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

Marco Beccali - University of Palermo

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Task 53

WHAT IS FREESCOO?

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

PRODUCT EVOLUTION AND CONFIGURATIONS

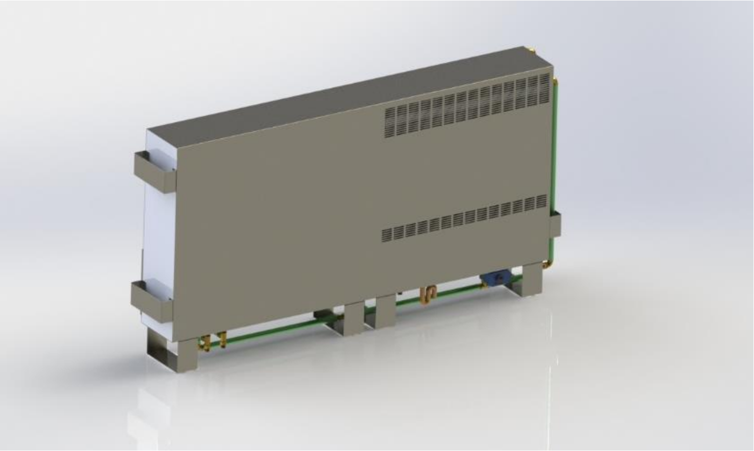
freescoo 1.0

freescoo 2.0

solarINVENT

freescoo Air handling unit

freescoo facade



COMPARISON OF THE ADSORPTION PROCESSES

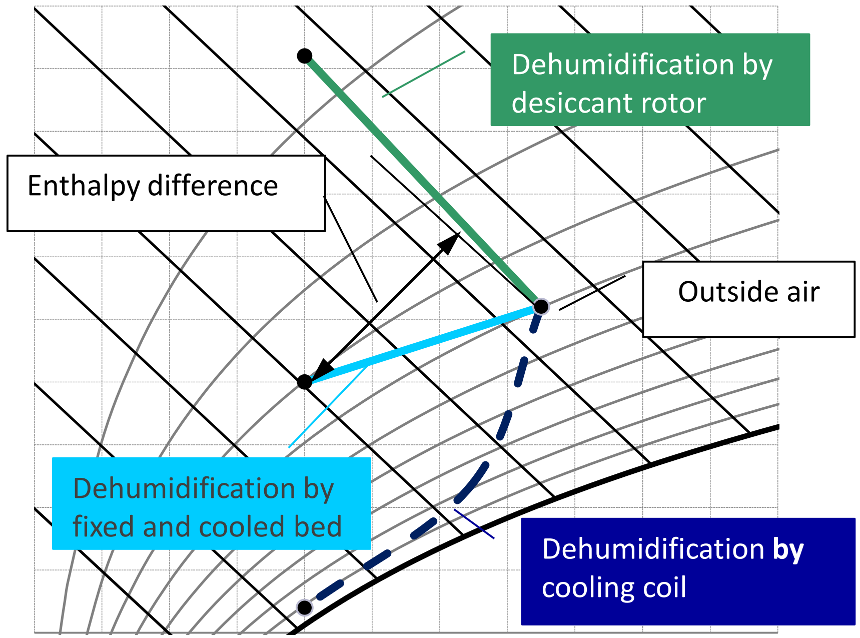
Dehumidification by desiccant rotor

- 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

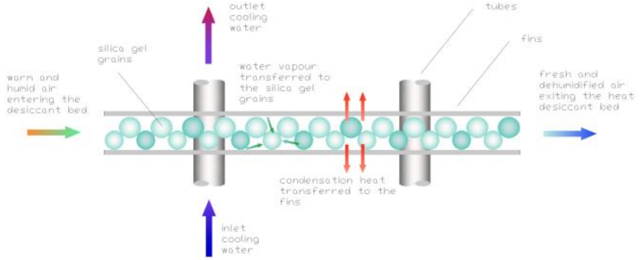
Dehumidification by fixed and cooled desiccant bed

- 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

temperatue



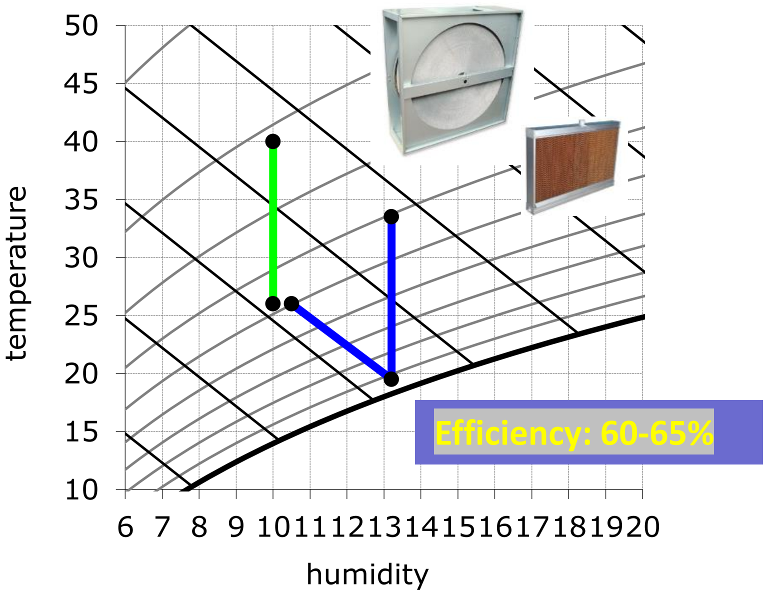
absolute humidity

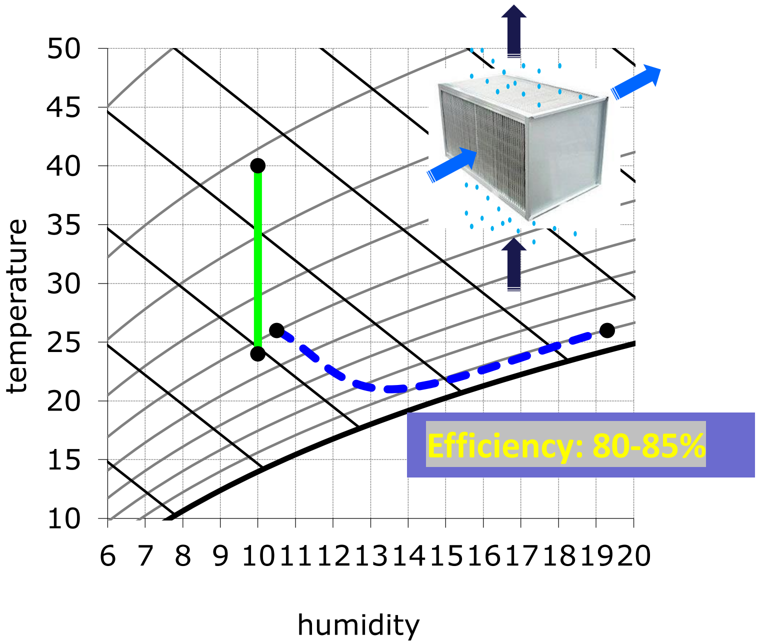


INDIRECT EVAPORATIVE COOLING: COMPARISON OF THE SOLUTIONS

- **Humidification inside** the heat exchanger **not possible**
- Secondary air flow passing through the channels rapidly increases its temperature

- **Humidification inside** the heat exchanger **possible**
- the temperature of the secondary air is close to the local wet-bulb temperature of the air stream which increases gradually during the humidifying process





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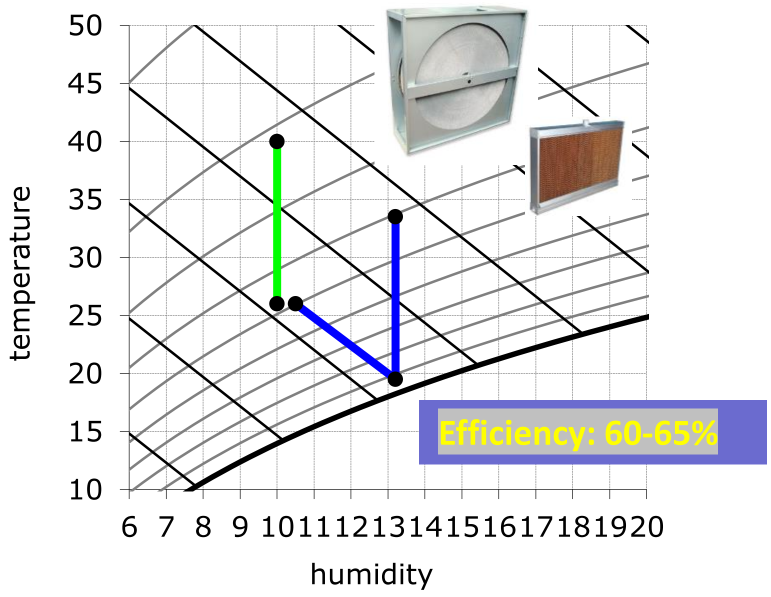

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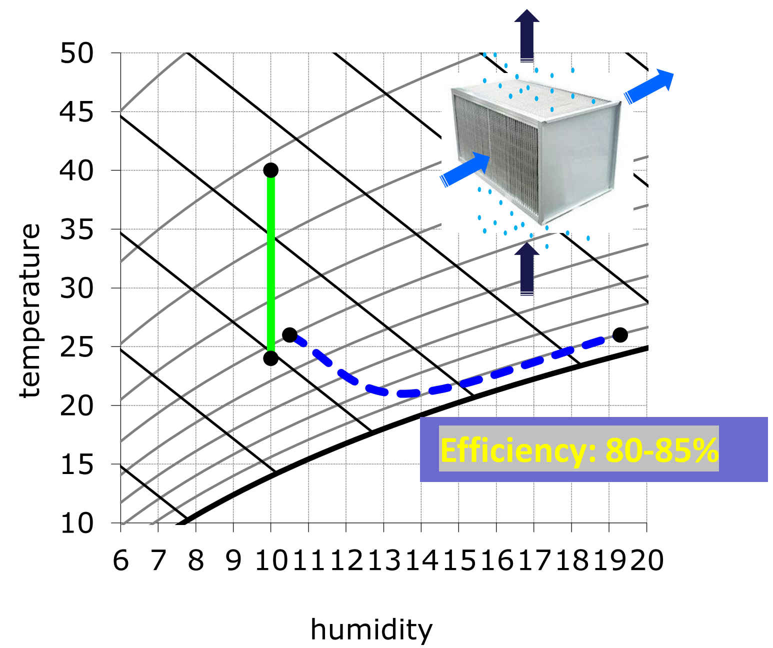
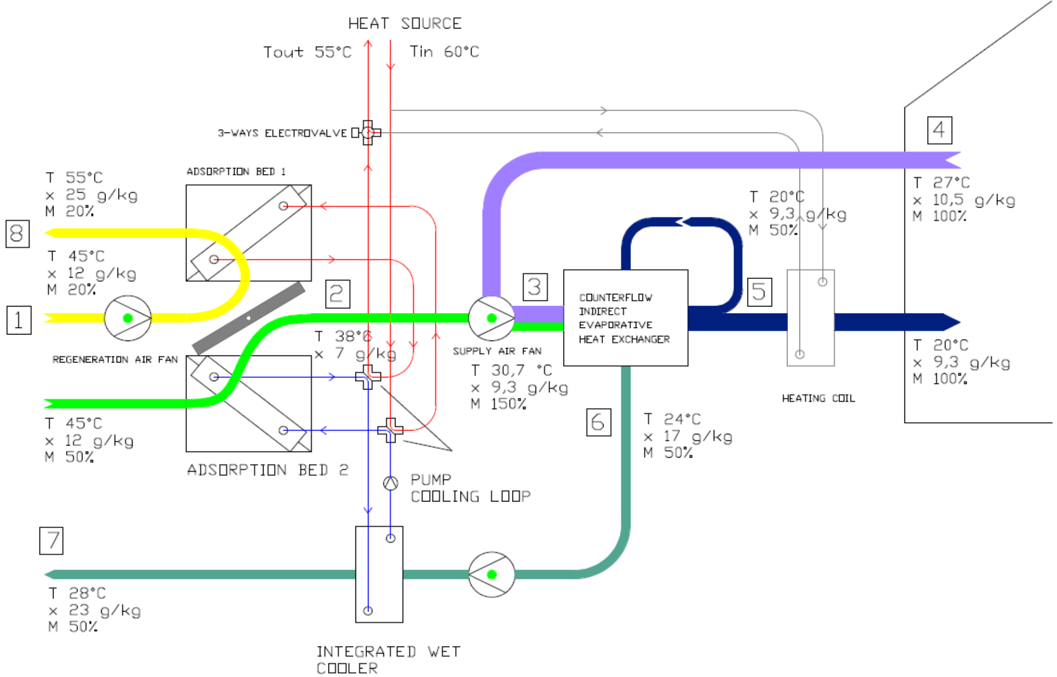
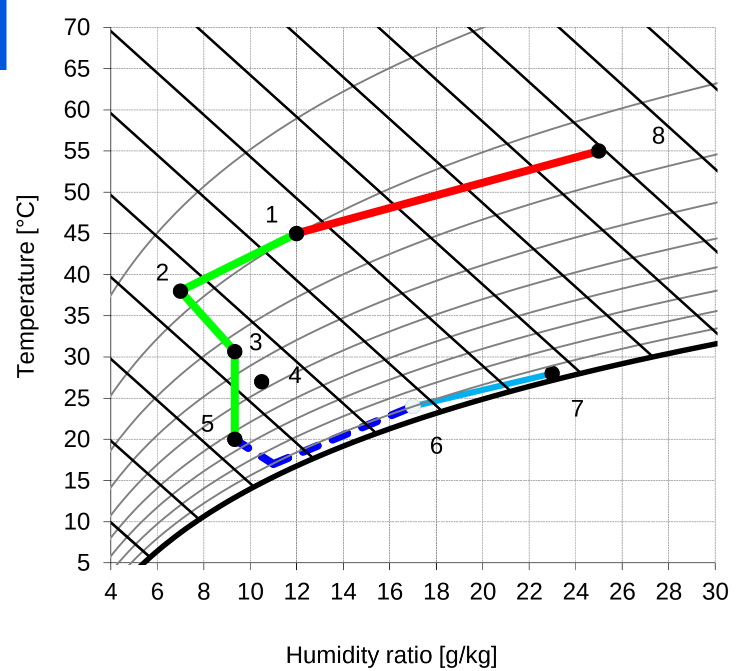
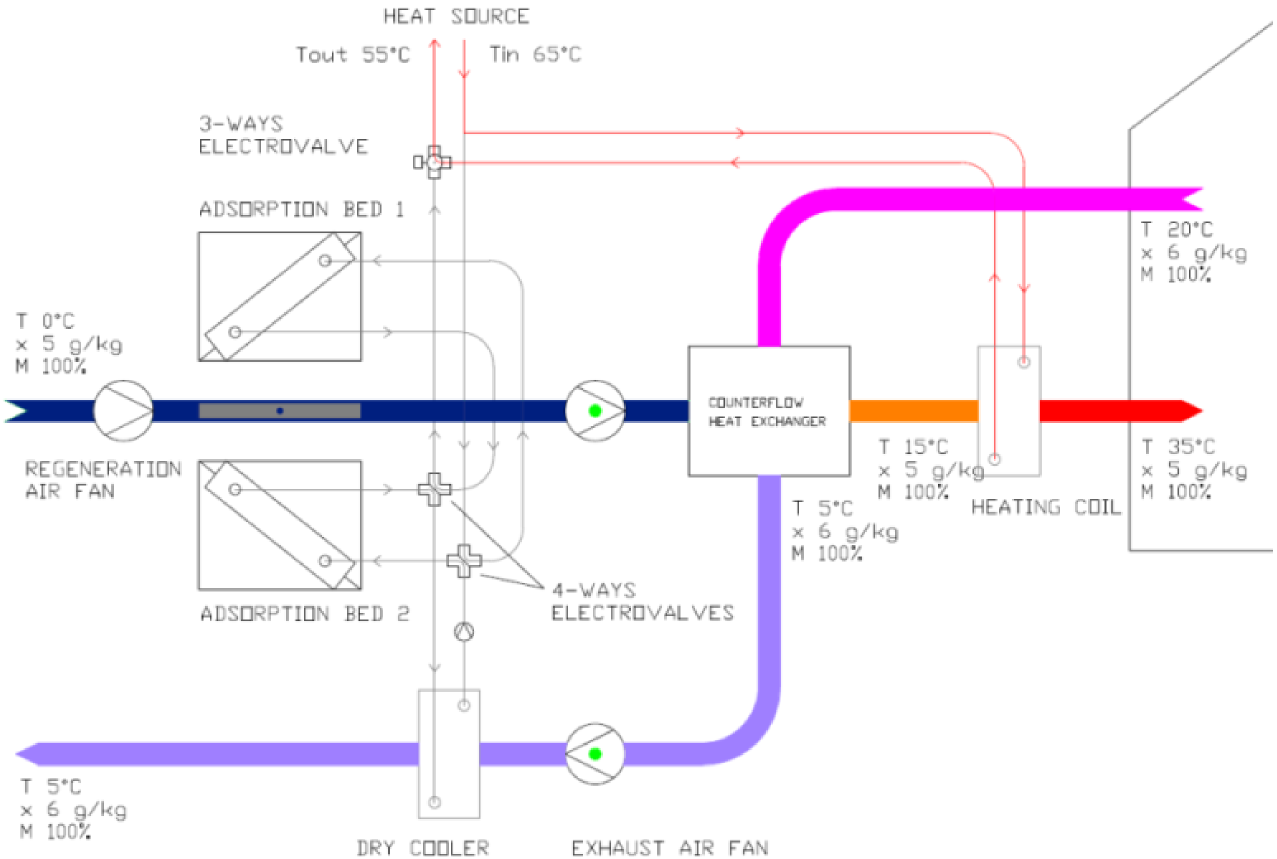






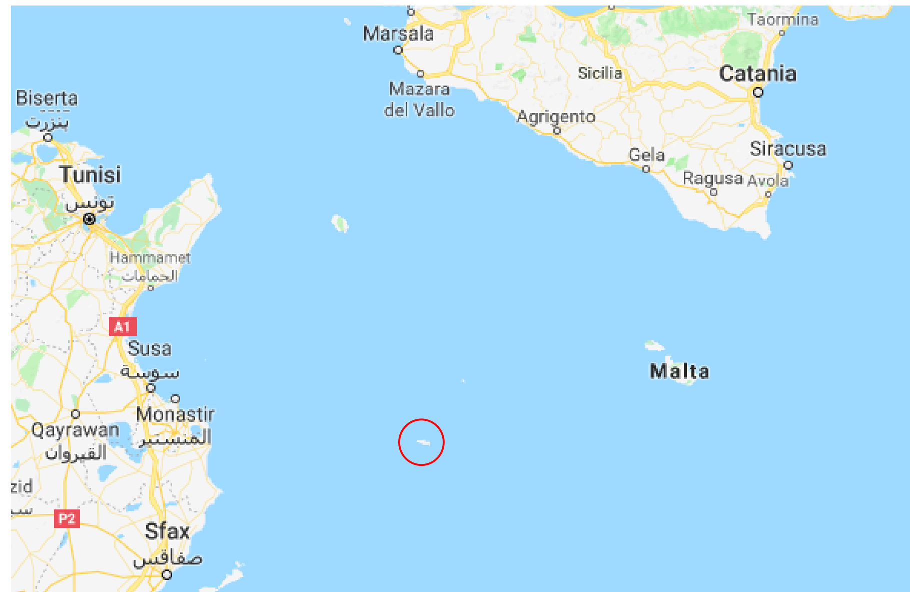
Description	x	T	h	Pos.
-	g/kg	°C	kJ/kg	-
Outside air	12	45.0	76.2	1
Outlet ADS bed	7.0	38.0	56.2	2
Mixing	9.3	30.7	54.7	3
Outlet EVA HX	9.3	20	43.8	5
Building	10.5	27.0	53.9	4
Inlet EVA – sec. side	9.3	20.0	43.8	4
Outlet EVA – sec. side	17	24	67.4	6
Outlet wet cooler	23.0	28.0	86.8	7
Outside air	12.0	45.0	76.2	1
Regeneration	25.0	55.0	120.3	8

THERMODYNAMICS
WINTER CYCLE



DESCRIPTION OF THE PROJECT

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



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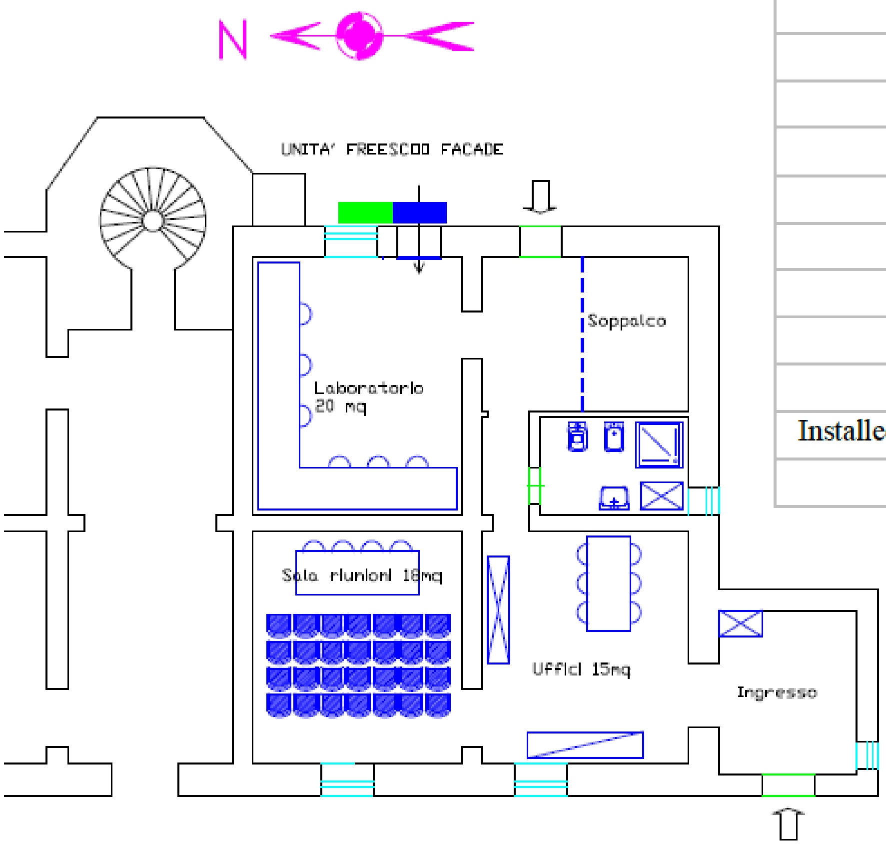

Description	Value	Unit
Volume of the conditioned space	140	[m^3]
Supply air flow rate	0-500	[m^3/h]
Rate of fresh air	30-50	[%]
Total max cooling power	2,5	[kW]
Heating power required for the regeneration	2,5	[kW]
Max Power absorbed	200	[W]
Rated EER for cooling	12,5	[-]
Solar collector area	3 x 1,91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

DESCRIPTION OF THE PROJECT

PERFORMANCE AT DESIGN SUMMER CONDITIONS
($T_{AMBIENT}$ = 35°C $X_{AMBIENT}$ = 16 G/KG, $T_{BUILDING}$ = 27°C $X_{BUILDING}$ = 10,5 G/KG))

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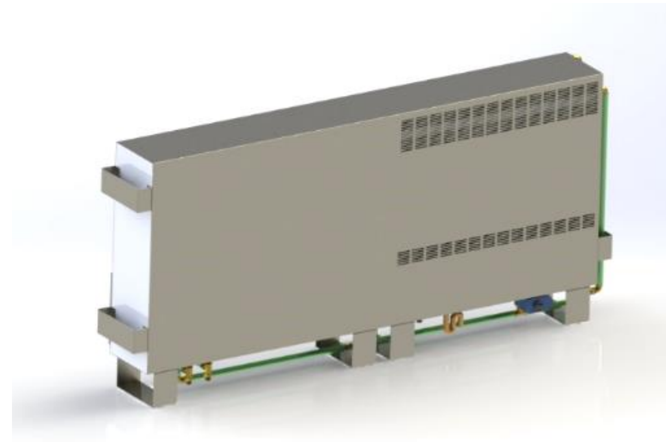
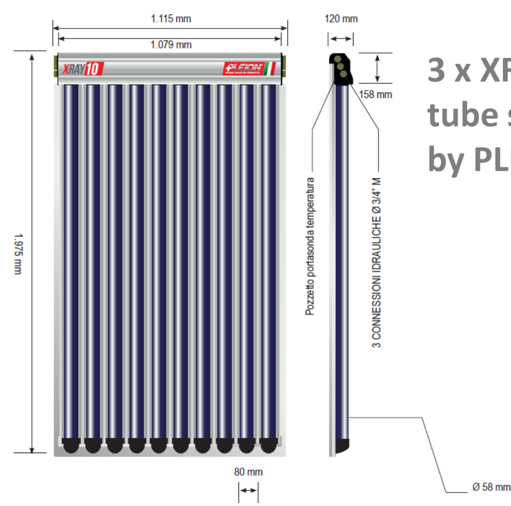
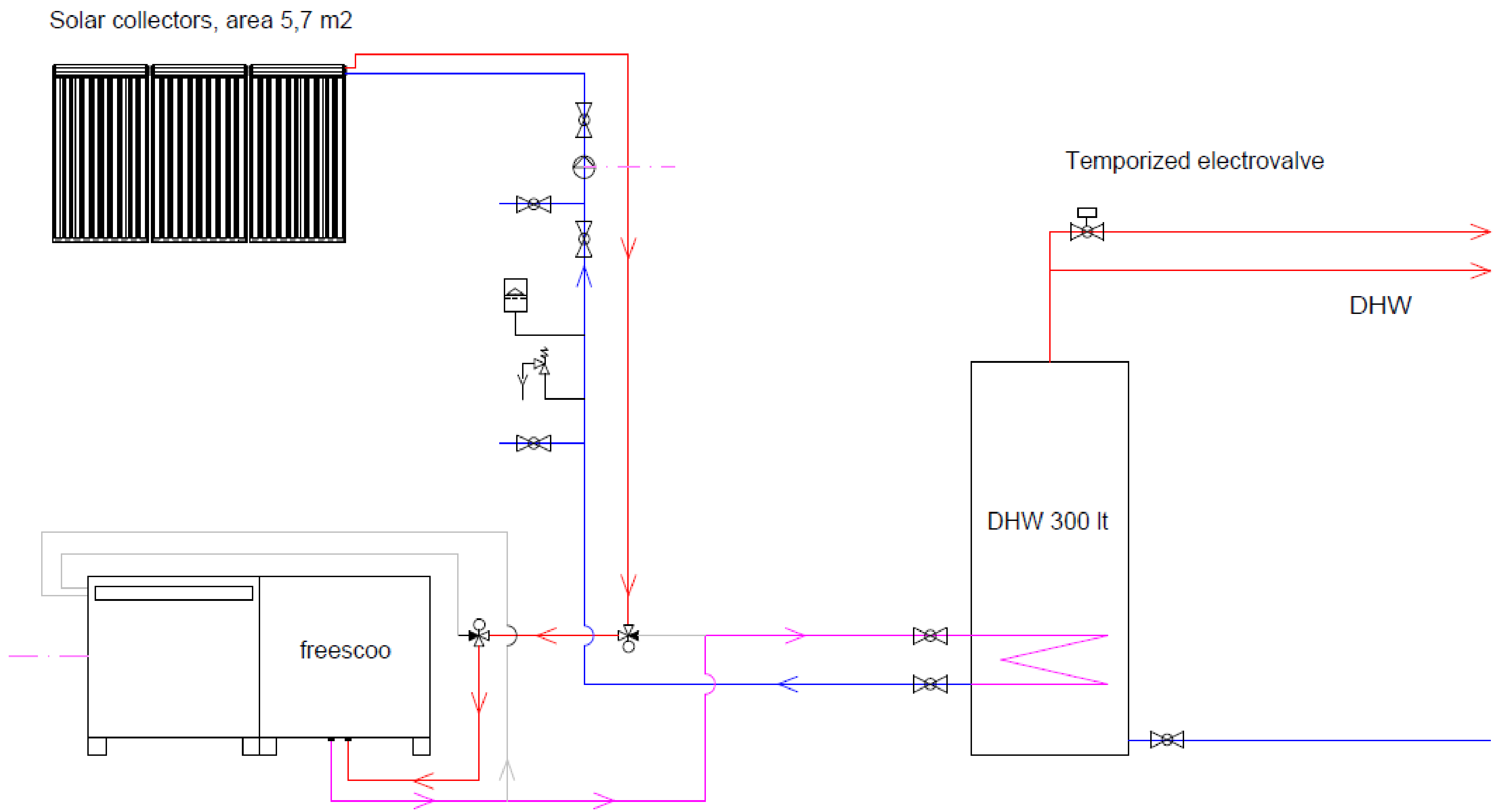
Design for façade integration





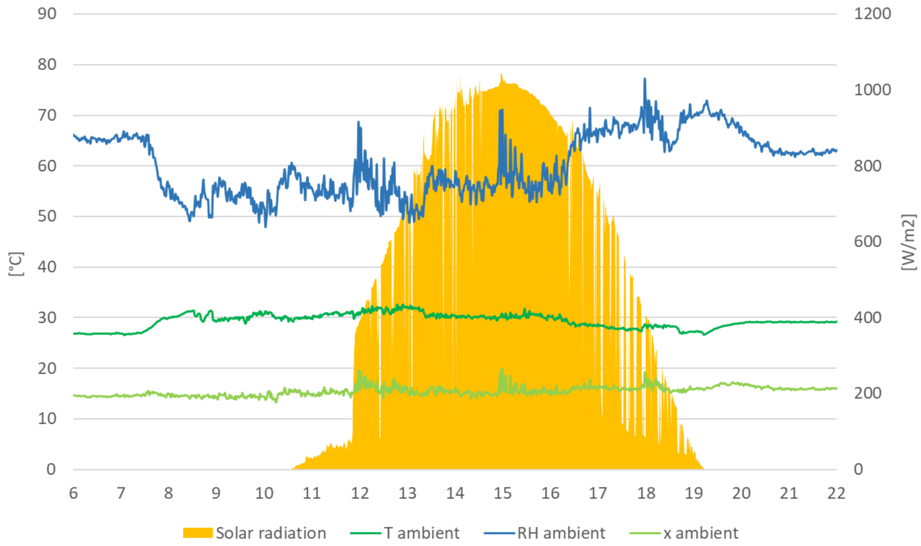
3 x XRAY 10 evacuated tube solar collectors by PLEION

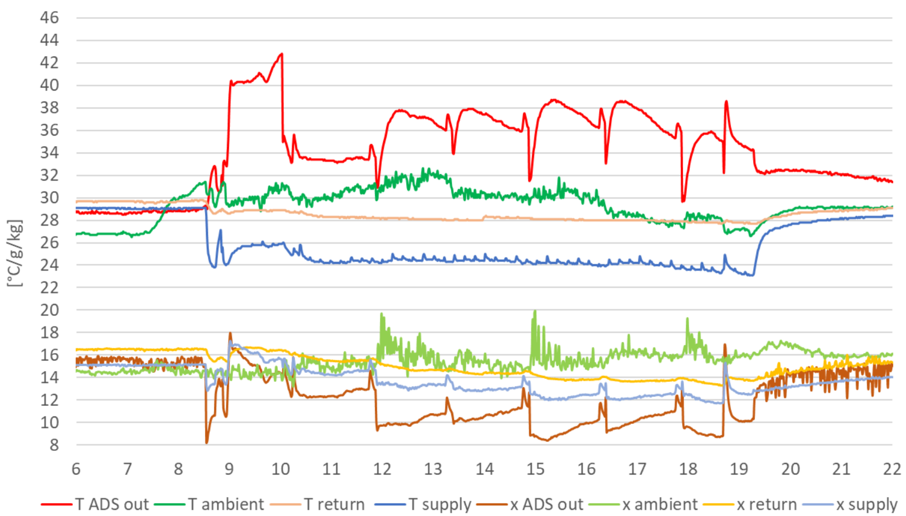
FREESCOO AT ENEA REASERCH CENTRE IN LAMPEDUSA (ITALY)



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	[%]

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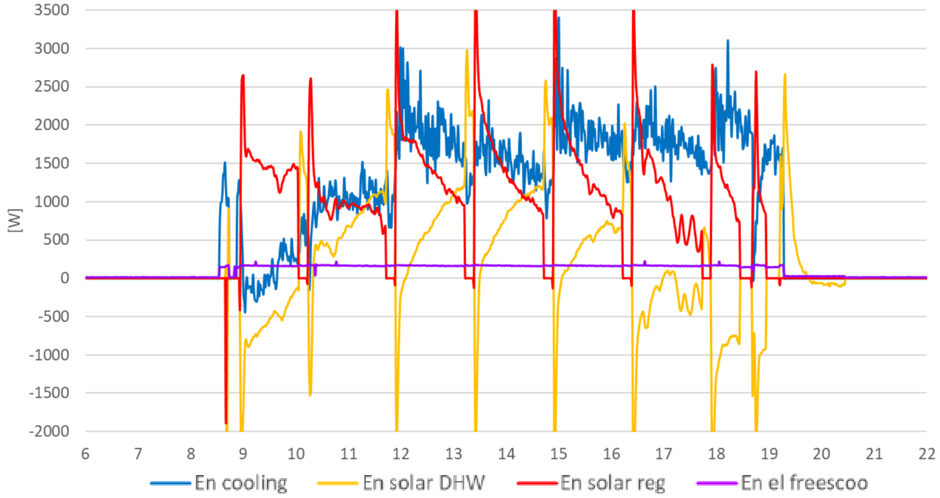

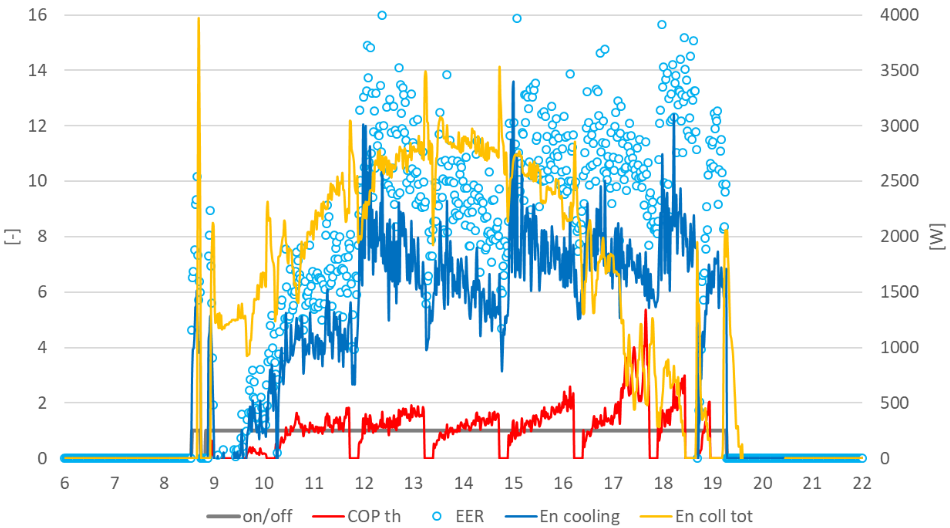

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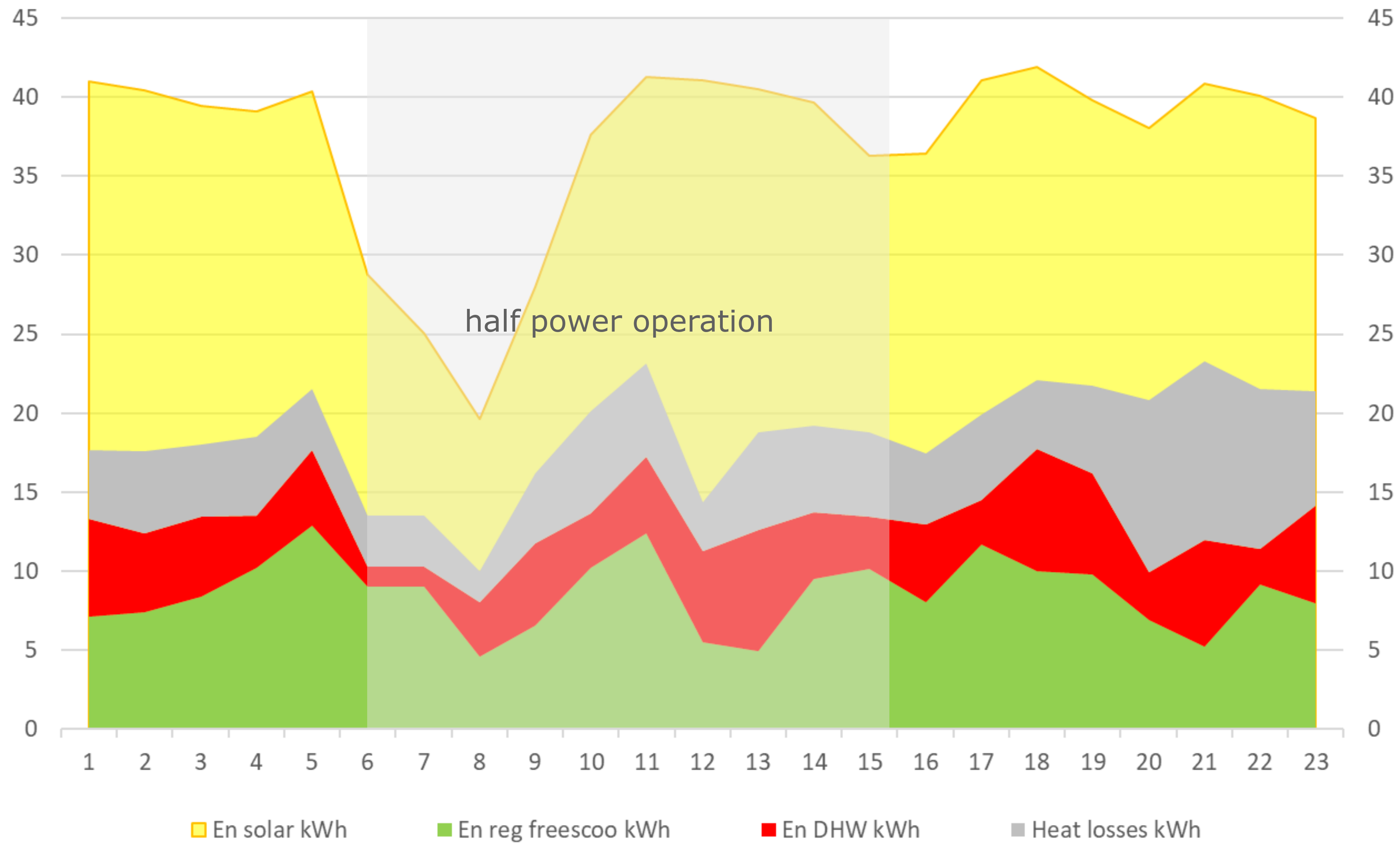
MID-TERM ENERGY PERFORMANCE (23 DAYS IN AUGUST 2018)



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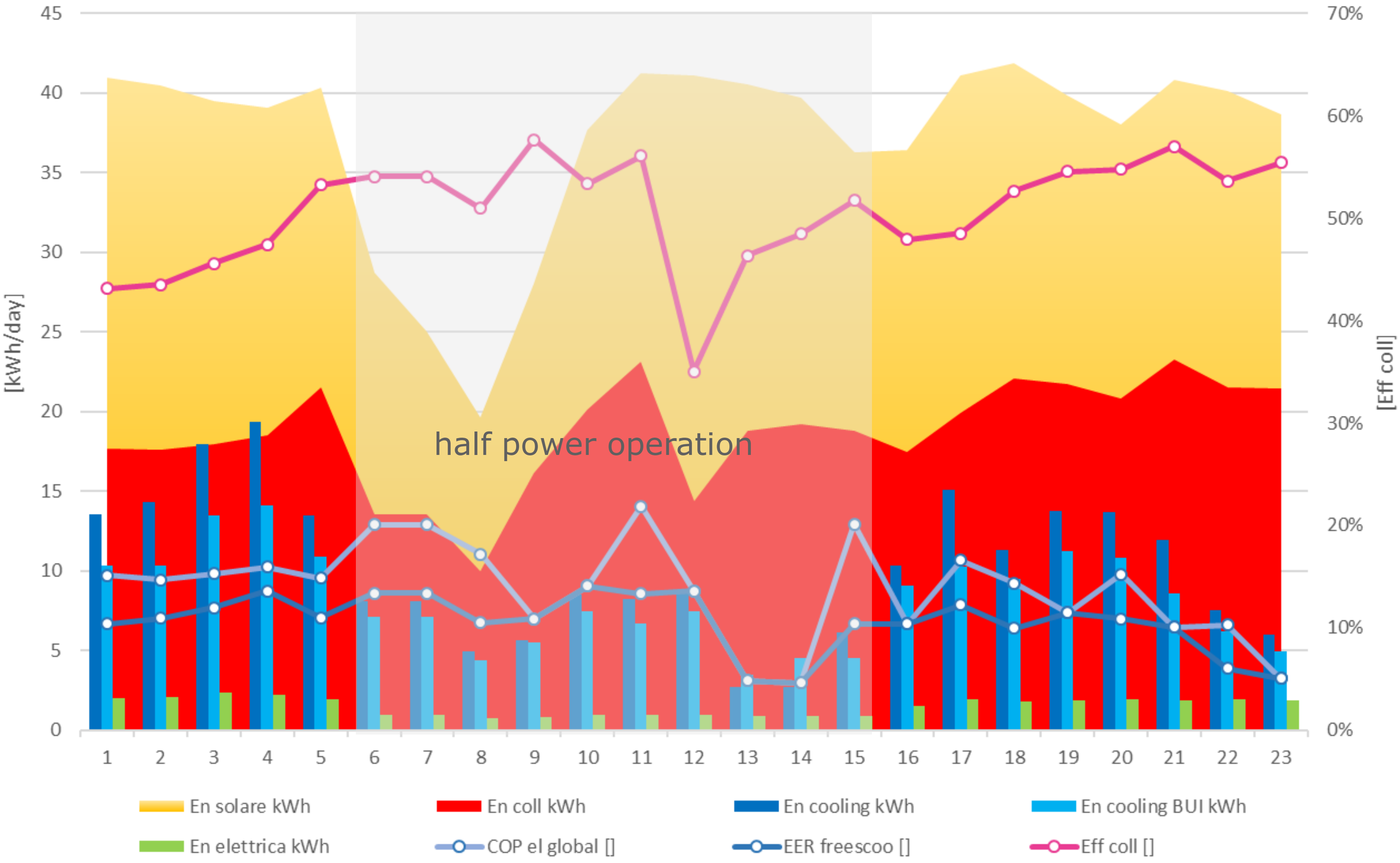

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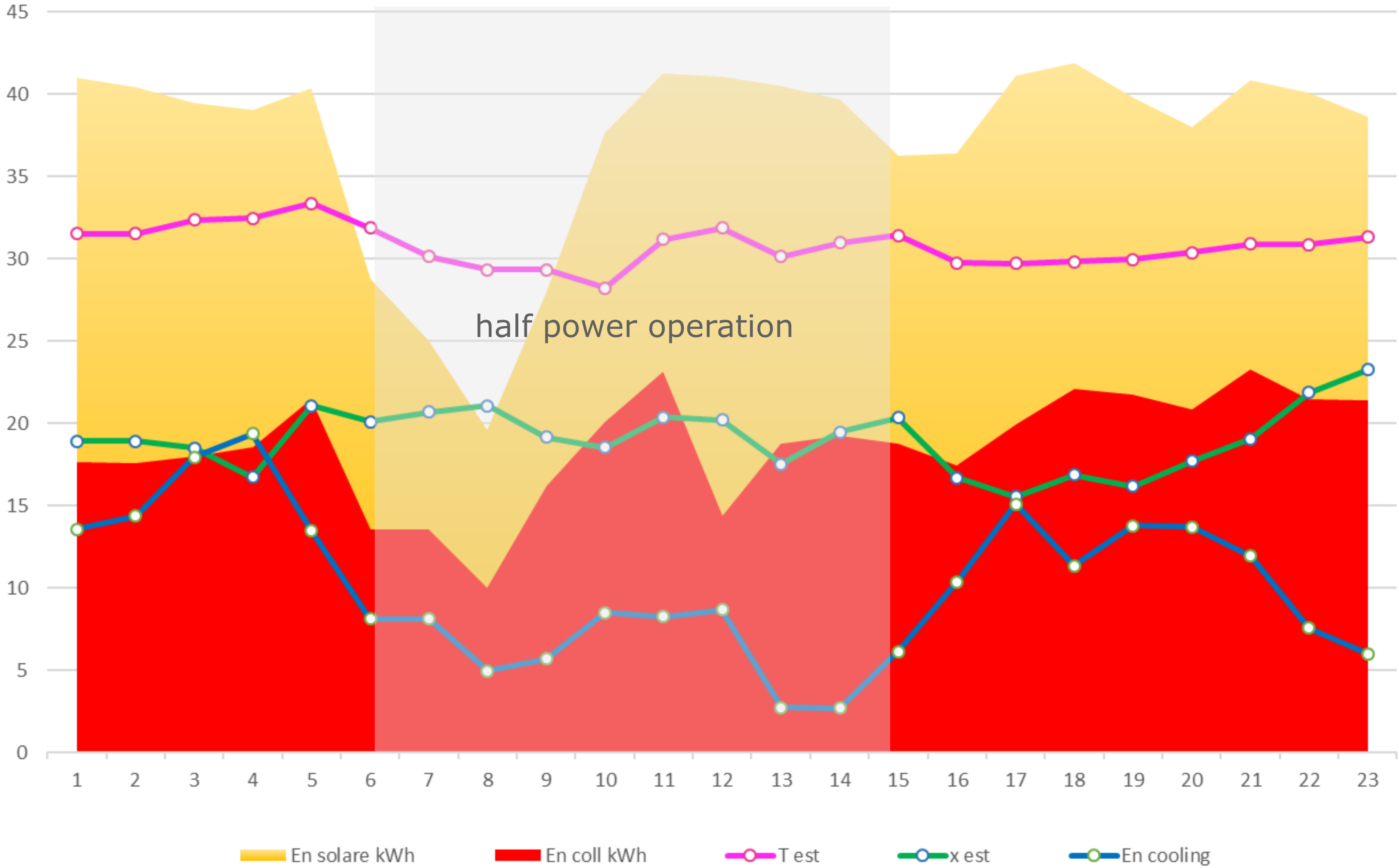
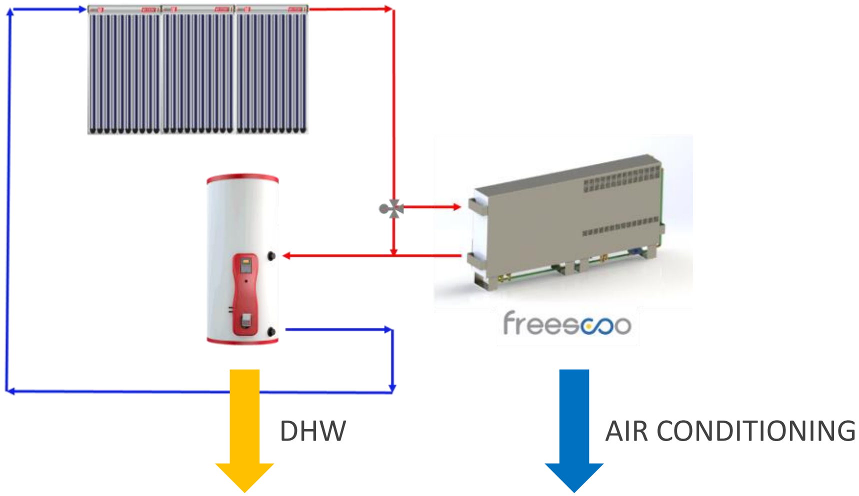
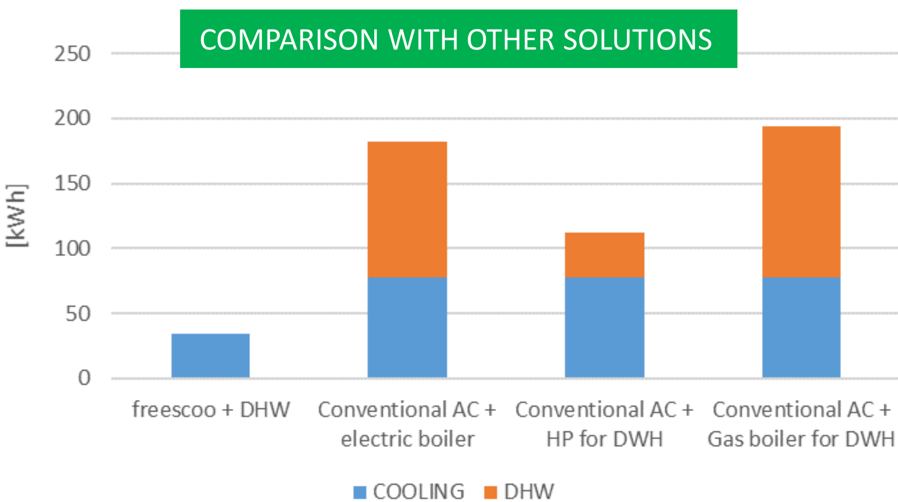


SUMMARY OF THE ENERGY PERFORMANCE





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%	[-]

ASSUMPTIONS FOR THE CALCULATIONS

Operation hours in cooling mode	230	[h]
LHV for gas	9.6	[kWh/sm³]
EER cond conv	3	[-]
HP for DHW	3	[-]
Gas boiler efficiency	90%	

ON GOING ACTIVITIES @THE TEST SITE

- a new lighting system with active dimming control has been installed
- installation of movable windows louvers are under study
- thermal insulation of the storage is going to be improved
- conditioned area has been fractioned with a temporary wall in order to reduce cooling loads

CONCLUSIONS

- The system operated very well in terms of energy efficiency (COP and EER)
- Its performance was influenced by the high ambient humidity which cannot be handled properly with the current size of the dehumidification stage and, in general by an undersizing of the machine
- this test was particularly hard concerning ambient conditions
- coupling of HVAC and DHW looks a good option while heat can be taken from the storage altought it is in series downward the Freescoo unit