ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ ΕΝΕΡΓΕΙΑΣ & ΚΛΙΜΑΤΙΚΗΣ ΑΛΛΑΓΗΣ

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ΚΕΝΤΡΟ ΑΝΑΝΕΩΣΙΜΩΝ ΠΗΓΩΝ ΚΑΙ ΕΞΟΙΚΟΝΟΜΗΣΗΣ ΕΝΕΡΓΕΙΑΣ

Solar Thermal Cooling: technology, cost and case study

IRENA– Cyprus event on Renewable Energy Applications for island tourism
Paphos, 29-30 May 2014

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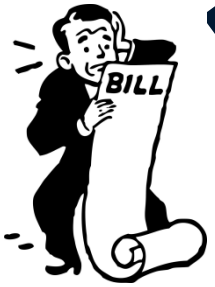
RES Division

Conventional cooling system



Electricity
40 MWh

0.15 €/kWh → 6000 €
Greece 2014

COPel = 2.5

Cooling
100 MWh

Cooling distribution system

(Supply water temp = 7oC)

Solar thermal cooling system

Thermal
166 MWh

COPth = 0.6

COPel = 20

Cooling
100 MWh

Cooling distribution system

(Supply water temp = 7oC)

Electricity
5 MWh

Cost 0.15 €/kWh → 750 €
Savings: 5,250€

Greece 2014

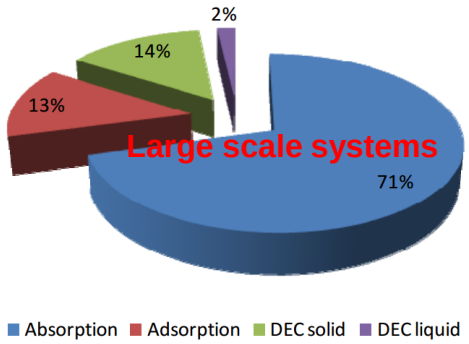
Electricity reduction by 87% !!!

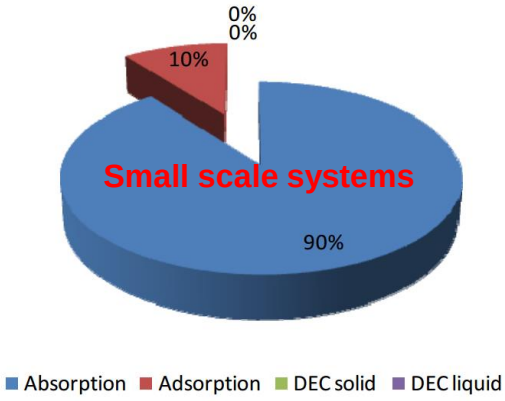
Basic thermal cooling methods

Method	Closed cycle		Open cycle	
Refrigereant 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

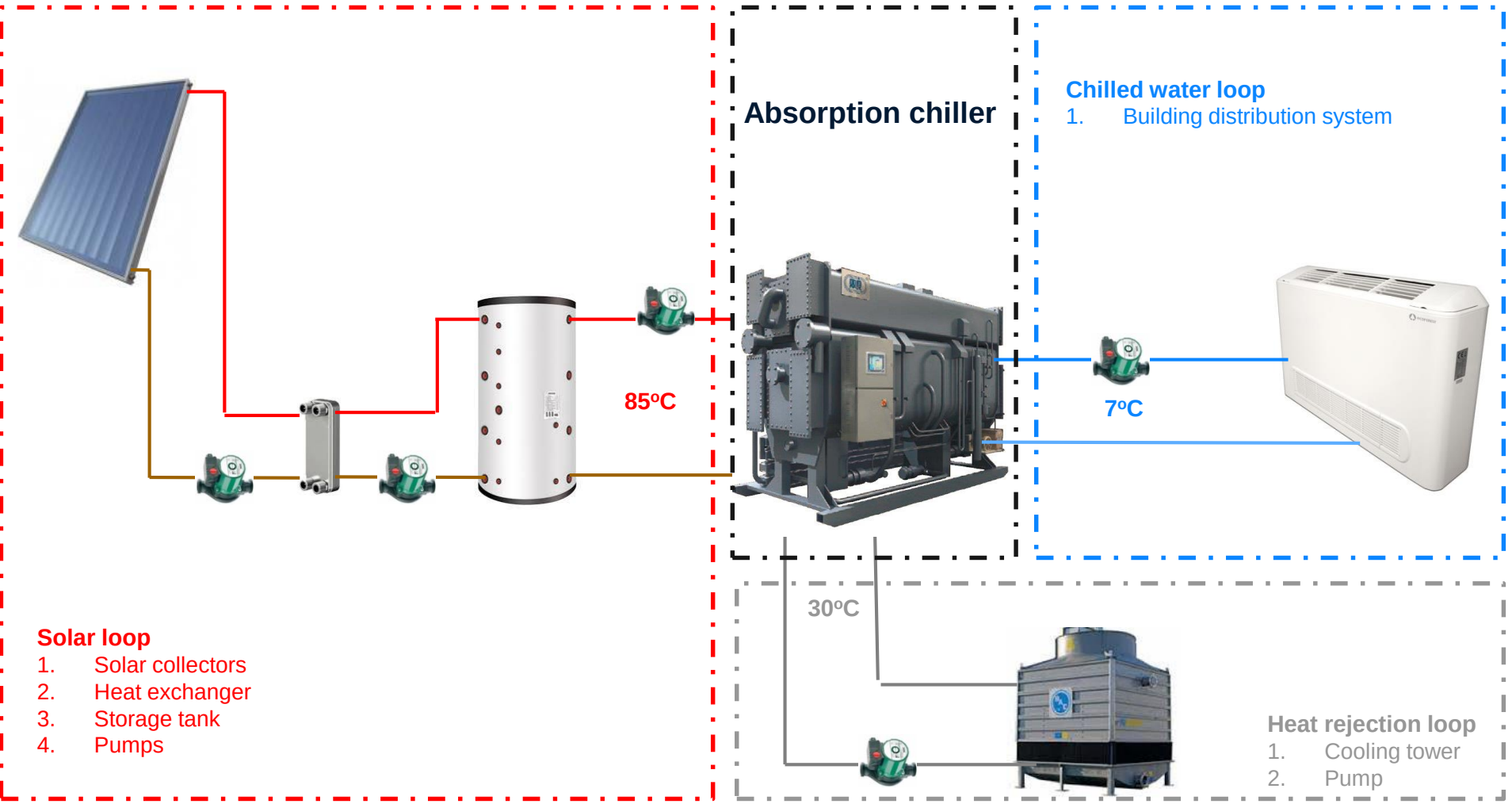
Absorption chillers

- ✓ Low cost
- ✓ Thermal efficiency = 0.7
- ✓ Chilled water = 7°C

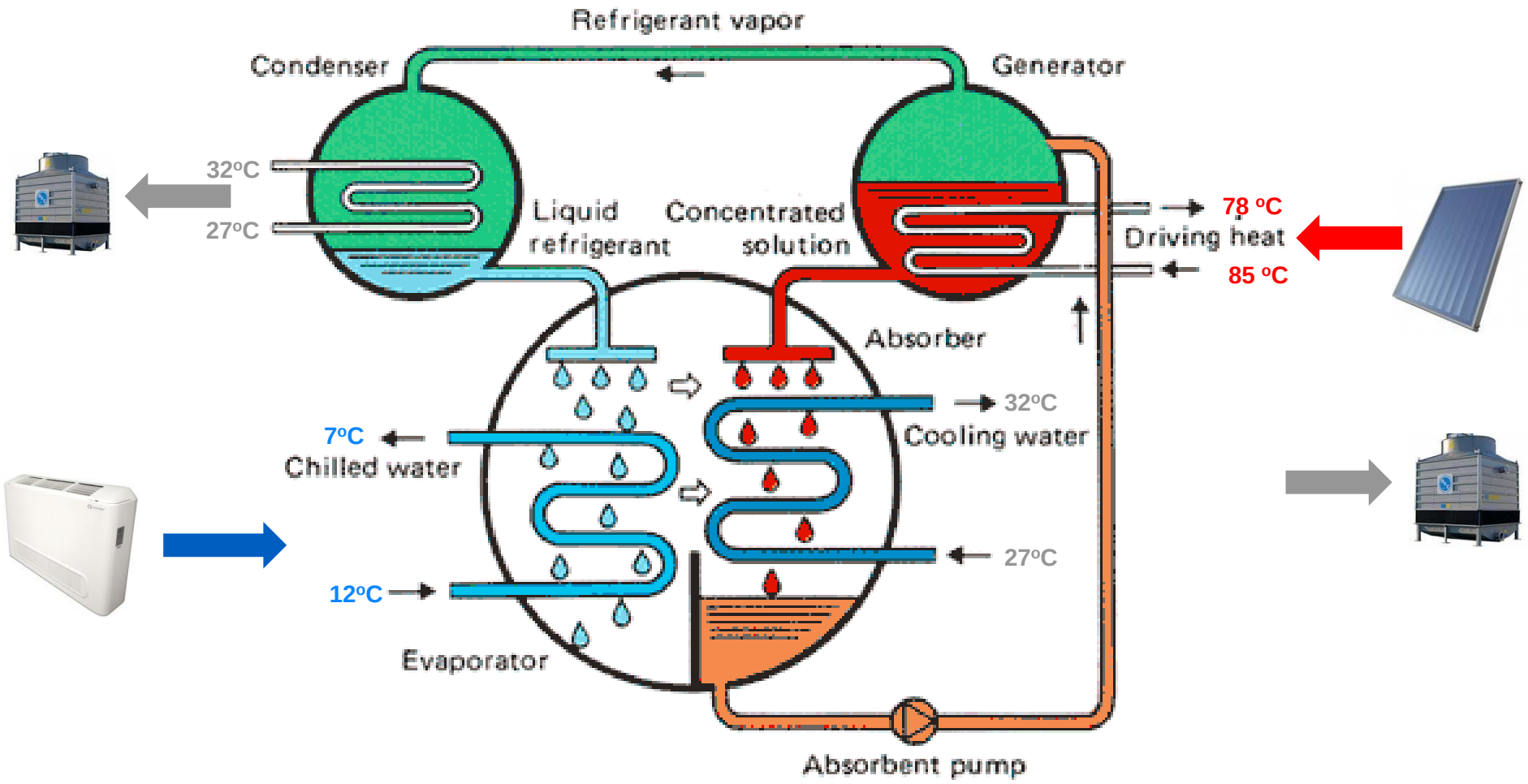




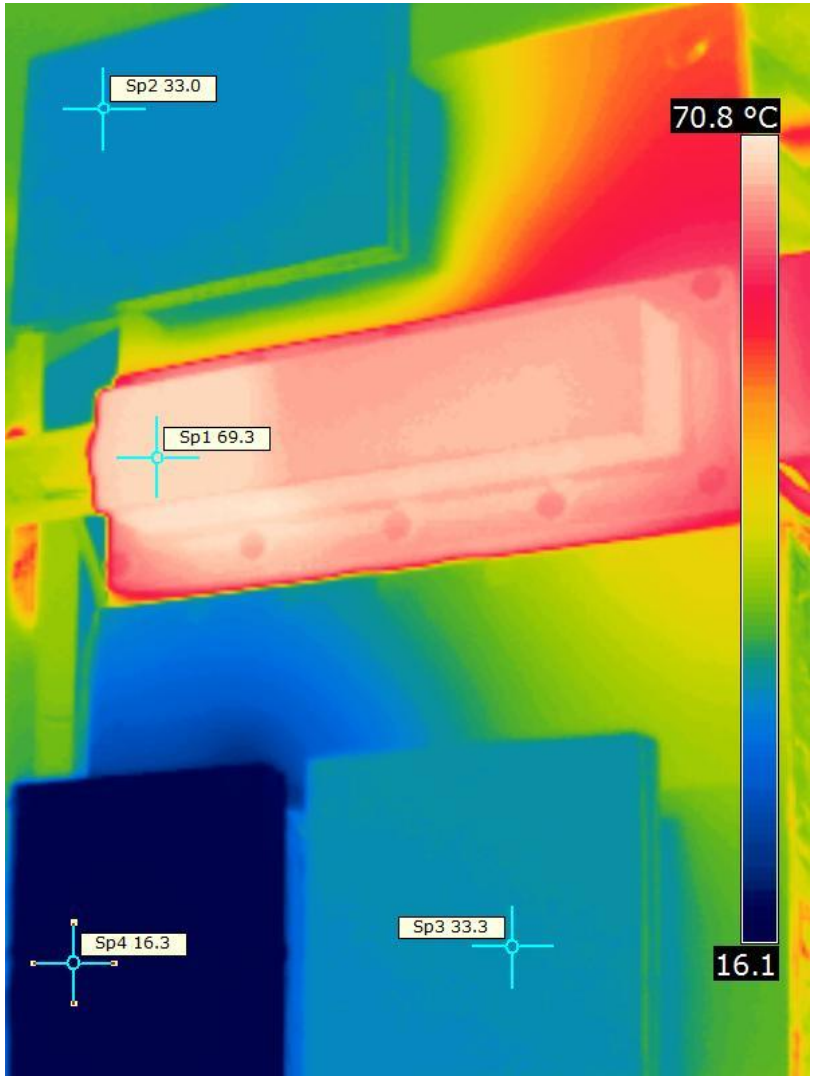
A typical solar cooling configuration

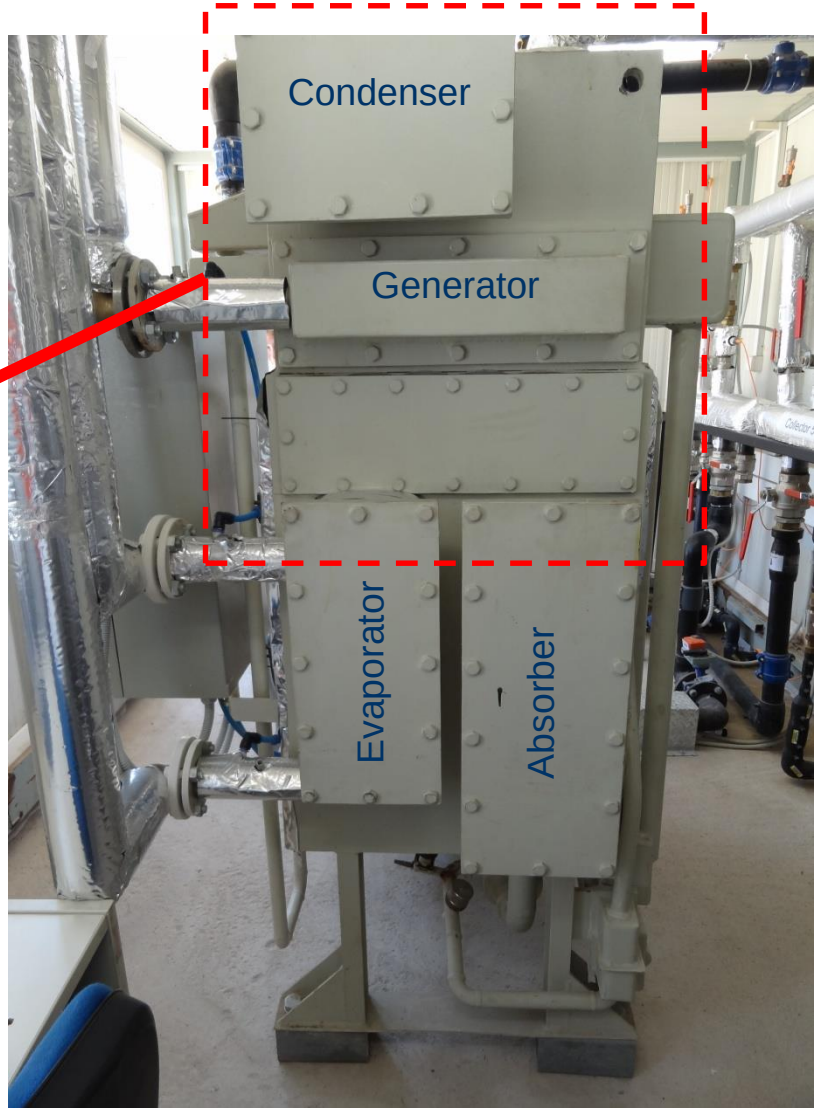


How does the absorption chiller work ?

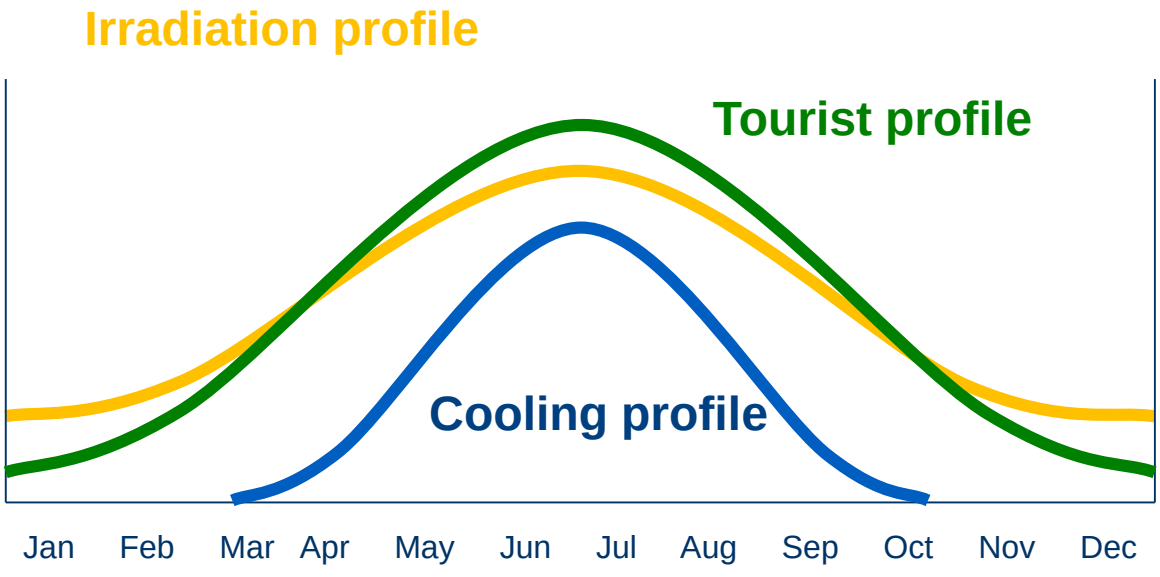


External “Thermal” view of the absorption chiller



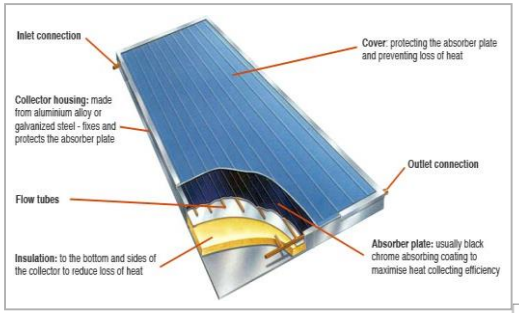


Why solar ?



- ✓ ***Free*** energy
- ✓ ***Environmental*** friendly
- ✓ ***Reliable*** technology
- ✓ ***Low*** operational ***cost***
- ✓ Perfect ***Time coincidence***
  - ✓ Solar potential
  - ✓ Tourist period
  - ✓ Cooling period
- ✓ Local ***added value***
- ✓ **Green tourism**
- ✓ *Reduction of black outs*
- ✓ *….*

Basic solar collector technologies



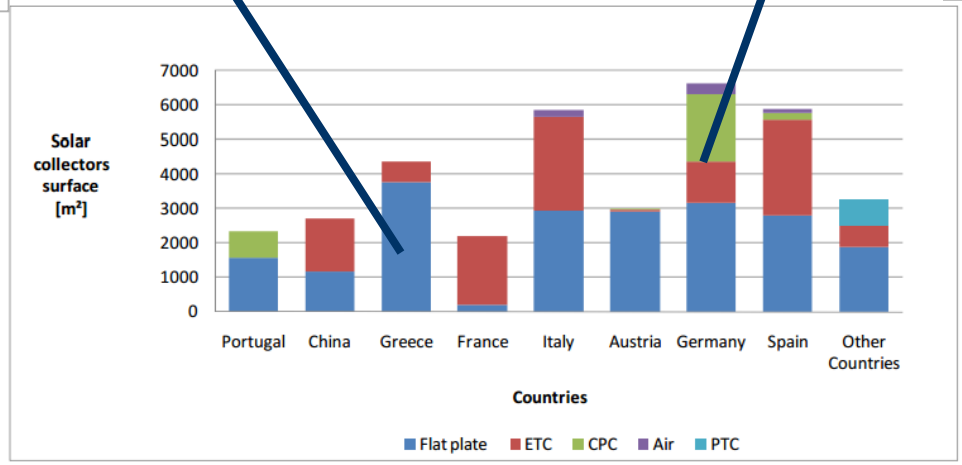


Figure 4.3: World wide installed solar collectors' surface for cooling purpose. The type of solar collectors used in each country is highlighted.

Design & Energy considerations
(Rule of thumbs)

Solar field
450m^2

1 kW → 4.5 m2

Cooling capacity
100 kW

Cooling Load
> 100 kW

Solar collectors

Absorption chiller

Hotel

Irradiation
2200 kWh/m^2

Solar efficiency = 35%

Hotel season Mar - Oct

Solar heat
200 MWh

Chiller thermal efficiency
COP_{th} = 0.7

Cooling production
> 140 MWh

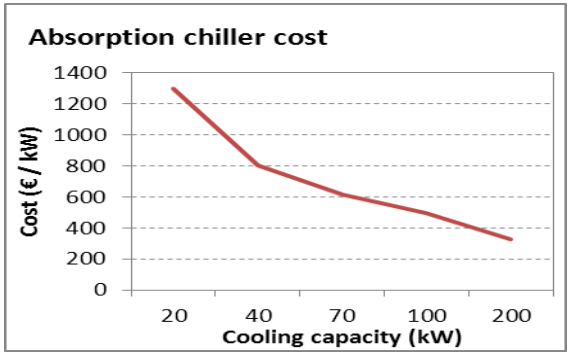
TIP

1 kW chiller cooling capacity → 3 - 6 m^2 solar collector area

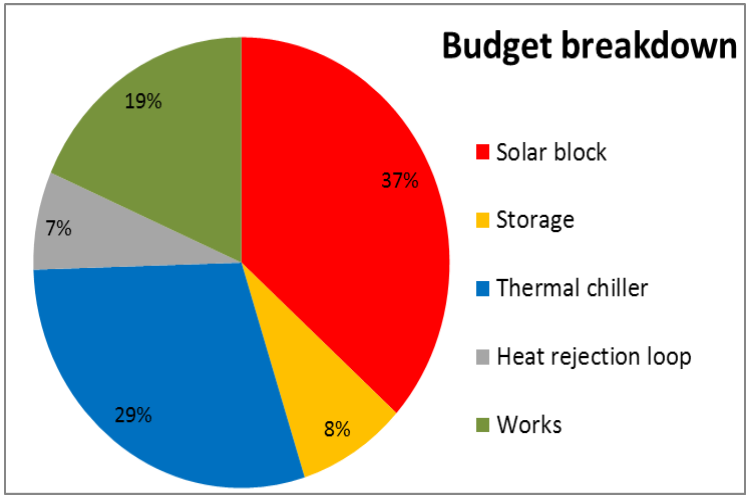
Cost considerations
(Rule of thumbs)

Solar collectors : 100 - 200€/ m^2

Absorption chiller : High **dependency** on cooling capacity



AA	Description	Percentage	Cost (€)
1	Solar loop (450m^2)	37%	58,468
2	Storage	8%	13,495
3	Thermal chiller (100kW)	29%	46,943
4	Heat rejection loop	7%	11,224
5	Services	18%	29,471
		Total cost	**159,602**



System cost → 355 €/ m^2 **OR** 1,596 € / kW

Case study: Hotel Rethimno Village

Building use	**Hotel**
Location	Rethimno, **Crete**
Capacity	**170 beds**
Occupancy	100% summer 45% winter
Air conditioned area	3,000 m^2
Cooling energy	728MWh/ year
Heating energy	300MWh/ year
Hot water energy	224 MWh/ year

Case study: Hotel Rethimno Village

Commissioned in ***2000***

Total solar area 650 m^2

(Flat plate with selective surface)

Solar area for cooling ***450 m^2***

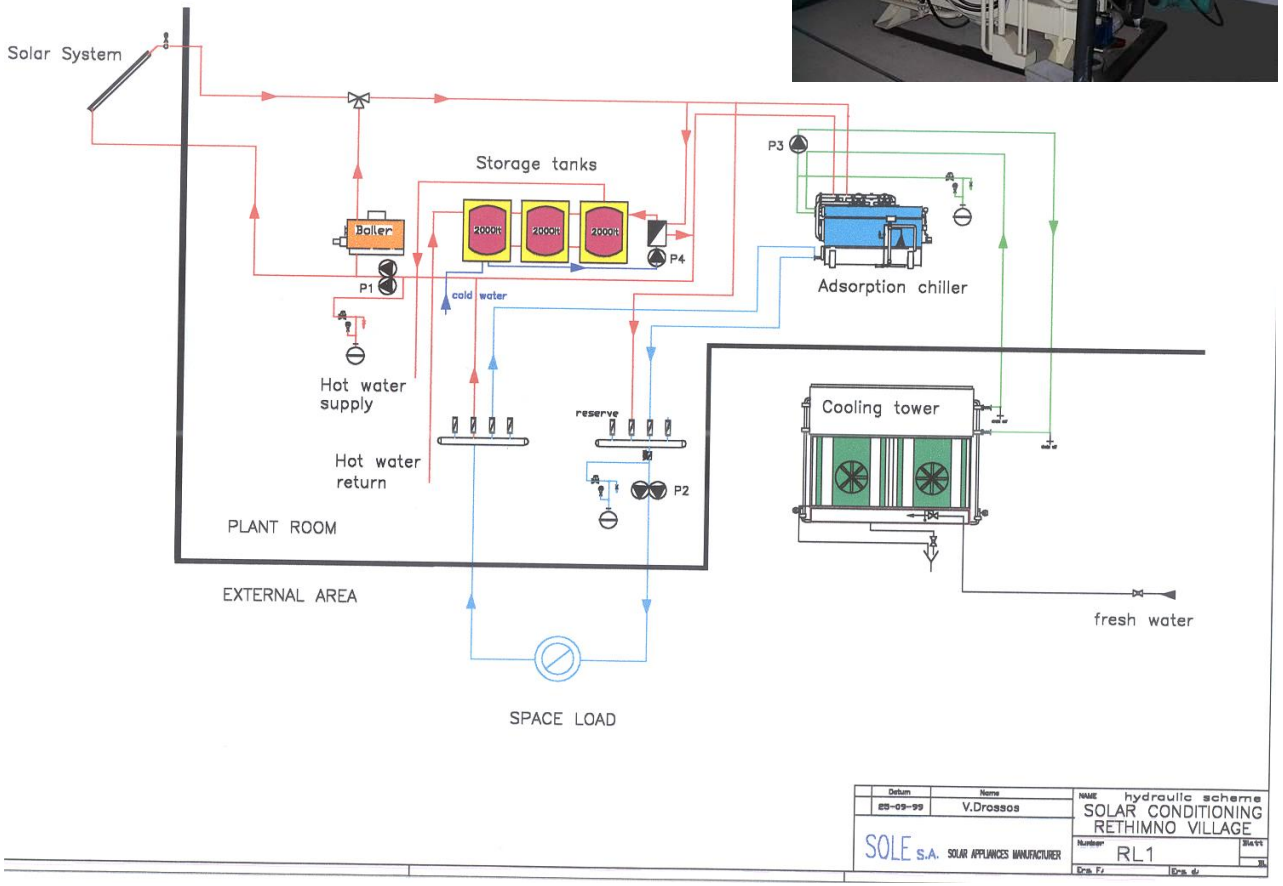
Absorption chiller ***100kW***

COP_{th} ***0.6***

Solar coverage ***43%***

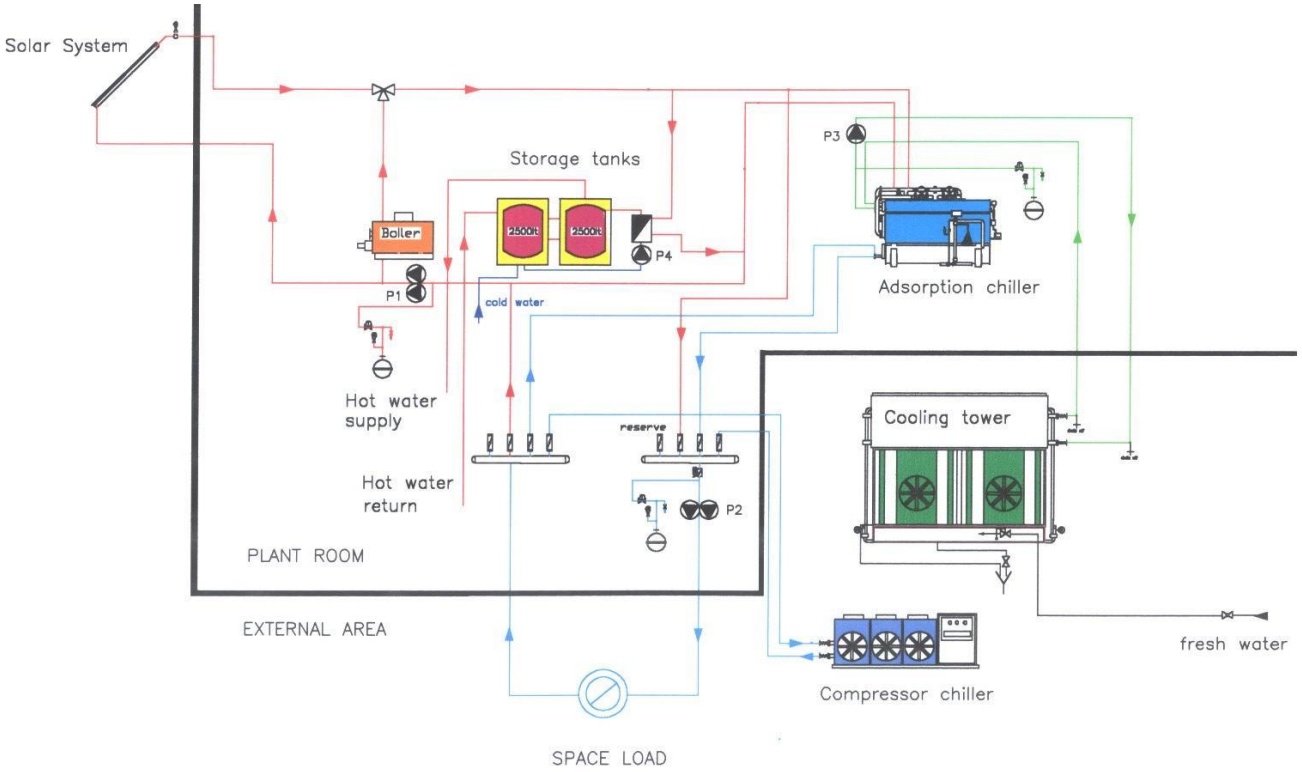
Total cost ***264,123€***

National subsidy ***50%***



Case study: Hotel Lentzakis

The **successful** case study of Rethimno Village was replicated to the hotel Lentzakis with similar design, solar and chiller technology, collector area, cooling capacity and energy loads.



Thank you for your attention

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