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

Alexander Thür – University of Innsbruck

On behalf of:

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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 – outside ambient air; 2 – inside room air; 3 – supply air.

Conventional split system vs Freescoo system.
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.

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

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What is freescoo?
How does freescoo work?

- In the first phase, external hot and wet air is dehumidified thanks to the passage through CPB (Cooled Packed Bed); now the air is dry with a similar temperature.
- In the 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).
**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

**Enthalpy difference**

**Outside air**

**Dehumidification by desiccant rotor**

**Dehumidification by fixed and cooled bed**

**Dehumidification by cooling coil**

**Absolute humidity**

**Temperature**

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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

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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
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3 x XRAY 10 evacuated tube solar collectors by PLEION

Solar collectors, area 5.7 m²
INSTANTANEOUS AND DAILY AVERAGE PERFORMANCE RESULTS FOR DAY 17

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### Description

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

#### Description and Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling energy – due to air handling</td>
<td>232</td>
<td>kWh</td>
</tr>
<tr>
<td>Cooling energy – to the building</td>
<td>188</td>
<td>kWh</td>
</tr>
<tr>
<td>Incident solar radiation</td>
<td>855</td>
<td>kWh</td>
</tr>
<tr>
<td>Solar collected heat</td>
<td>429</td>
<td>kWh</td>
</tr>
<tr>
<td>Solar heat used for regeneration of the desiccant</td>
<td>197</td>
<td>kWh</td>
</tr>
<tr>
<td>Solar heat used for DHW preparation</td>
<td>105</td>
<td>kWh</td>
</tr>
<tr>
<td>Electricity consumed</td>
<td>34</td>
<td>kWh</td>
</tr>
<tr>
<td>Total water consumption for cooling</td>
<td>450</td>
<td>l</td>
</tr>
<tr>
<td>Mean daily water consumption</td>
<td>19.5</td>
<td>l/day</td>
</tr>
<tr>
<td>Total hours of operation</td>
<td>230</td>
<td>h</td>
</tr>
<tr>
<td>Mean daily hours of operation</td>
<td>10</td>
<td>h</td>
</tr>
<tr>
<td>Total DHW water consumption</td>
<td>1480</td>
<td>l</td>
</tr>
<tr>
<td>Global electrical COP (HVAC + DHW)</td>
<td>9.8</td>
<td>[-]</td>
</tr>
<tr>
<td>EER (freescoo HVAC)</td>
<td>6.8</td>
<td>[-]</td>
</tr>
<tr>
<td>COP th (freescoo HVAC)</td>
<td>0.96</td>
<td>[-]</td>
</tr>
<tr>
<td>Solar collector efficiency</td>
<td>50.2%</td>
<td>[-]</td>
</tr>
</tbody>
</table>

### 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%

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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 although it is in series downward the freescoo machine.
Thank you for your attention

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