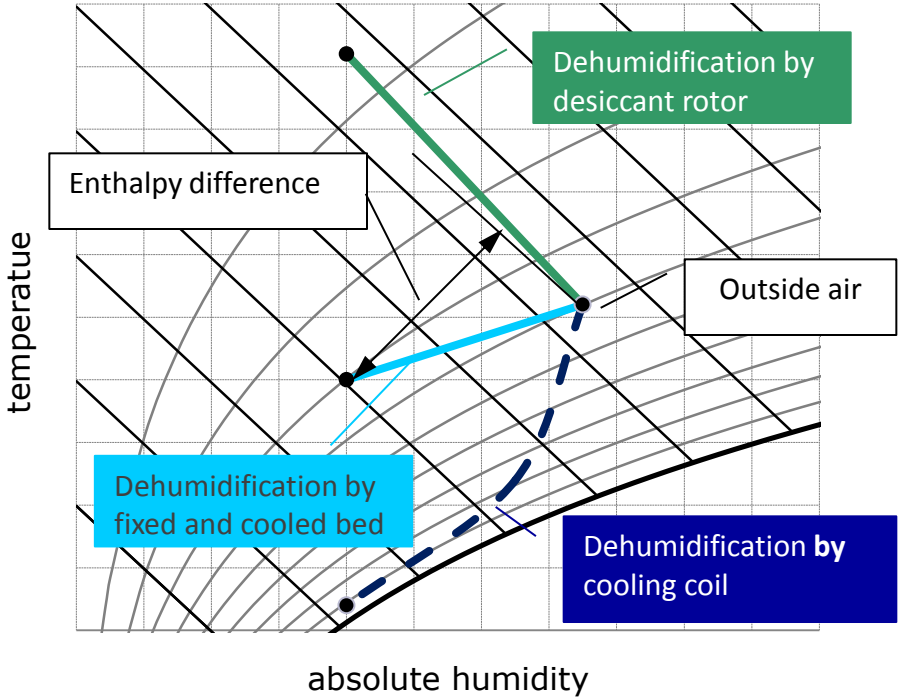
Dehumidification by desiccant rotor

- Adsorption process realized by means of desiccant rotors is a quasi – isoenthalpic transformation
- It presents the disadvantage of causing a temperature increase of the desiccant material
- No enthalpy difference between in and out

Dehumidification by fixed and cooled desiccant bed

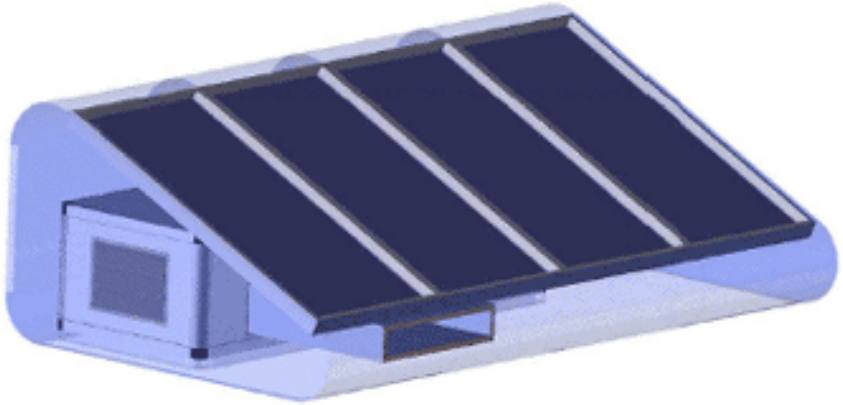
- Adsorption heat can be rejected
- The thermodynamic process causes an enthalpy difference between inlet and outlet air conditions
- In general, the temperature of air exiting the adsorption bed can be lower than the one of incoming air
- Downstream indirect evaporative cooling process can operate at low temperature





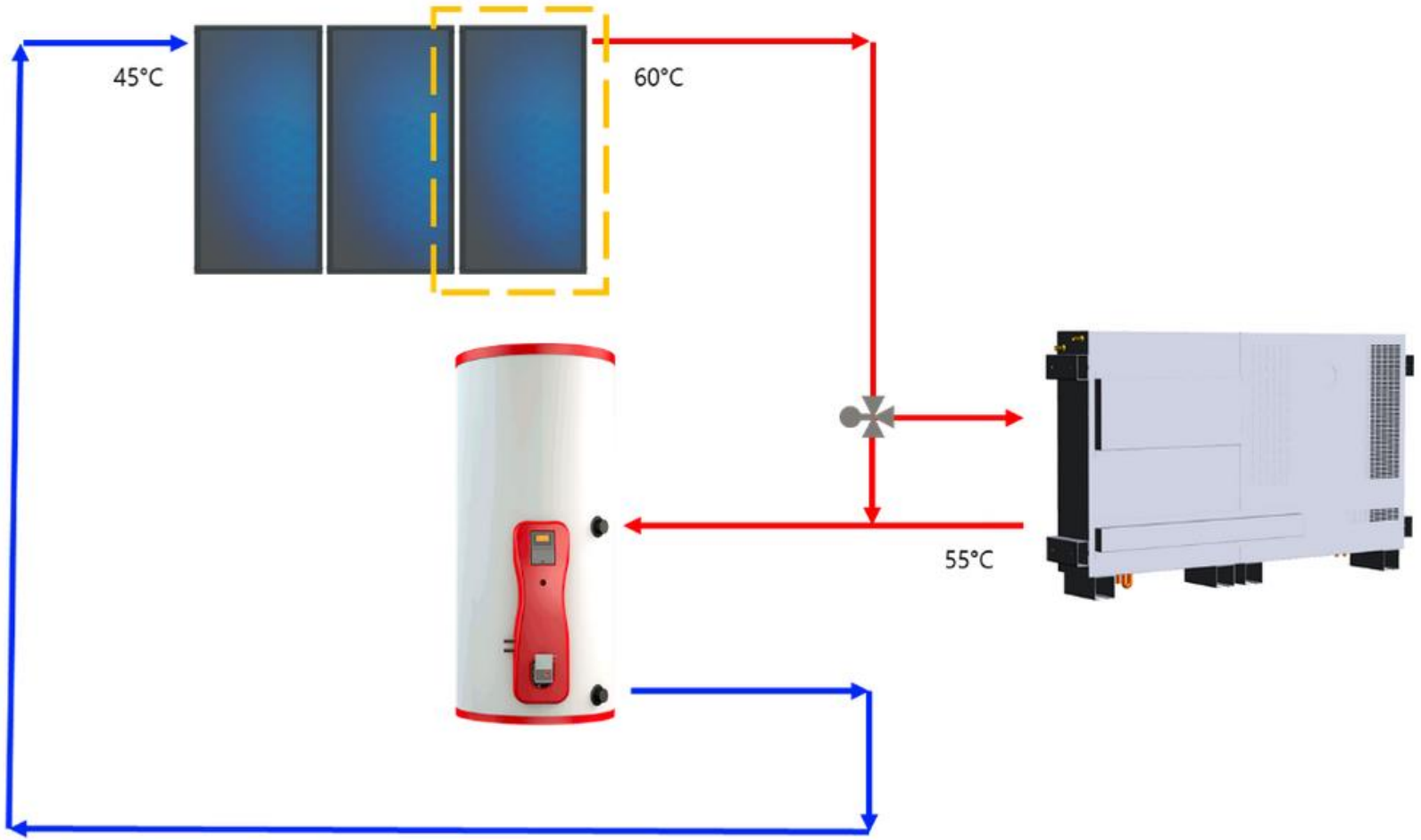
freescoo - demonstration systems

Marrakech:
Ventilation: 1500 m3/h
Cooling: 6.2 kW
Water consumption: 2 L/kWh

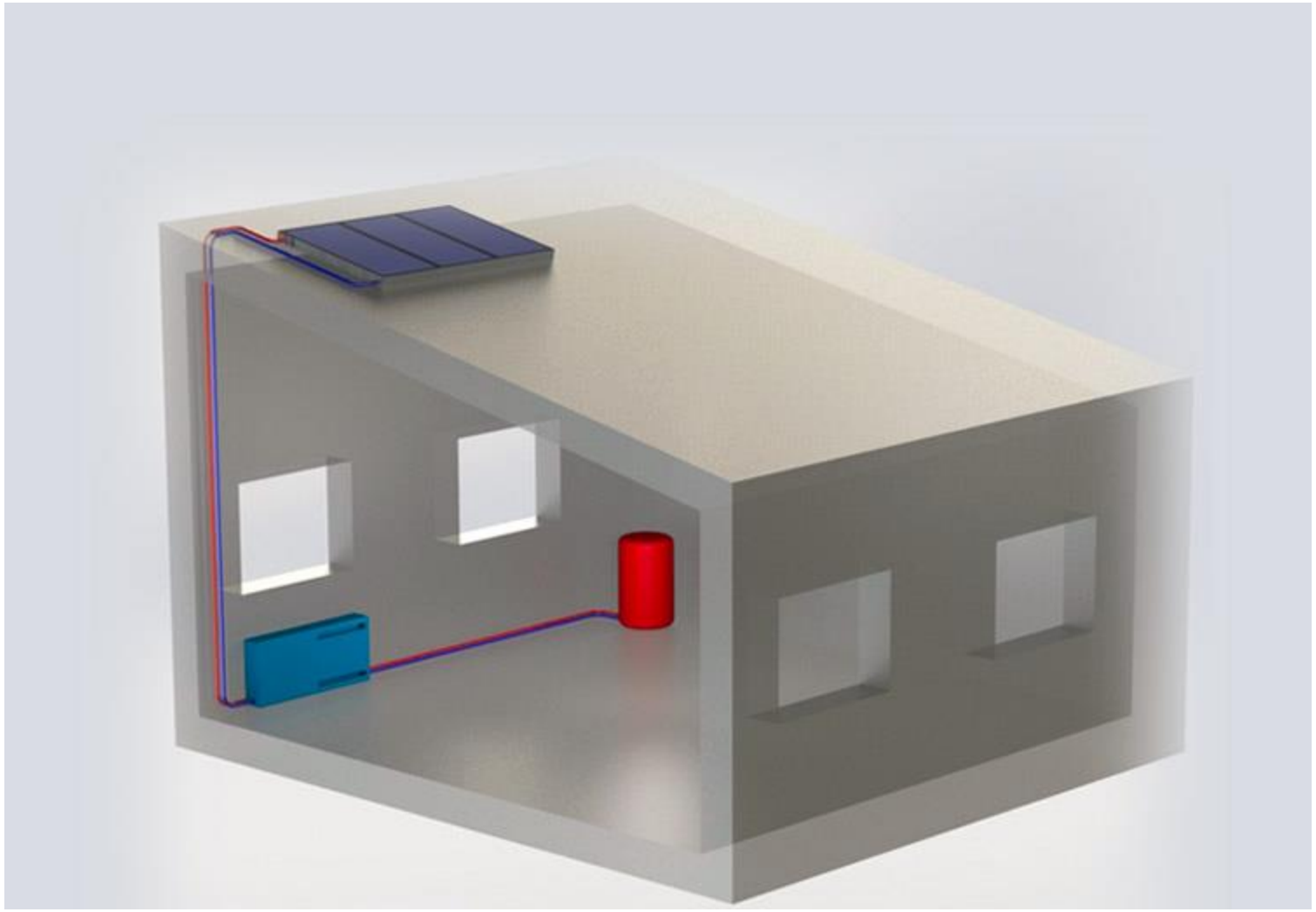


freescoo – split system including solar domestic hot water

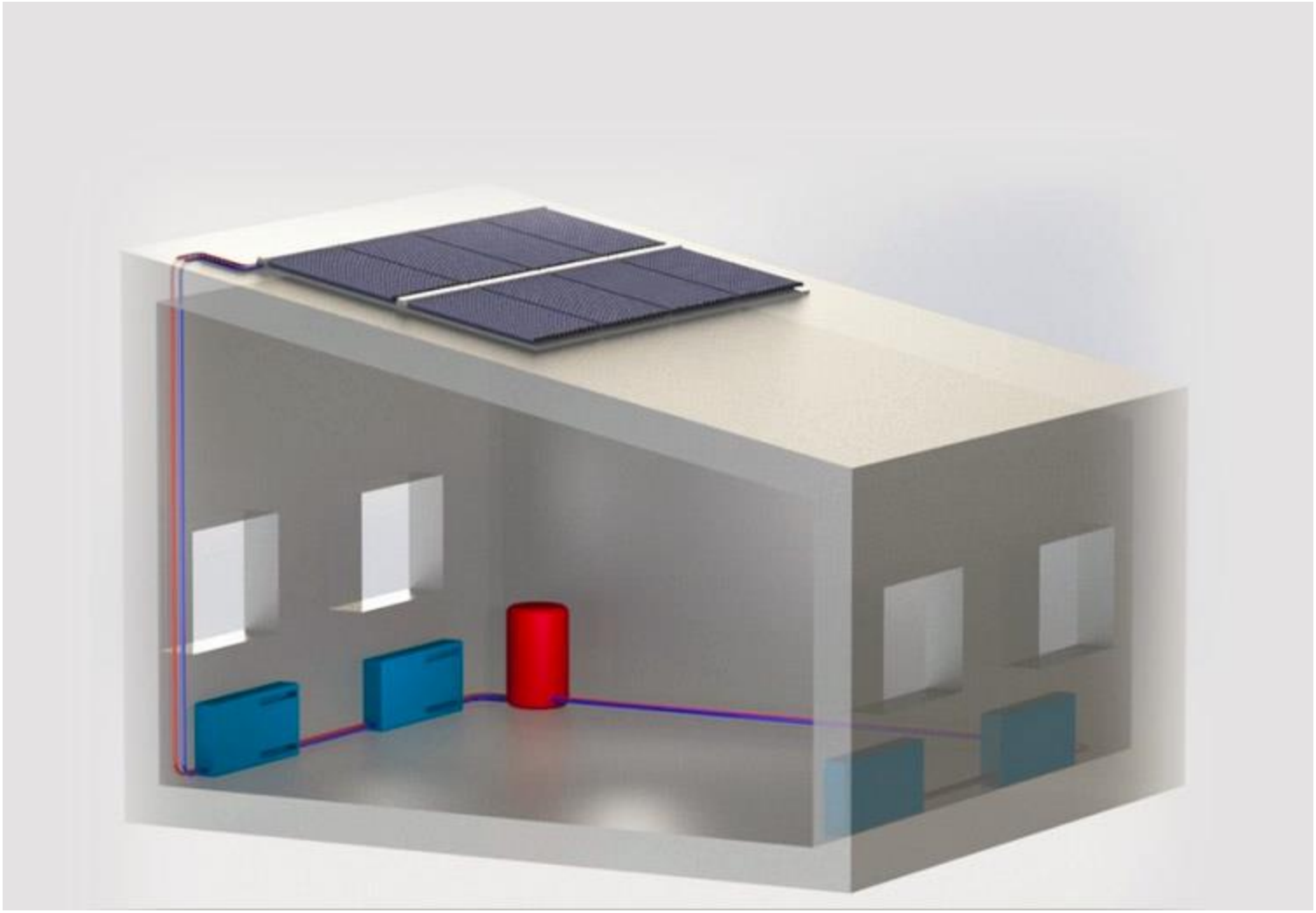
Example of freescoo facade system configuration



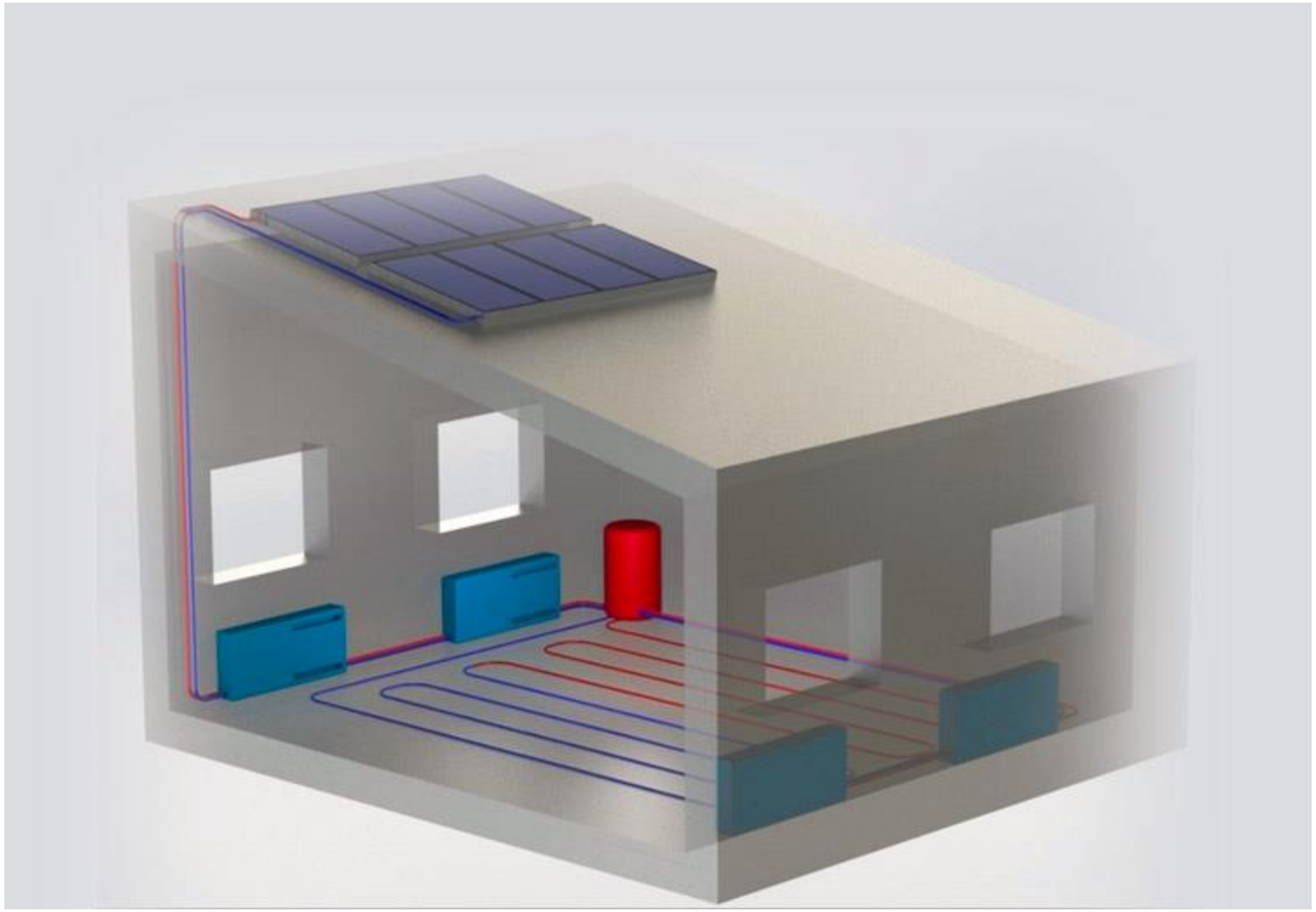
freescoo – split system including solar domestic hot water



freescoo – split system including solar domestic hot water and space air heating



freescoo – split system including solar domestic hot water and space floor heating

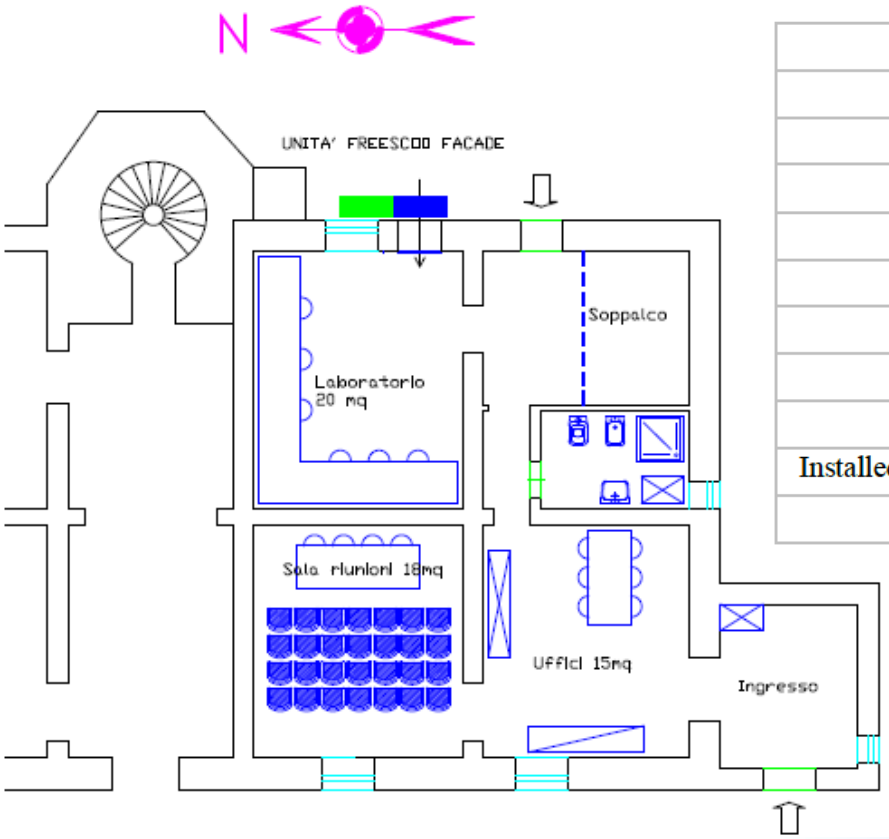


DESCRIPTION OF THE PROJECT

The location: Lighthouse at Lampedusa island
Latitude: 35° 30’ N
Longitudine: 12° 36’ E

freescoo unit

DESCRIPTION OF THE PROJECT

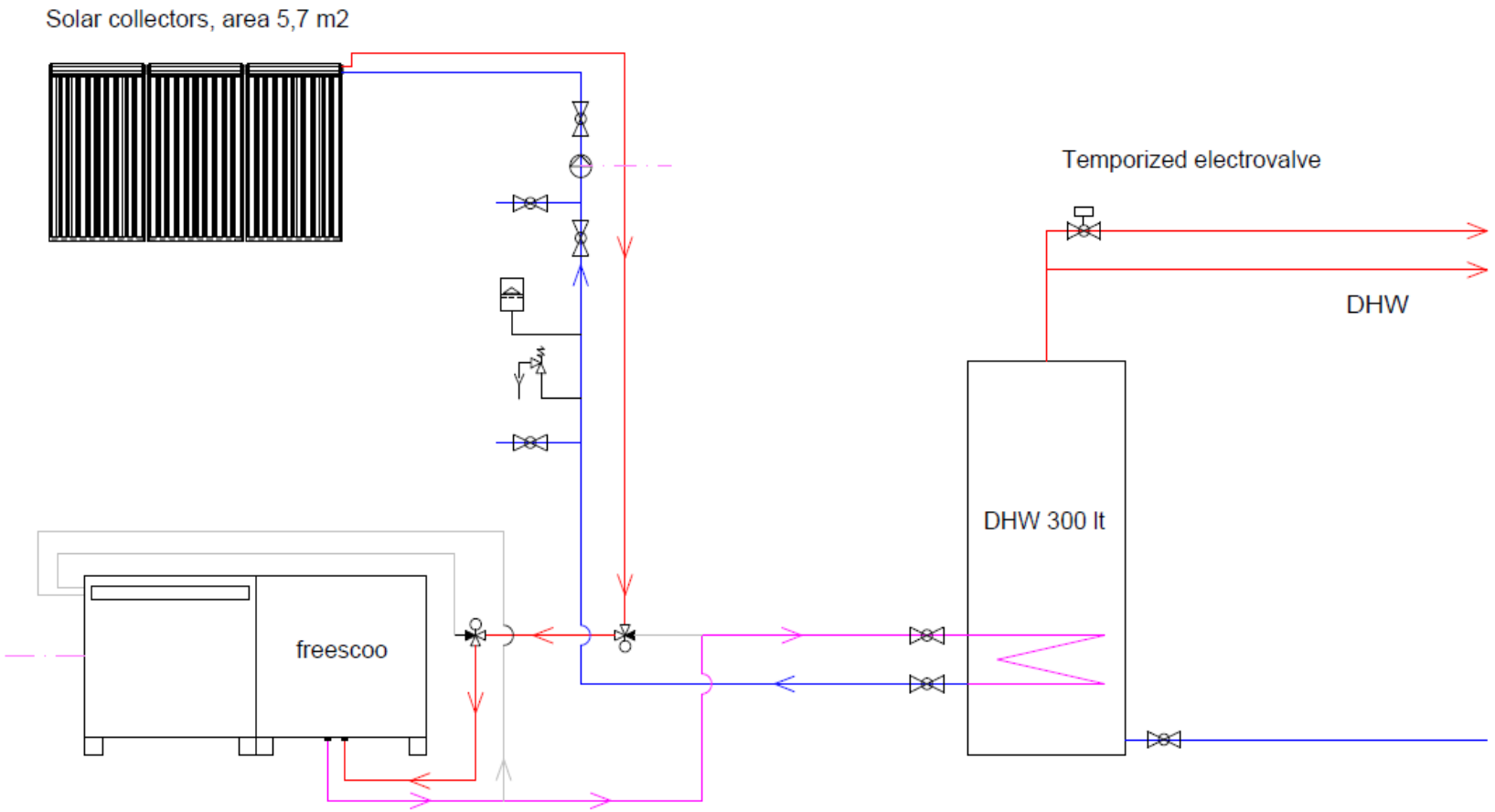


Description	Value	Unit
Volume of the conditioned space	140	[m^3]
Supply air flow rate	0-500	[m^3/h]
Rate of fresh air	30-50	[%]
Total max cooling power	2,5	[kW]
Heating power required for the regeneration	2,5	[kW]
Max Power absorbed	200	[W]
Rated EER for cooling	12,5	[-]
Solar collector area	3 x 1,91	[m^2]
Installed solar collector power (including DHW production)	3,6	[kW]
Volume of DHW storage tank	300	[lt]

Design for façade integration

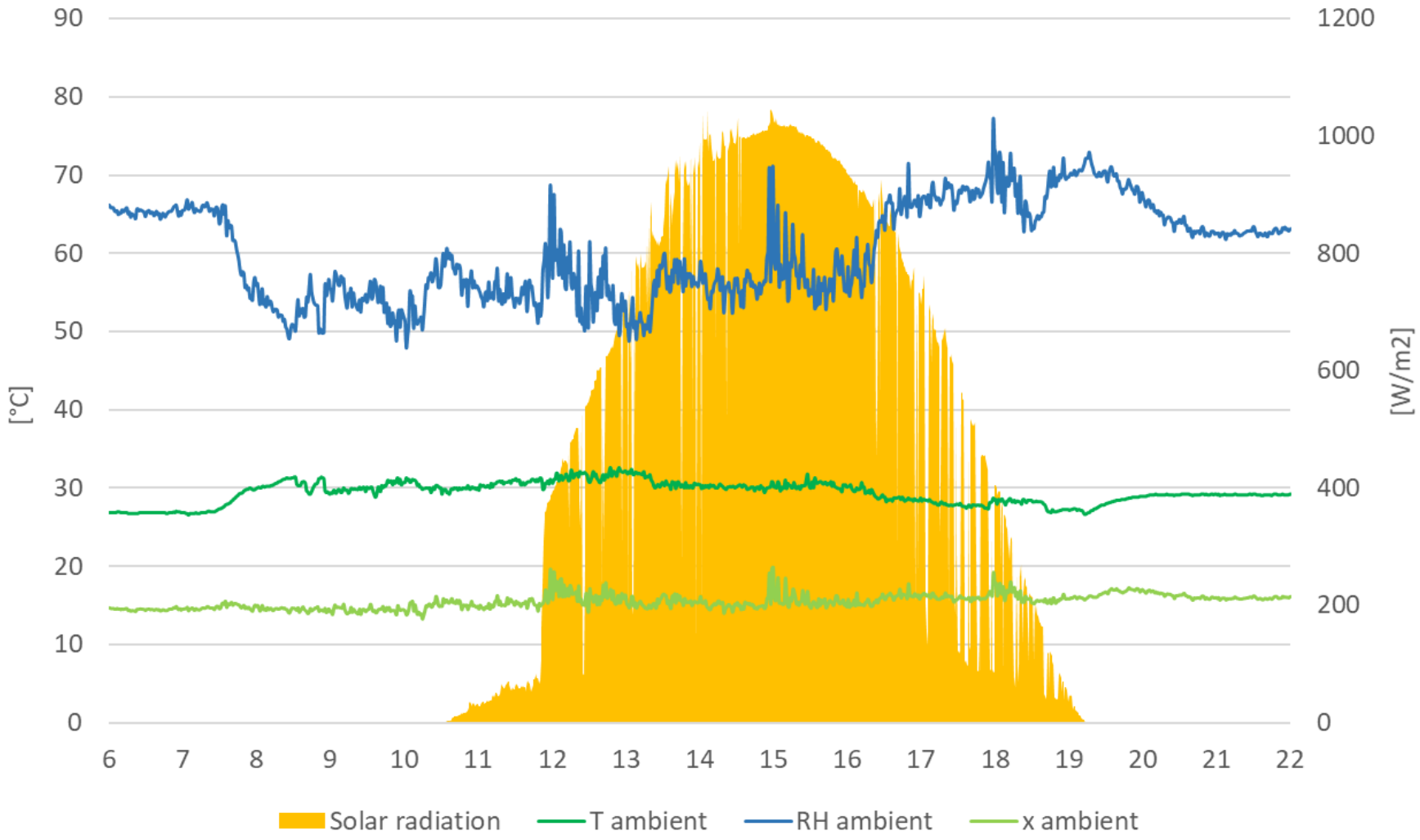
FREESCOO AT ENEA REASERCH CENTRE IN LAMPEDUSA (ITALY)

3 x XRAY 10 evacuated tube solar collectors by PLEION



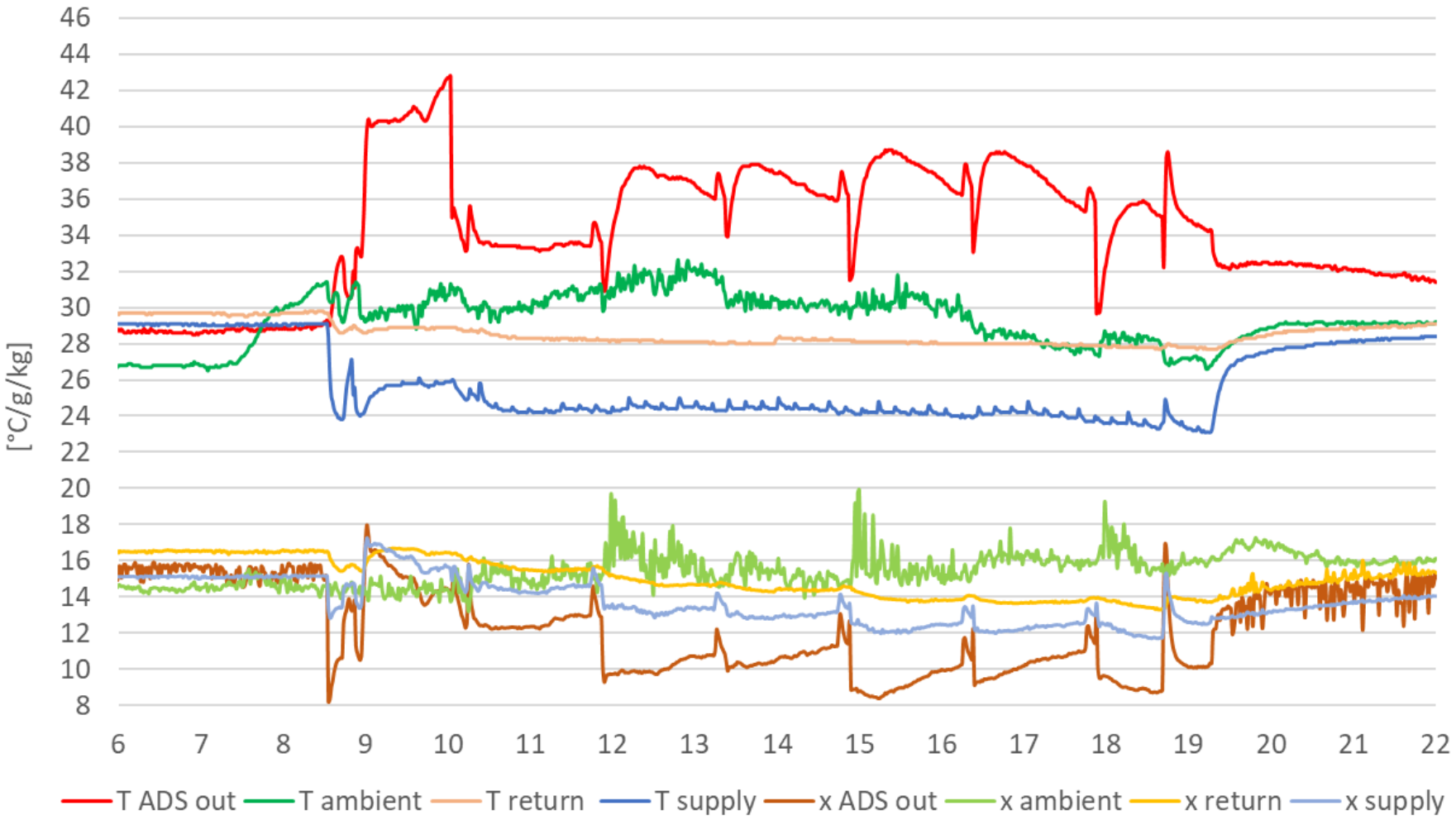
INSTANTANEOUS AND DAILY AVERAGE PERFORMANCE

RESULTS FOR DAY 17



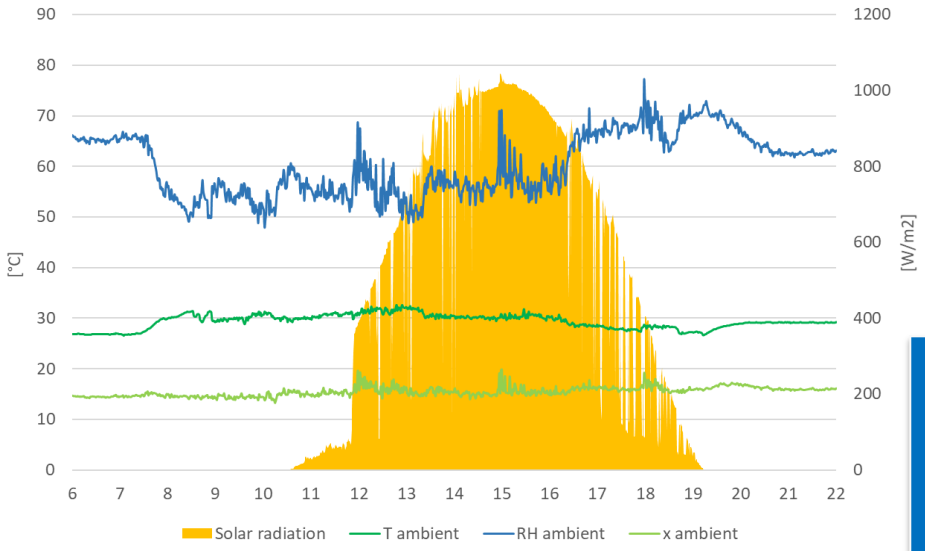
INSTANTANEOUS AND DAILY AVERAGE PERFORMANCE

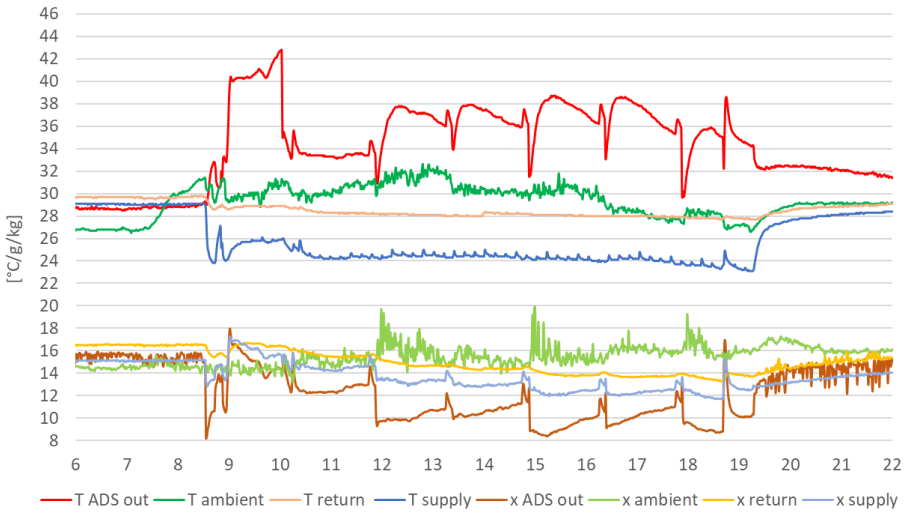
RESULTS FOR DAY 17



INSTANTANEOUS AND DAILY AVERAGE PERFORMANCE

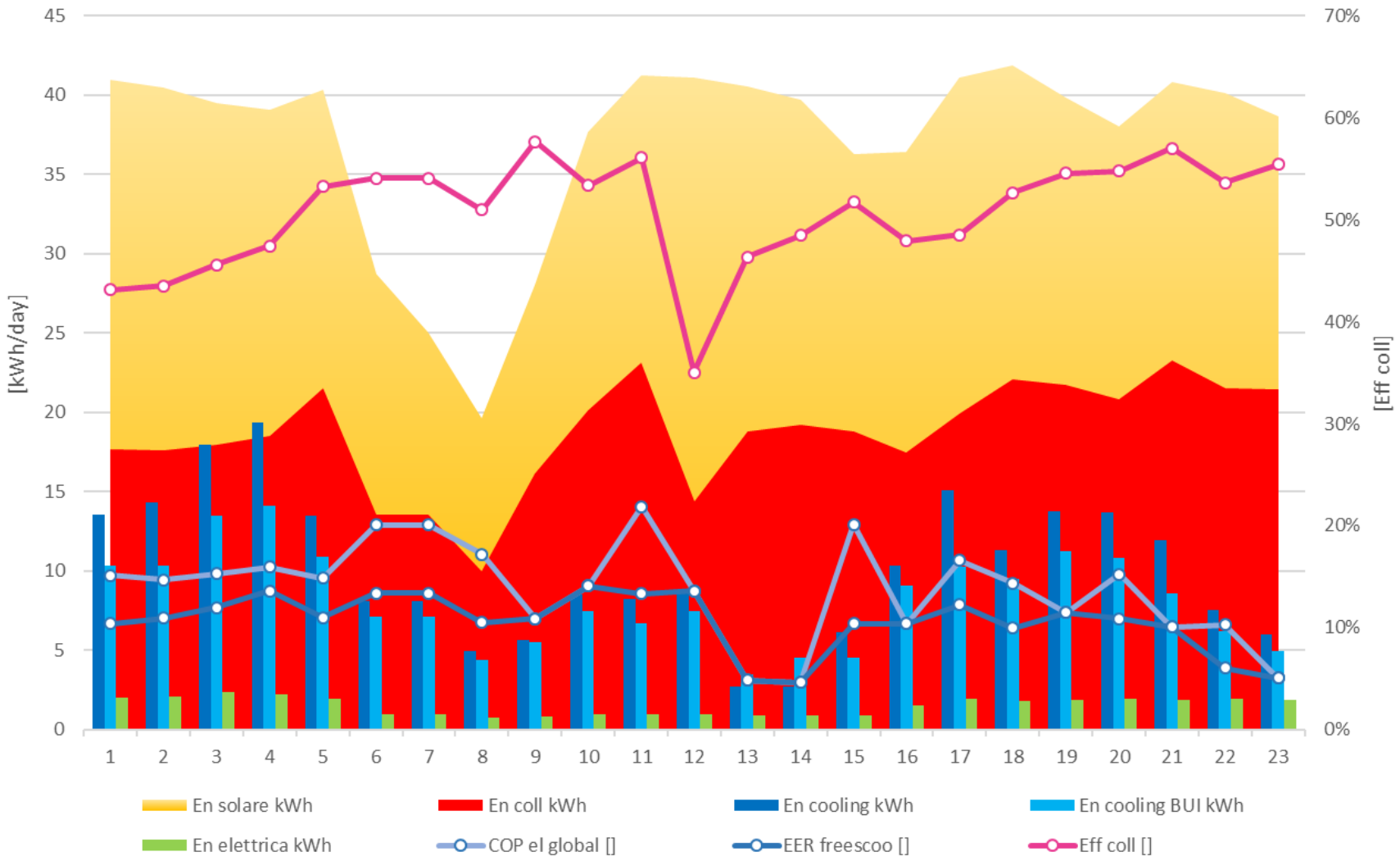
RESULTS FOR DAY 17



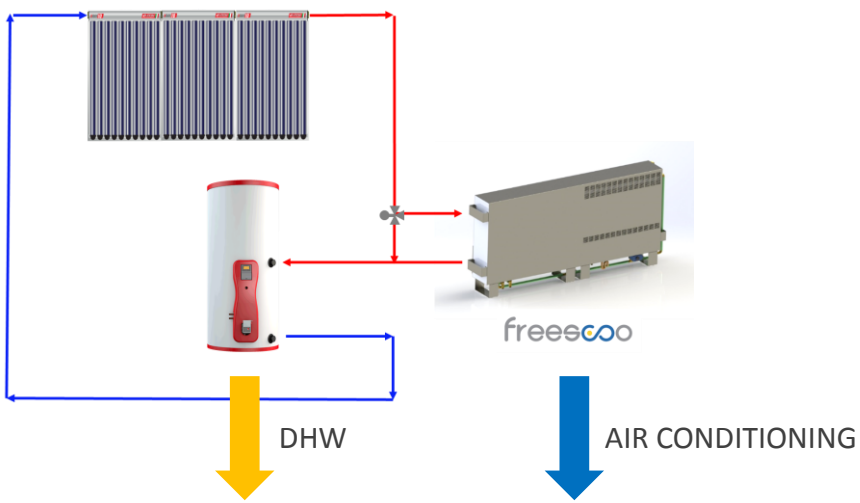


Description	Value	Unit
Cooling energy – due to air handling	15,1	[kWh]
Cooling energy – to the building	10,3	[kWh]
Incident solar radiation	41,1	[kWh]
Solar collector heat	19,9	[kWh]
Electricity consumed	1,9	[kWh]
Total water consumption for cooling	26,8	[l]
Total hours of operation	10,6	[h]
Total DHW consumption	155	[l]
Global electrical COP (HVAC + DHW)	10,7	[-]
EER (freescoo HVAC)	7,9	[-]
COP th (freescoo HVAC)	1,3	[-]
Solar collector efficiency	48	[%]

MID-TERM ENERGY PERFORMANCE (23 DAYS IN AUGUST 2018)

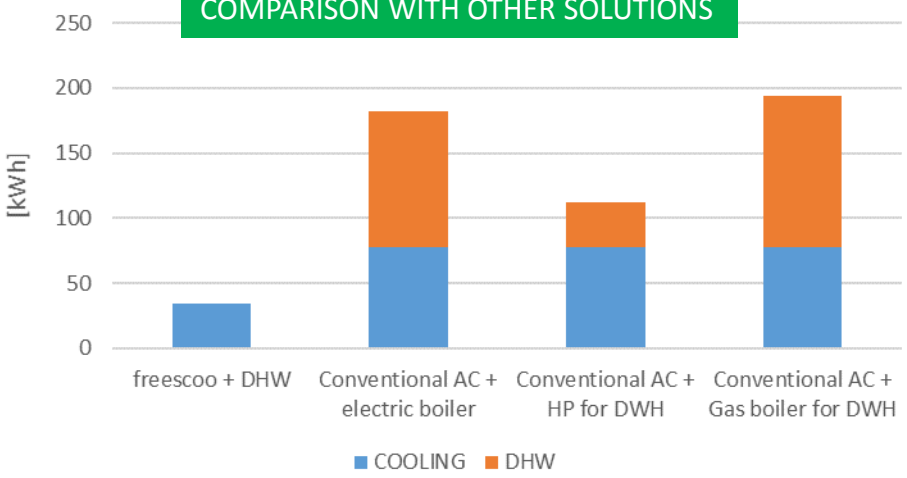


SUMMARY OF THE ENERGY PERFORMANCE



Description	Value	Unit
Cooling energy – due to air handling	232	[kWh]
Cooling energy – to the building	188	[kWh]
Incident solar radiation	855	[kWh]
Solar collected heat	429	[kWh]
Solar heat used for regeneration of the desiccant	197	[kWh]
Solar heat used for DHW preparation	105	[kWh]
Electricity consumed	34	[kWh]
Total water consumption for cooling	450	[l]
Mean daily water consumption	19,5	[l/day]
Total hours of operation	230	[h]
Mean daily hours of operation	10	[h]
Total DHW water consumption	1480	[l]
Global electrical COP (HVAC + DHW)	9,8	[-]
EER (freescoo HVAC)	6,8	[-]
COP th (freescoo HVAC)	0,96	[-]
Solar collector efficiency	50,2%	[-]

COMPARISON WITH OTHER SOLUTIONS



ASSUMPTIONS FOR THE CALCULATIONS

Operation hours in cooling mode	230	[h]
LHV for gas	9.6	[kWh/sm^3]
EER cond conv	3	[-]
HP for DHW	3	[-]
Gas boiler efficiency	90%	

CONCLUSIONS

- This test was particularly hard concerning ambient conditions
- Its performance was influenced by the high ambient humidity which cannot be handled properly with the actual size of the dehumidification stage and, in general by an undersizing of the machine
- The system operated quite well in terms of energy efficiency but it was not adequate in providing proper comfort conditions
- Coupling of HVAC and DHW looks a good option while heat can be taken from the storage altough it is in series downward the freescoo machine

Thank you for your attention

Alexander Thür – University of Innsbruck

On behalf of:

Authors: Marco Beccali[1], Pietro Finocchiaro[2], Biagio Di Pietra[3], Mario Motta[4]

1 University of Palermo, Palermo (Italy)
2 SolarInvent, Catania (Italy)
3 ENEA, Palermo (Italy)
4 Polytechnic of Milan, Milan (Italy)