

# ENERGY PERFORMANCES AND LIFE CYCLE ASSESSMENT OF ADVANCED SOLAR DEC FREESCOO UNITS

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## ABSTRACT

A new compact solar DEC air conditioner concept is presented here. The cooling process is based on the use of fixed and cooled adsorption beds and advanced evaporative cooling concepts. This solution permits to increase the energy performances of the whole cooling process in comparison to the standard desiccant rotor bases DEC cycles. The indirect evaporative cooling process is realized using optimized wet plate heat exchangers which allow low supply temperatures to the room and overall energy performances.

The experimental results of an optimized configuration of the freescoo unit together with the Life Cycle Assessment are presented.

# freescoo

## DESCRIPTION OF THE SYSTEM

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

Main features of the system are:

- Compactness, since every component is included in one casing
- Use of the Cooled Packed Bed (CPB) technology and high efficiency evaporative cooling concepts
- The integrated solar PVT air collector is used to drive the cooling process
- The electricity needed to drive the system is by the solar PVT collector
- In the wintertime system provides heat to the room when the sun is shining

Freescoo is a patented solution by the SOLARINVENT srl.

## ENERGY PERFORMANCES

In the framework of a research project with the ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development), two freescoo units for applications in residential and small office buildings have been installed in 2014 in Rome (ENEA Casaccia) and at DEIM Dep. of the University of Palermo.

Monitoring results are related to 40 days of operation of the unit installed at UNIPA (July 2015).

Energy performances of the system were analyzed according to the monitoring procedure for solar cooling systems developed by the Task 38 and 48 IEA experts.

## LIFE CYCLE ASSEMENT

The study aimed at evaluating the energy and environment impacts of the manufacturing and operation phase of the Freescoo solar DEC air conditioning system. The analysis was carried out through the application of the LCA methodology, in accordance with the standards of the ISO 14040 series.

The eco-profiles of materials and energy sources are mainly referred to the Ecoinvent database. The total primary energy consumption connected to the construction phase is about 27,2 GJ.

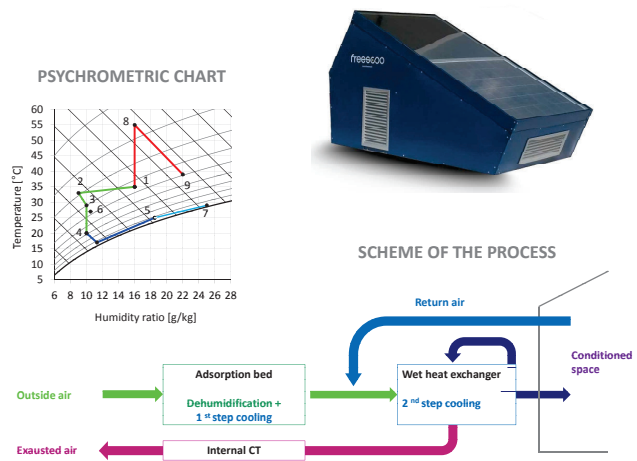
After the analysis of the construction phase, the primary energy consumption and related environmental impacts related to the usage phase have been calculated.

Monitored performance results such as the average cooling energy delivered, EER and water consumption, and other have been used to extrapolate seasonal performances for 90 days of operation.

The major impacts are related to the construction phase (87-89% of the total).

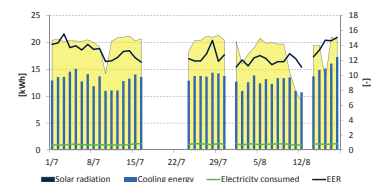
Comparing the energy performances related to the usage phase between the freescoo unit and a generic conventional air conditioning (EER=3 assumed), it turns out that the conventional unit has a primary energy consumption about 16 times higher. Similar values can be obtained looking at the environmental impacts.

Taking into account the whole primary energy consumption needed both for the construction and the usage of the freescoo unit for 15 years (31171MJ), it turns out that this value is about the half of the primary energy consumption related just to the usage phase of the generic conventional air conditioning unit.

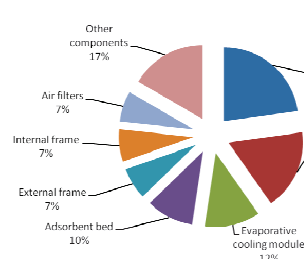


## MONITORED ENERGY PERFORMANCES OF THE UNIPA FREESCOO UNIT

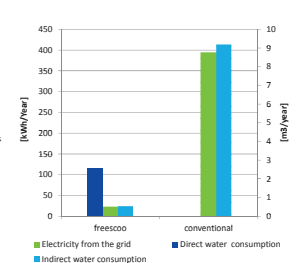
| Energy Indicator  | Unit | Total |
|---|------|-------|
| Solar radiation available                                   | kWh  | 765   |
| Cooling energy delivered                                    | kWh  | 533   |
| COP <sub>sys</sub> (including indirect evaporative cooling) | kWh  | 1.1   |
| Electricity consumed  | kWh  | 41    |
| EER   | -    | 12,8  |
| EER <sub>grid</sub>   | -    | 50,7  |
| Water consumption   | l    | 1151  |
| Hours of operation  | h    | 479   |



## CONSTRUCTION PHASE: PRIMARY ENERGY DISTRIBUTION



## USAGE PHASE: WATER AND ELECTRICITY NEED



## PRIMARY ENERGY CONSUMPTIONS

| Impact category                    | Total | Construction | Usage |
|------------------------------------|-------|--------------|-------|
|                                    | MJ    | MJ           | MJ    |
| Non-renewable, fossil              | 23333 | 20192        | 3141  |
| Non-renewable, nuclear             | 4349  | 3879         | 470   |
| Non-renewable, biomass             | 0     | 0            | 0     |
| Renewable, biomass                 | 287   | 258          | 28    |
| Renewable, wind, solar, geothermal | 54    | 43           | 11    |
| Renewable, water                   | 3149  | 2858         | 291   |
| Total                              | 31171 | 27230        | 3941  |

## ENVIRONMENTAL IMPACTS

| Impact indicator              | Unit         | Total | Construction | Usage |
|-------------------------------|--------------|-------|--------------|-------|
| Climate change                | kg CO2 eq    | 1828  | 1595         | 233   |
| Ozone depletion               | kg CFC-11 eq | 0     | 0            | 0     |
| Photochemical ozone formation | kg NMVOC eq  | 6     | 5            | 1     |
| Acidification                 | molc H+ eq   | 13    | 11           | 1     |
| Terrestrial eutrophication    | molc N eq    | 19    | 17           | 2     |