



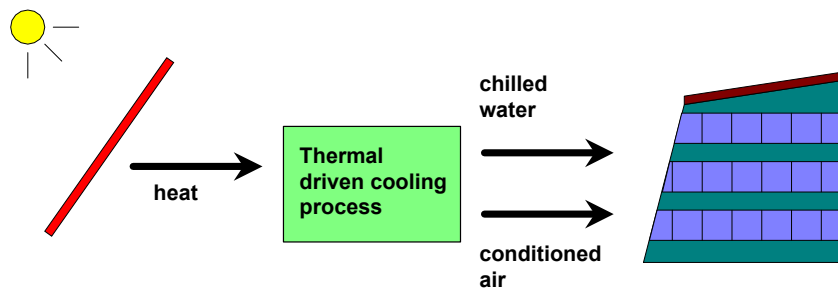
## Solar Cooling Technologies & Applications

Christodoulaki Rosie  
 PhD cand. Mech. Eng.  
 MSc Environmental design & engineering  
 BSc Physics



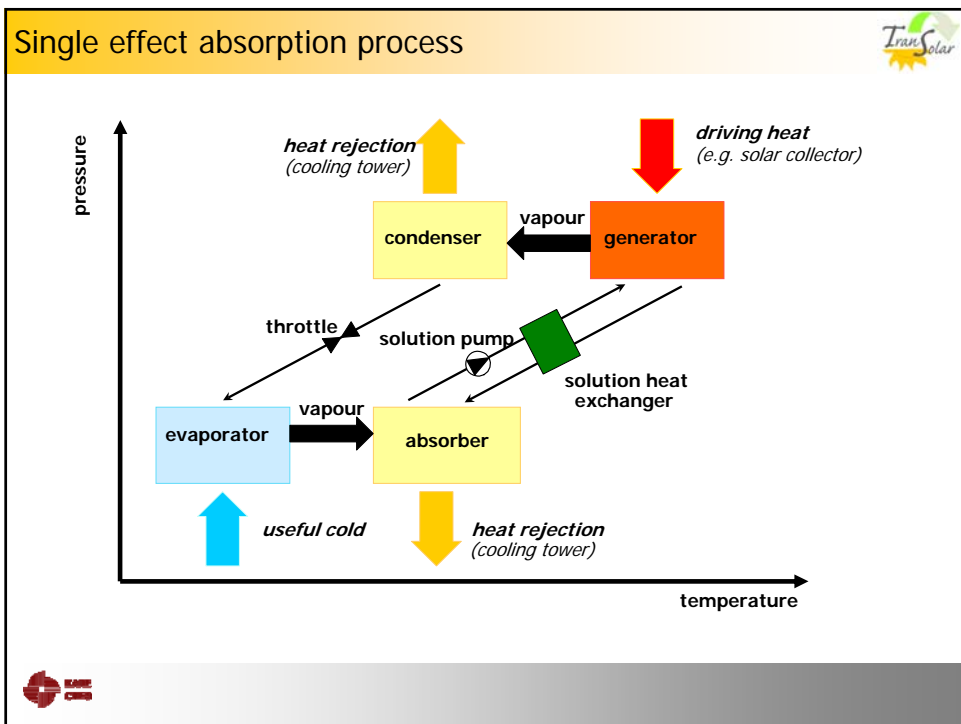
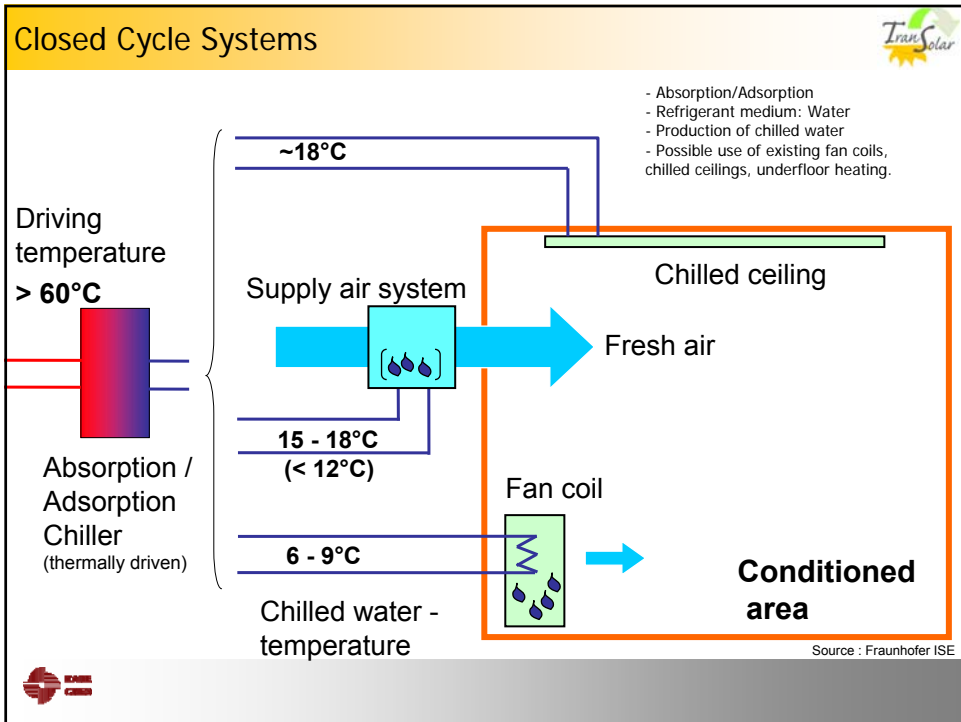
## Solar Cooling Technologies

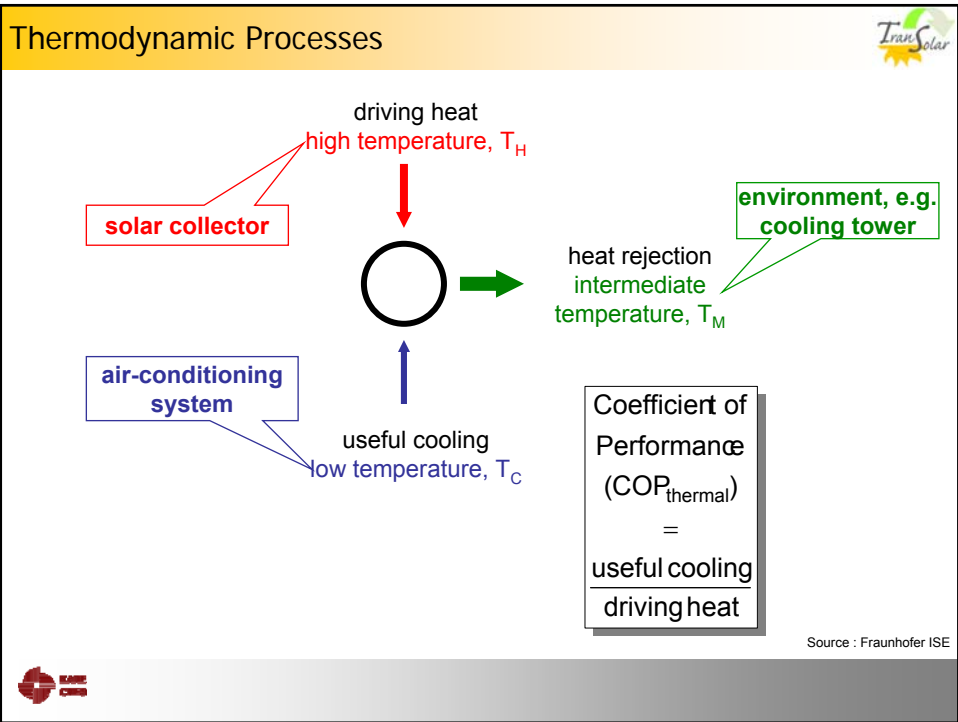
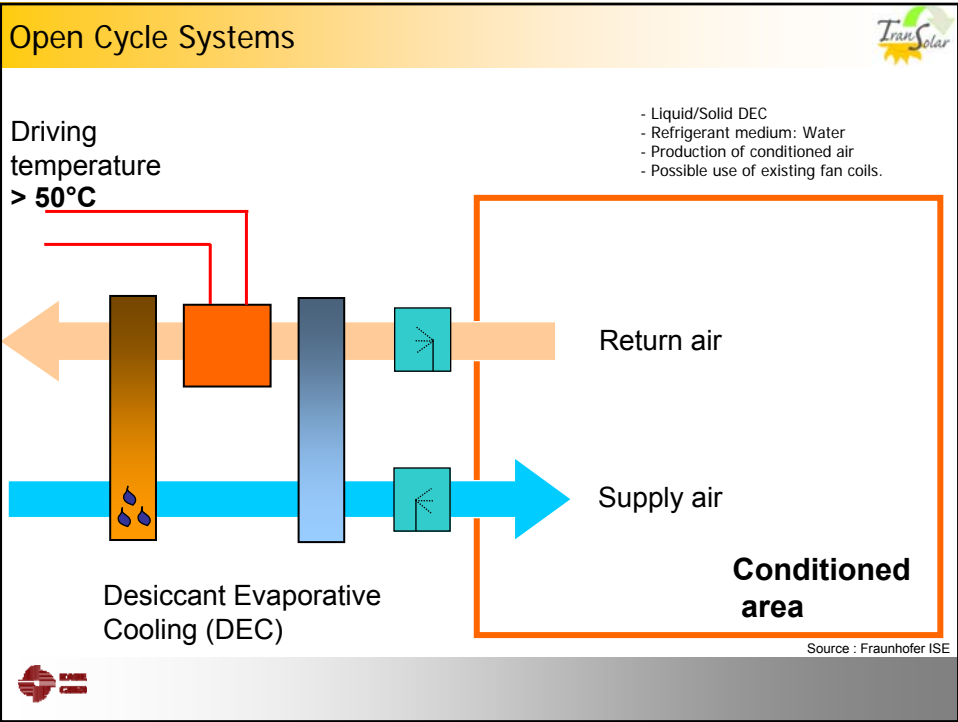
1. Closed Cycle
  - i. Absorption Chillers
  - ii. Adsorption Chillers
2. Open Cycle
  - i. Solid Desiccant Evaporative Cooling
  - ii. Liquid Desiccant Evaporative Cooling



Source : Fraunhofer ISE, Solamext







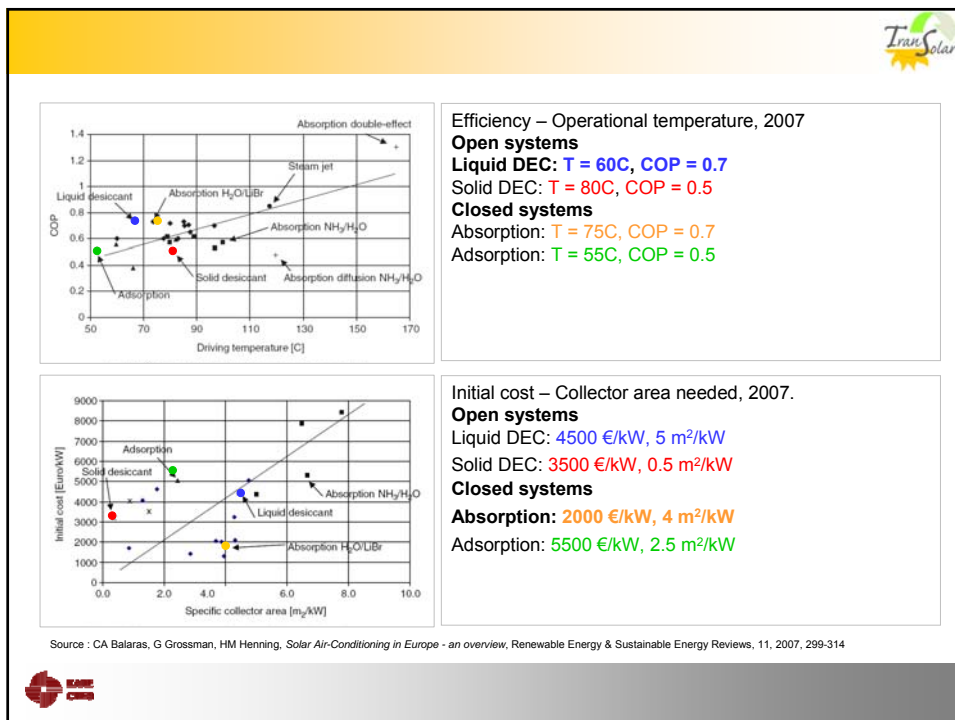


## Solar Cooling Systems Overview



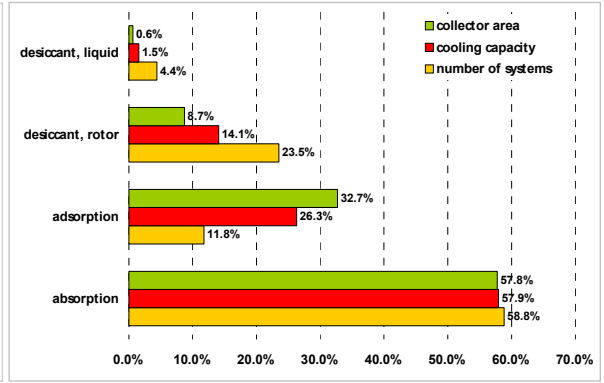
Method	Closed cycle		Open cycle	
Refrigerant cycle	Closed refrigerant cycle		Refrigerant (water) is in contact to the atmosphere	
Principle	Chilled water		Dehumidification of air and evaporative cooling	
Phase of sorbent	solid	liquid	solid	liquid
				
Typical material pairs	water - silica gel	water - lithium bromide ammonia - water	water - silica gel, water - lithium chloride	water - calcium chloride, water - lithium chloride
Market available technology	Adsorption chiller	Absorption chiller	Desiccant cooling	Close to market introduction
Typical cooling capacity (kW cold)	50 – 430 kW	15 kW – 5 MW	20 kW – 350 kW (per module)	
Typical COP	0.5 – 0.7	0.6 – 0.75 (single effect)	0.5 – >1	> 1
Driving temperature	60 – 90 °C	80 – 110 °C	45 – 95 °C	45 – 70 °C
Solar collectors	Vacuum tubes, flat plate collectors	Vacuum tubes	Flat plate collectors, solar air collectors	Flat plate collectors, solar air collectors

Source : EU Altener Project Climasol



### Solar Cooling Systems

- installed in Europe
- Absorption: 58%
  - Solid DEC: 23%
  - Adsorption: 12%
  - Liquid DEC: 4%




Source : HM Henning, *Solar Assisted air conditioning of buildings – an overview*, Applied Thermal Engineering, 27, 2007, 1734-1749.



### Solar Cooling Applications

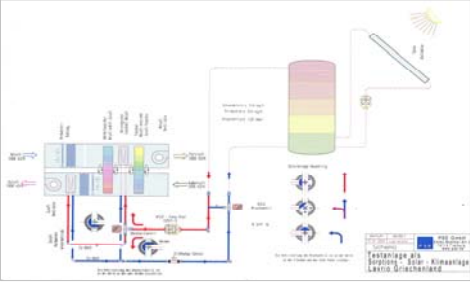







### PENA, CRES technological park, Athens, EI

**PENA, Lavrio**  
**Solar cooling Solid DEC system**  
 Demo & research application for CRES

In operation since	2007
Air conditioned area	84m <sup>2</sup>
Collector type	10 m <sup>2</sup> , Calpak flat-plate
Collector fluid	water-glycol
Operation temperature	60°C
Nominal air flow rate	1100 m <sup>3</sup> /h
Min. air volume flow rate	373 m <sup>3</sup> /h
Desiccant cooling system	solid LiCl
Brand of desiccant unit	Klingenburg



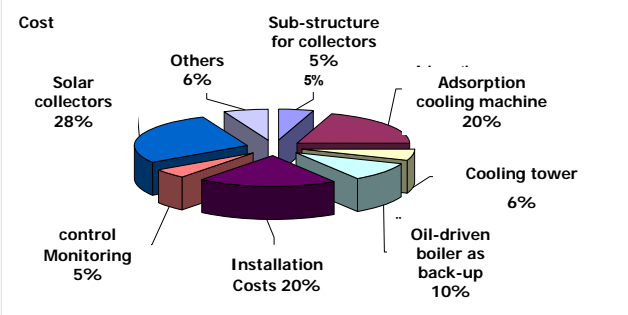


### Sarantis, Cosmetics industry, Inofita Viotias, EI



Operation 1999


- One of the largest installations in the world
- 2,700 m<sup>2</sup> flat plate collectors (SOLE)
- 2 adsorption cooling machines, 350 kW cooling each
- 3 compression cooling machines, 350 kW


**Cost**




Component	Percentage
Solar collectors	28%
Adsorption cooling machine	20%
Installation Costs	20%
Oil-driven boiler as back-up	10%
Cooling tower	6%
Others	6%
Sub-structure for collectors	5%




**GICB wine cellar Banyuls/mer, Fr** 



- 130 m<sup>2</sup> evacuated tube collectors
- 52 kW<sub>cooling</sub>
- Investment cost: 1,6 MF (1991)

Source : TECSOL



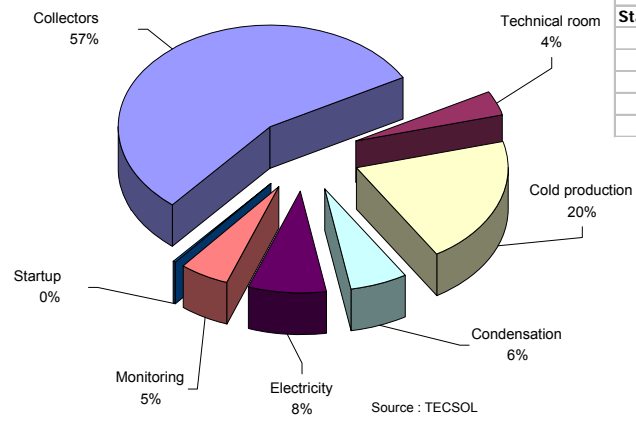
**DIREN Guadeloupe, Fr** 

- Chilled surface: 570 m<sup>2</sup>
- 61 m<sup>2</sup> evacuated tube collectors
- 35 kW<sub>cooling</sub>
- Absorption chiller



Source : TECSOL





	€ . HT
Solar collectors	89 314
Technical room	6 065
Cold production	32 263
Condensation	9 920
Electricity	13 108
Monitoring	8 422
Startup	610
<b>Total HT:</b>	<b>159 701</b>
€ . HT / kWf	4 563
Collectors (€ / m <sup>2</sup> )	1 441





**Cosmetic laboratory, Sophia Antipolis, Fr** 





- 570 m<sup>2</sup> evacuated tube collectors
- 210 kW cooling
- Investment cost: 2500 € / kWf






**Academic Hospital of Freiburg, De** 

- Adsorption cooling: 70 kWcooling
- Evacuated tube collectors direct flow: initially 90 m<sup>2</sup>, then increased at 170 m<sup>2</sup> (2001)
- Air flow: 8000 m<sup>3</sup>/h





*Thank you for your attention!*



**Centre for Renewable Energy Sources  
Solar Thermal Department**  
19km. Marathonos av., 19009, Pikermi  
tel. 00302106603300, fax. 00302106603301  
[www.cres.gr](http://www.cres.gr)

**Rosa Christodoulaki**  
[rozi@cres.gr](mailto:rozi@cres.gr)

