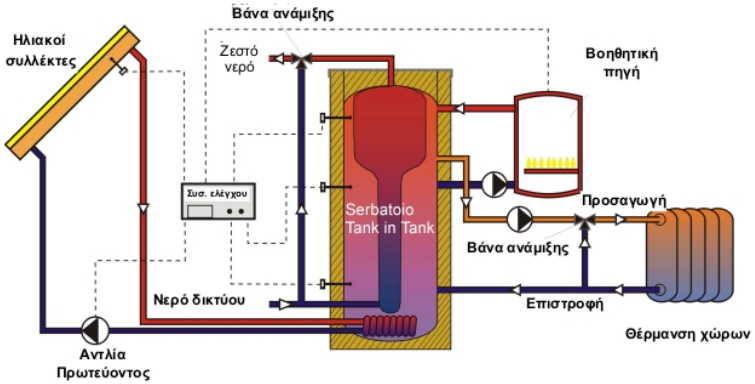


Solar Thermal Systems in Buildings

Dimitrios Chasapis
R.E.S. Technology Eng
CRES Solar Thermal Department

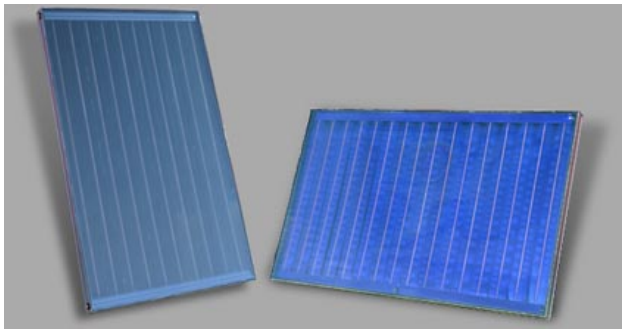
ΚΑΠΕ CRES
Extend Accredited Renewables Training for Heating
Intelligent Energy Europe
sollet
SOLARGE
Enlarging Solar Thermal Systems in Multi-Family-Houses, Hotels, Public and Social Buildings in Europe

Why solar thermal?

Contents

- **Solar thermal collectors**
  - *Collector types and uses*
- **Domestic (Sanitary) hot water preparation**
  - *DHW heating systems*
- **Combi systems**
  - *Operation, properties and examples*
- **Solar cooling (Solar Combi+) systems**
  - *Solar chillers, properties and examples*
- **High-Combi**
  - *High solar fraction (<80%) heating and cooling system*

Solar thermal collectors



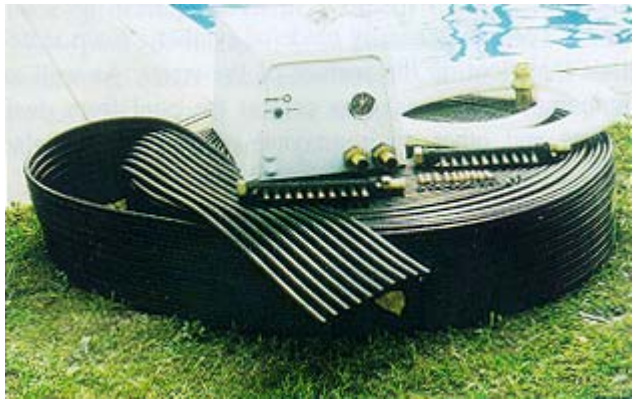
flat plate

vacuum

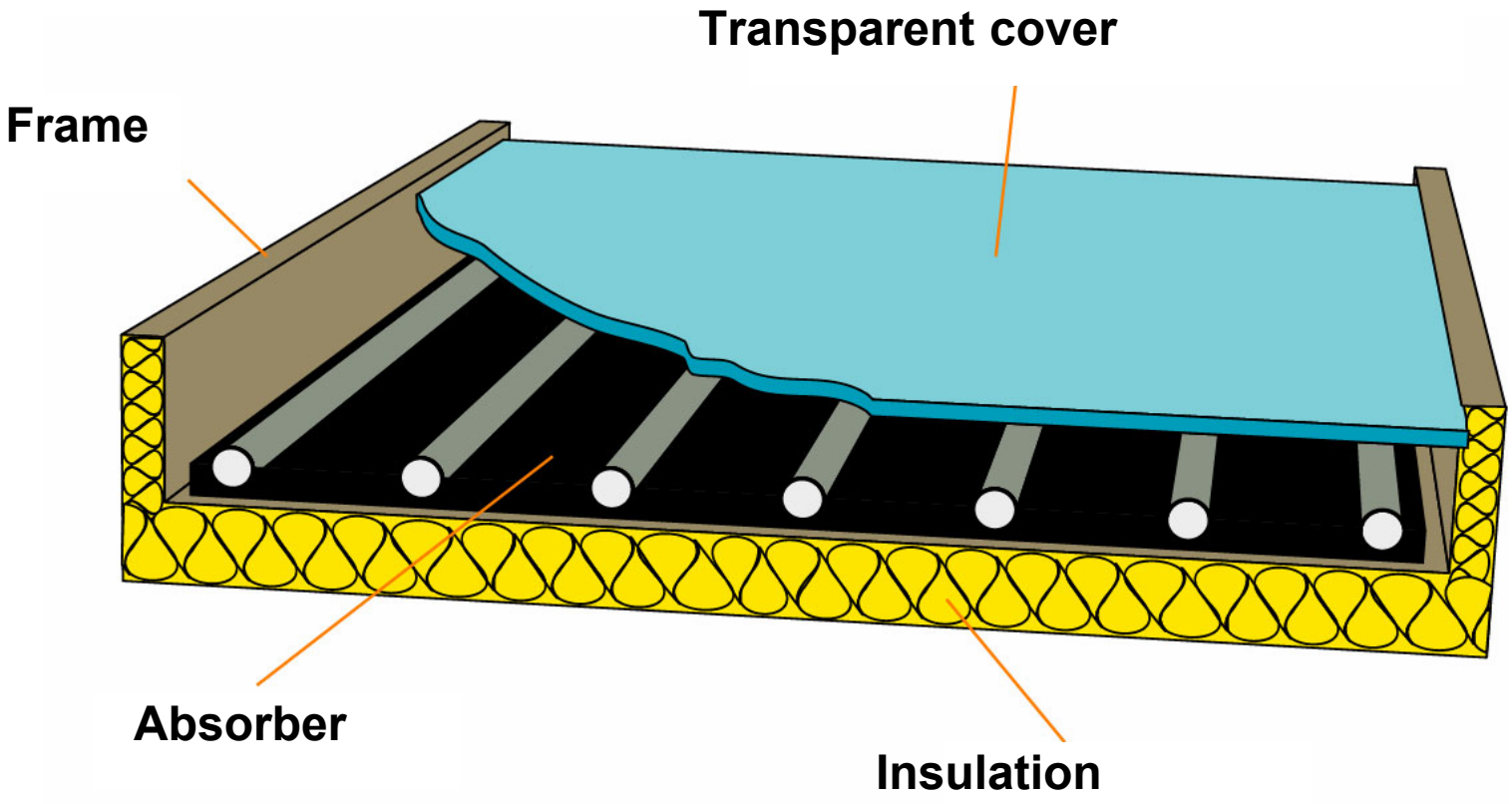
(evacuated tubes)

unglazed

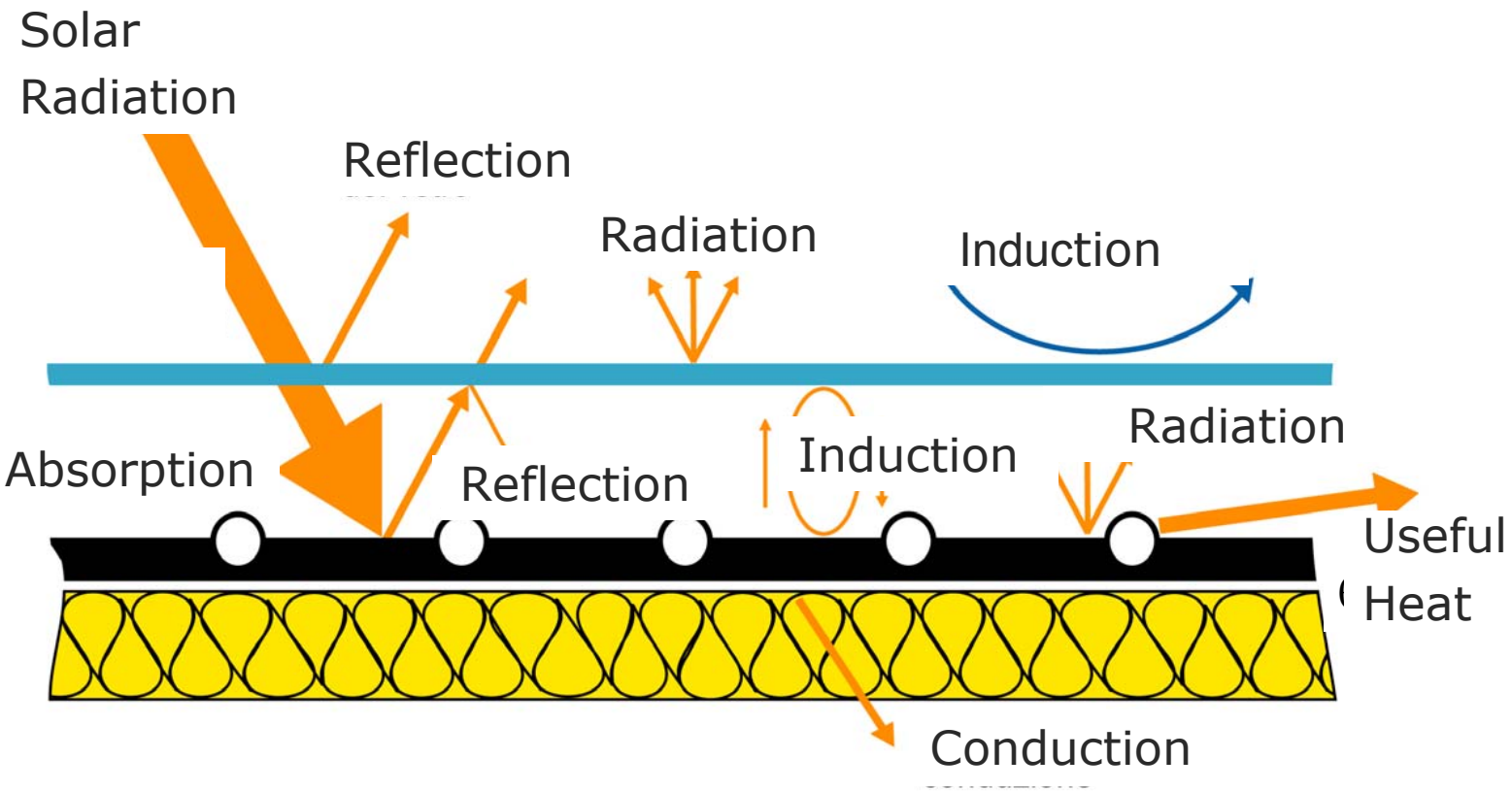
(plastic)



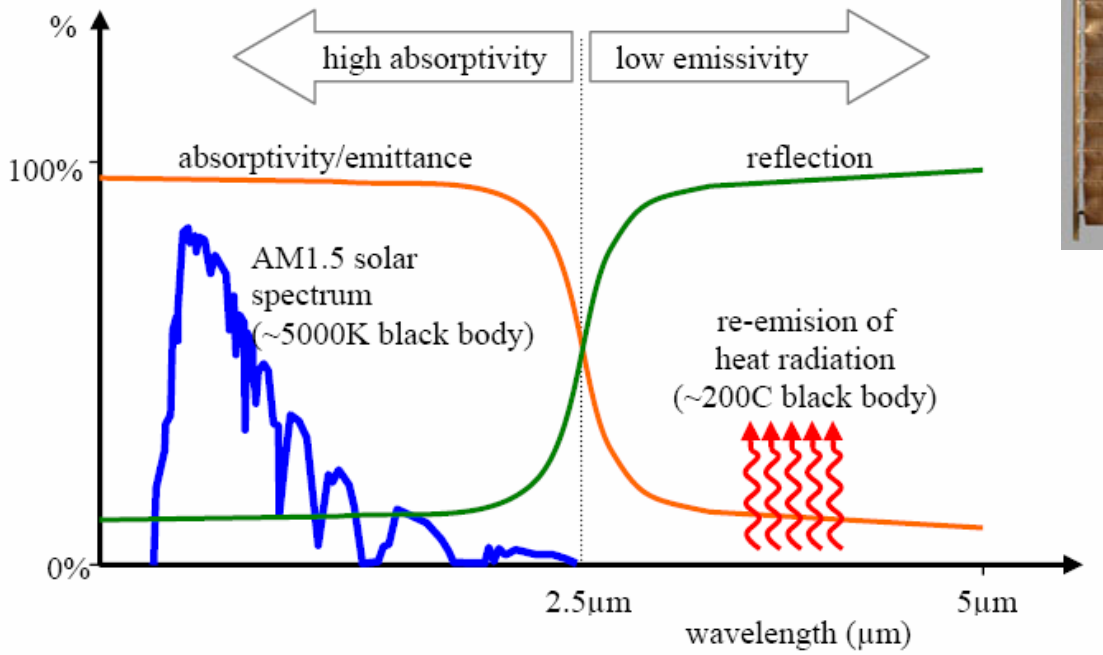
Flat plate collectors



Flat plate collectors



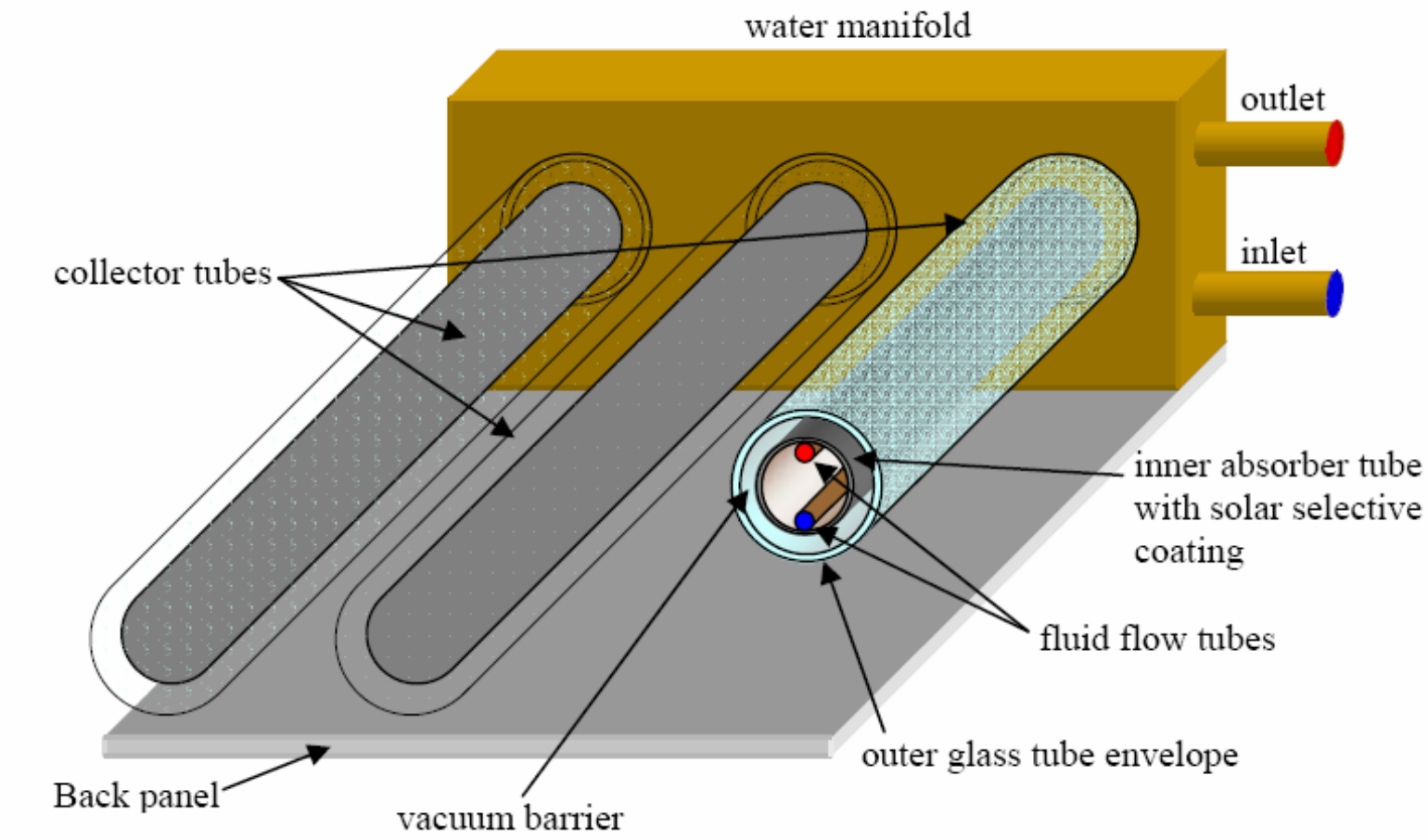
Absorption surface



Source :CREST, Loughborough Uni

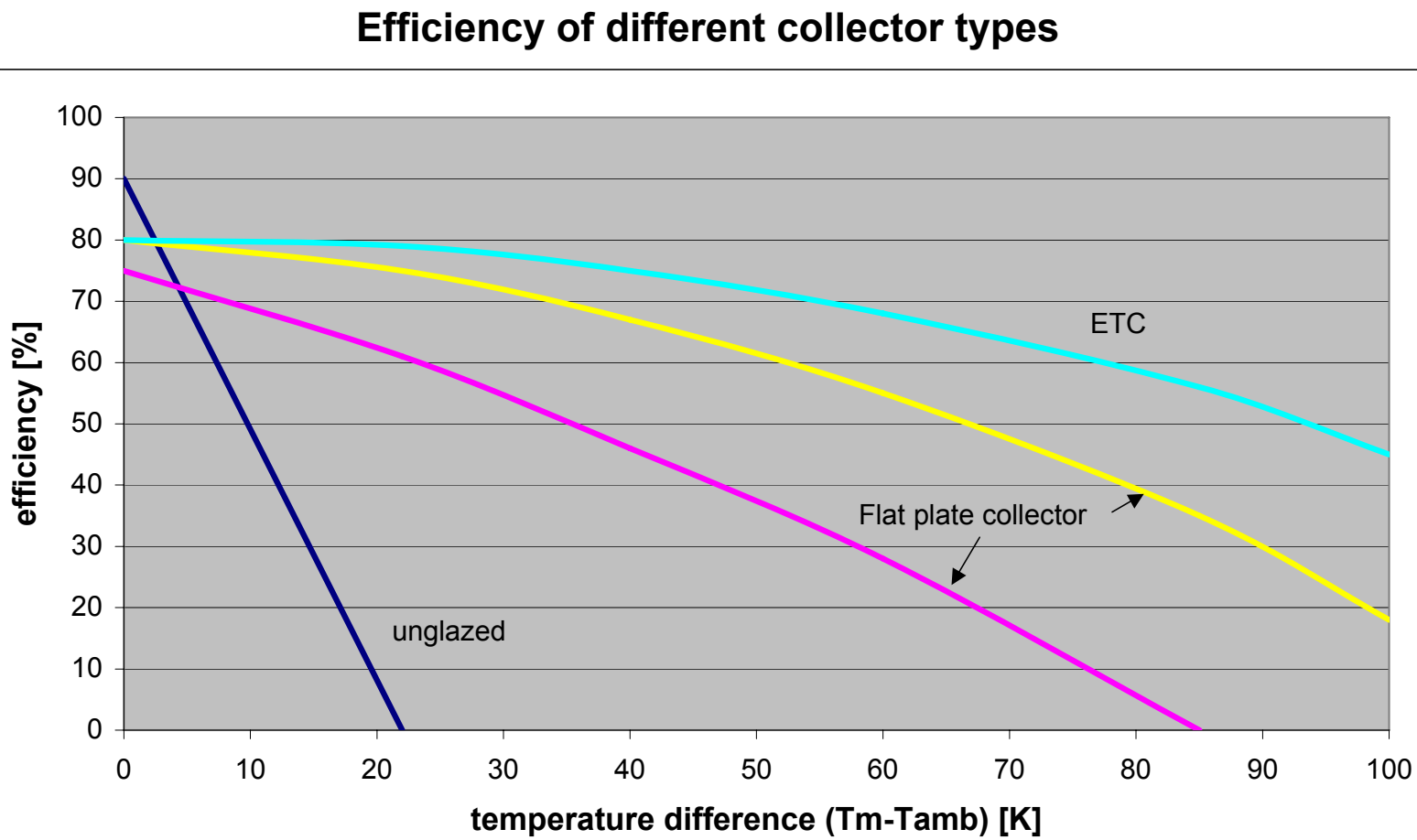
Source:Dimas Solar

Vacuum tube collectors (evacuated tubes)



Source :CREST, Loughborough Uni

Collector type efficiencies



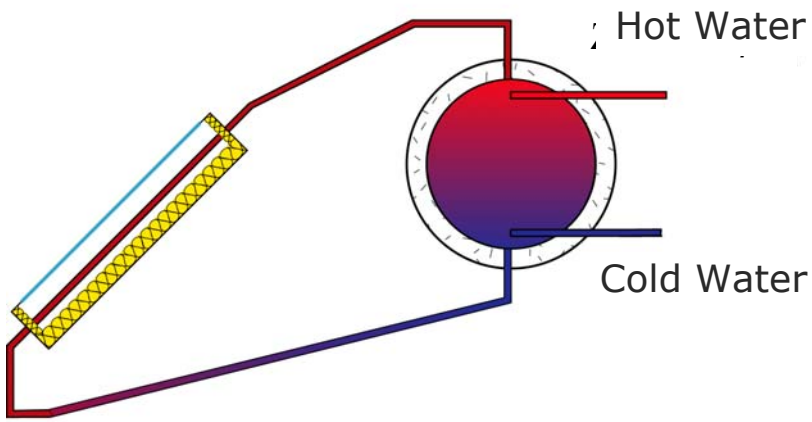
Solar thermal collector characteristics

Collector Technology	Cost	Performance (kWh/m²/year)	Typical Use
Unglazed	Low	300	Pool Heating
Flat Plate Collectors (Black paint)	Mid	650	Pool Heating, DHW
Flat Plate Collectors (Selective surface)	Mid	700	DHW, Space Heating, Solar Cooling
Vacuum Tube	High	850	Space Heating, Solar Cooling

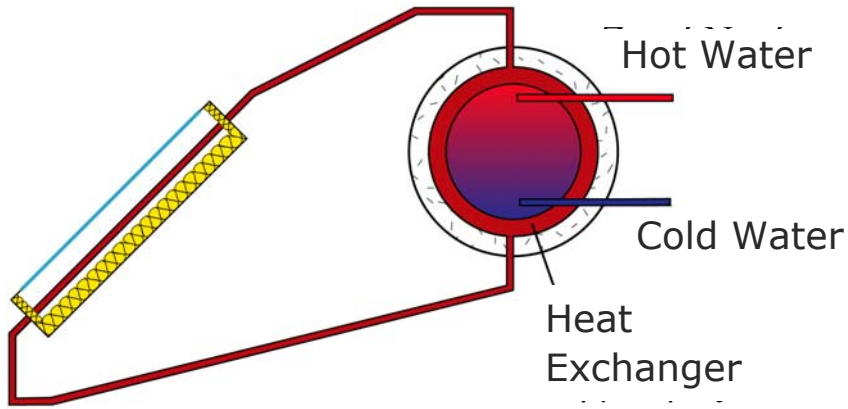
DHW Preparation

DHW heating systems

Solar thermal systems
Thermosyphonic



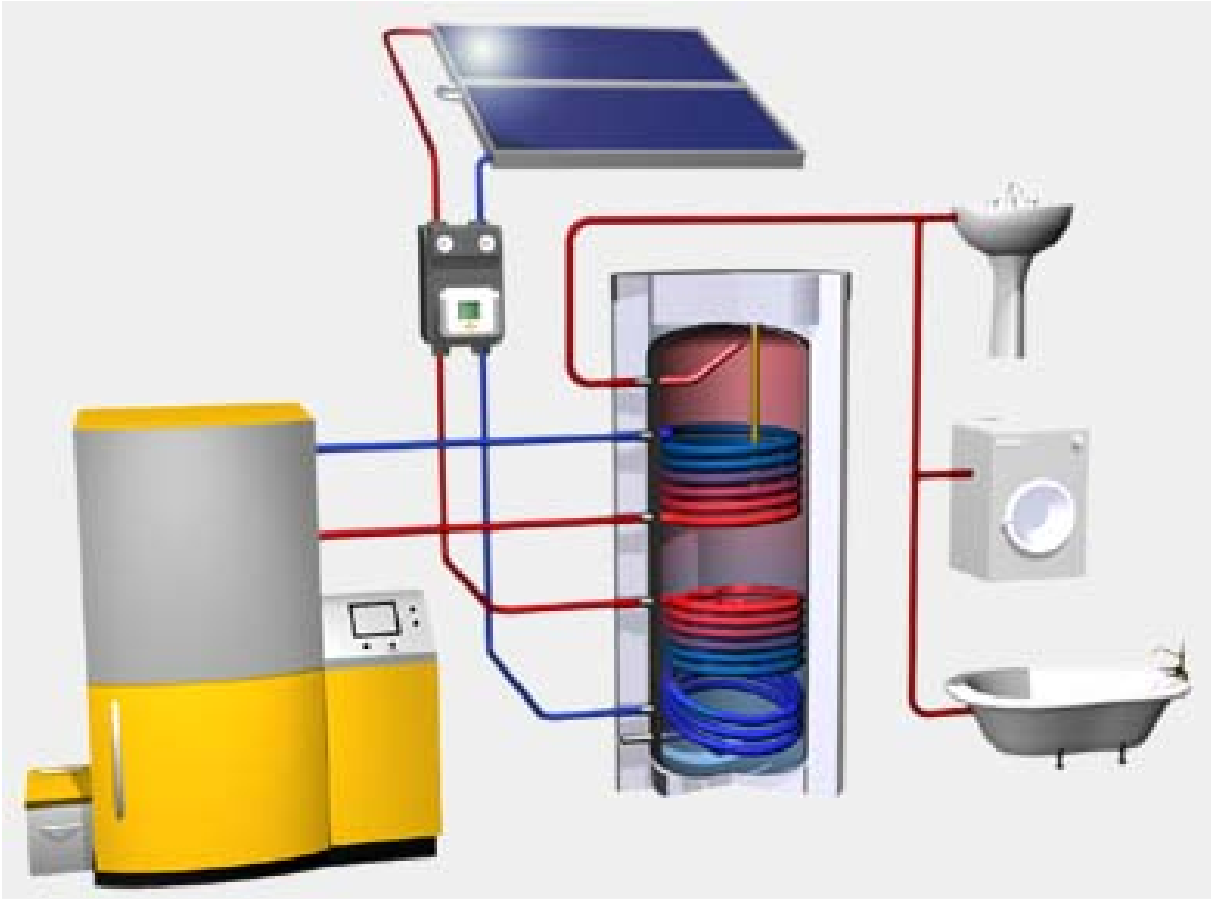
Open Circuit



Closed Circuit

Πηγή:Target/DGS

Solar thermal systems
Forced circulation



Source:IfaS

Combi Systems

– *Operation, properties and examples*

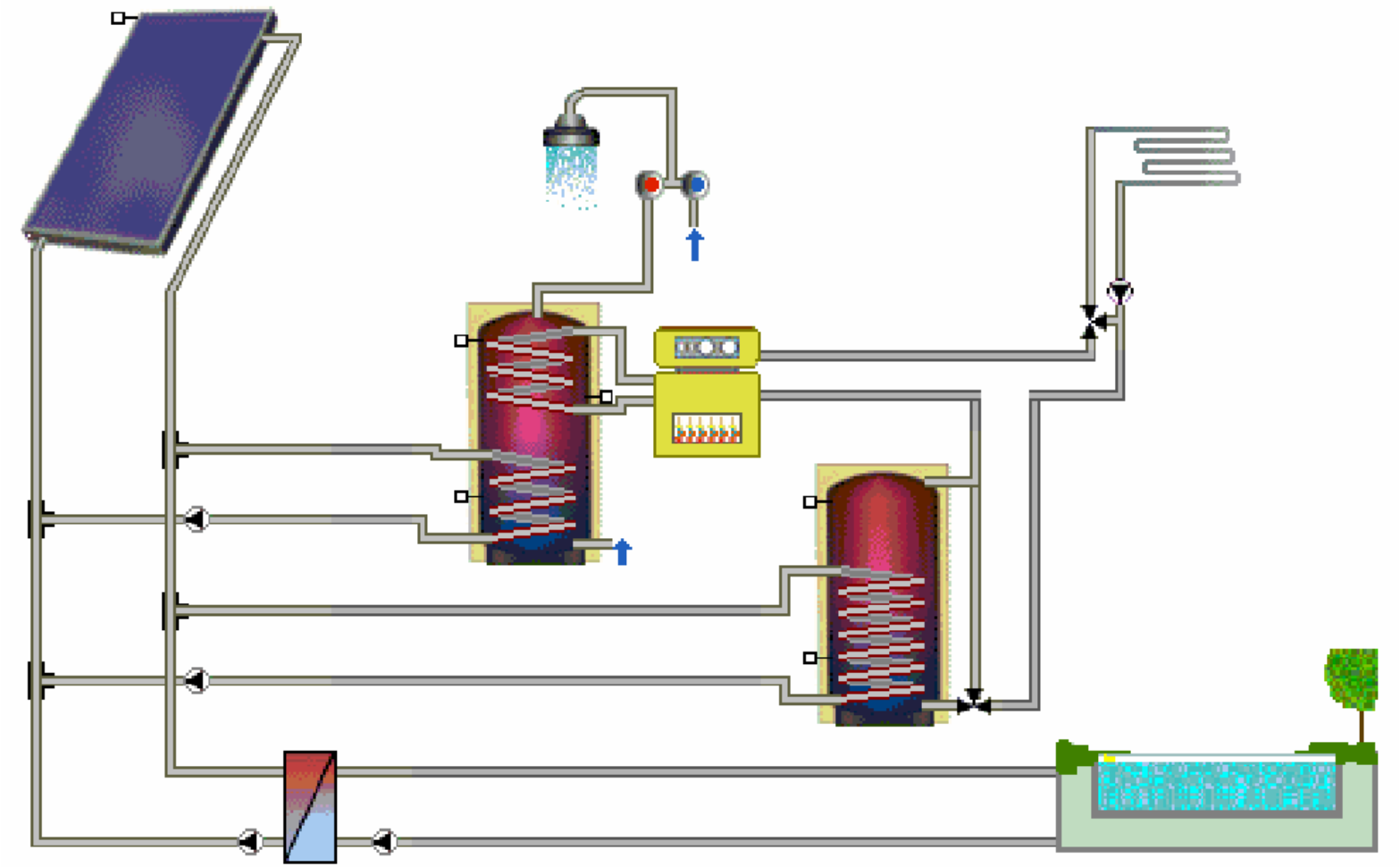
«combi» systems
General description

"Solar combisystems" or "combi": solar thermal systems used to for space and domestic water heating.

10 basic variations (International Energy Agency – IEA, Solar Combisystems, Solar Heating & Cooling Programme, Task 26)

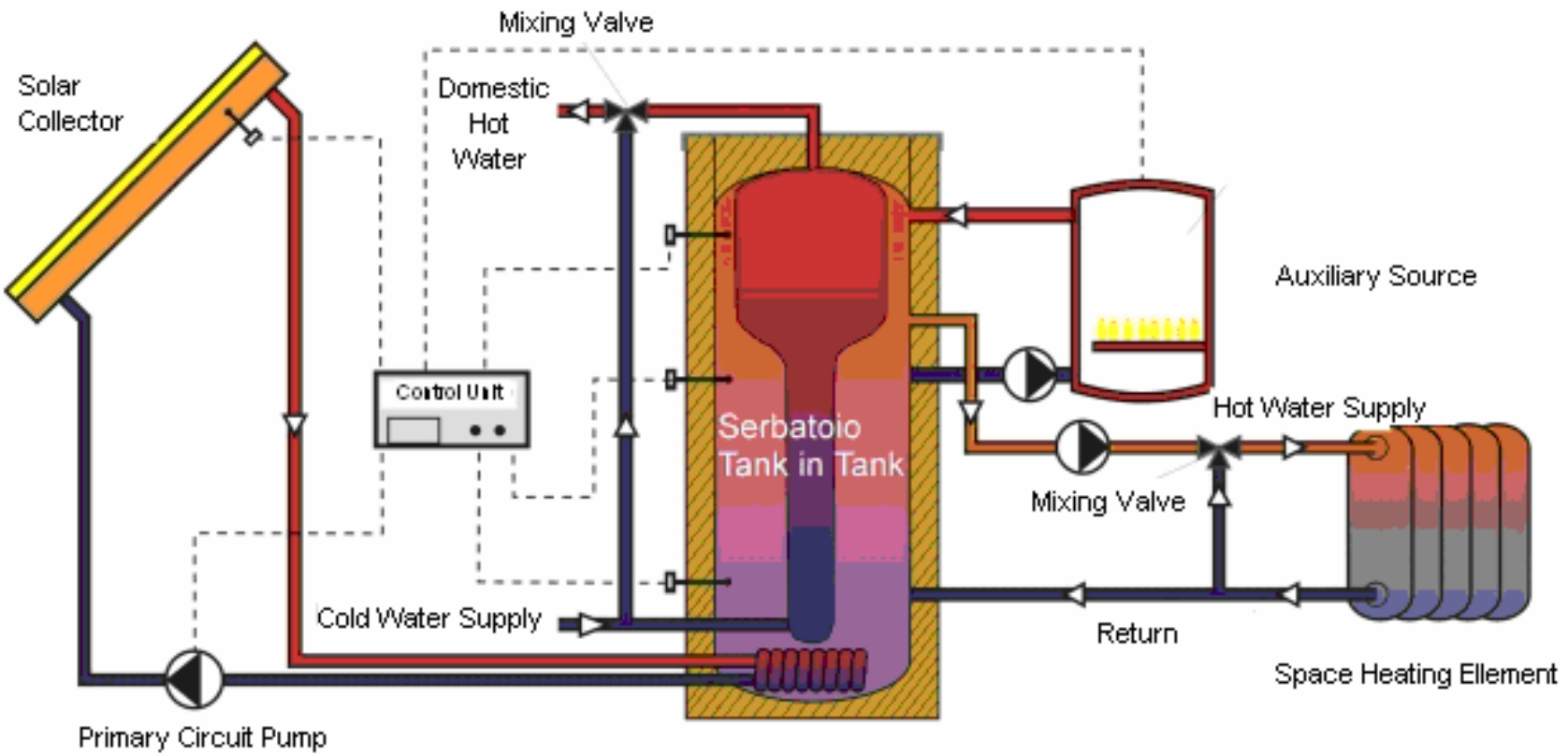
Combi systems

Schematic diagram of a combi system

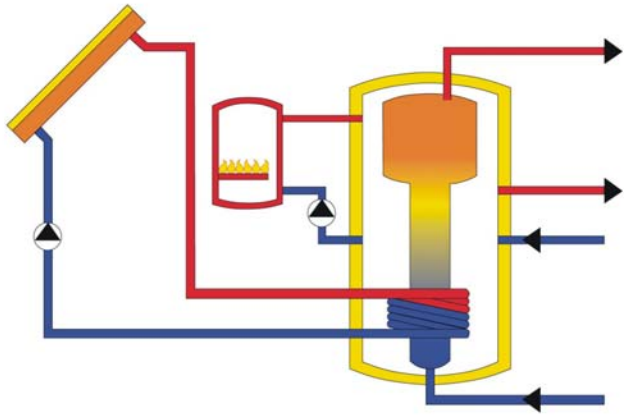


Combi system

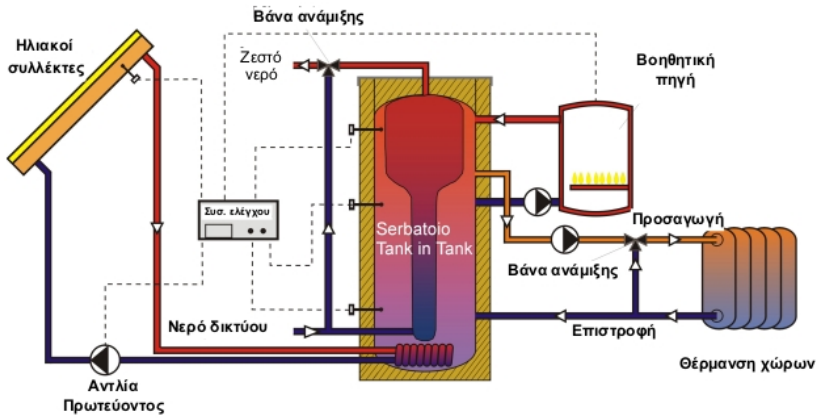
Schematic diagram with combi-tank



Combi system
combi-tank



Combi systems
Properties



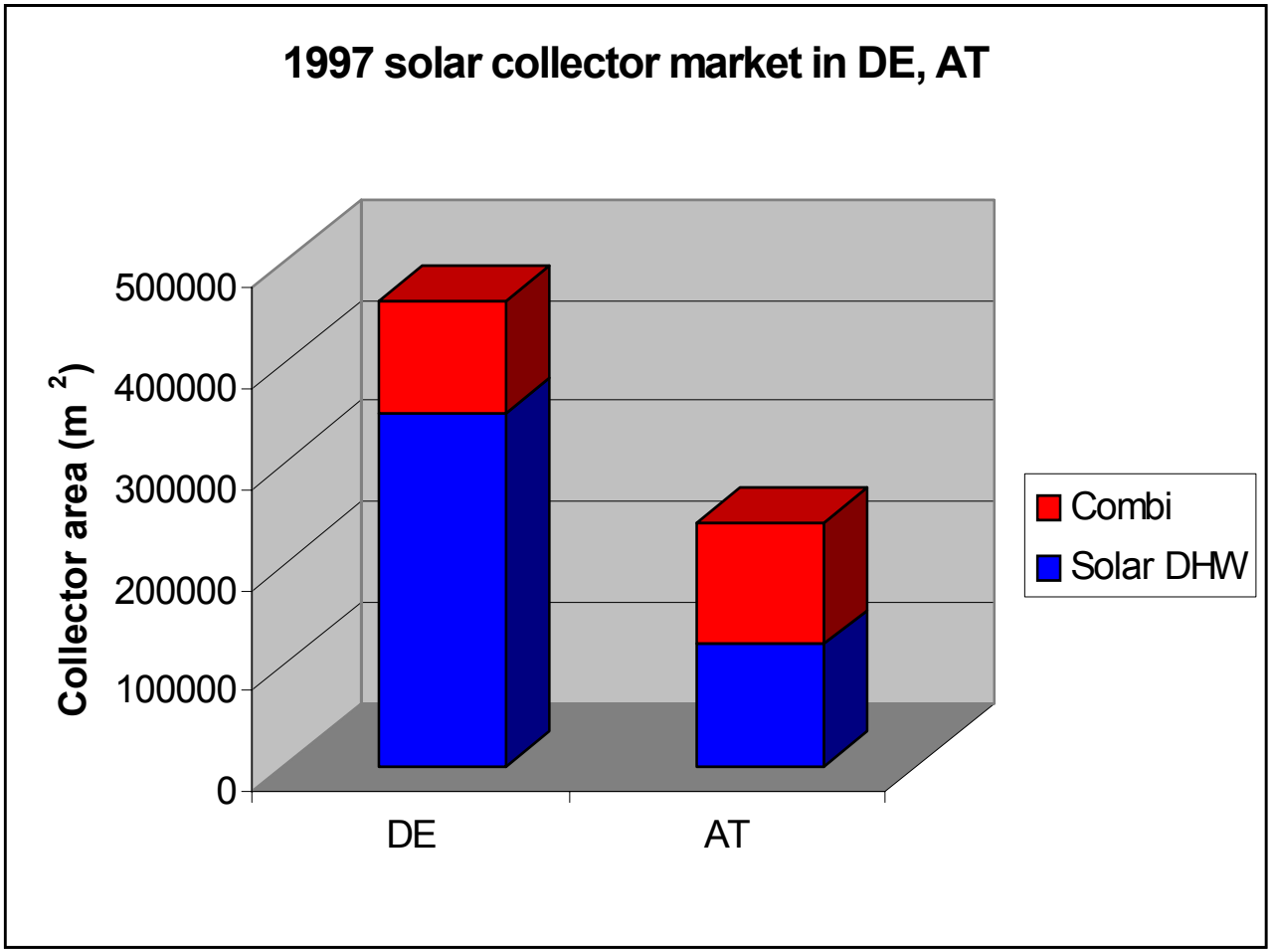
- Higher Energy Saving
  - Introduction of the solar technology to space heating
  - Vast potential
- Cost comparable to common solar thermal systems
- Possibility to combine with (solar) space cooling systems

Combi systems
Advantages

Source: Sonnenkraft

- Used in:
  - Houses
  - Hotels – Hospitals etc.
  - Industry
- Have already enter the European Market
- Very favorable climate conditions in Southern Countries
  - 30-50% Solar coverage
  - 100% (combined with biomass)

Advanced Combi market



The installation of "SOLLET" project at CRES

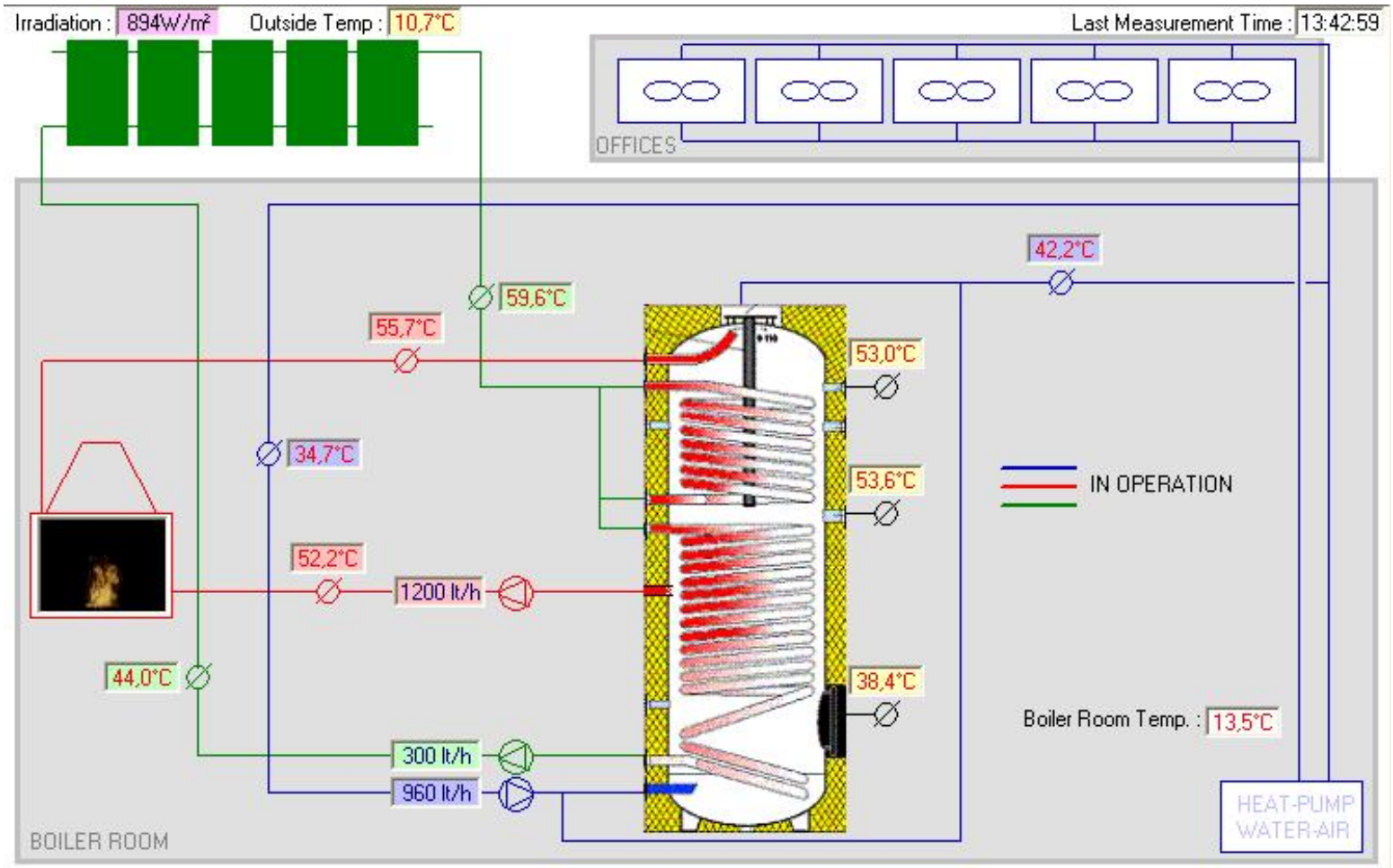
60m^2 Offices

Solar Thermal Collectors, 13.5m^2

Hot Water Storage Tank, 500l

Biomass Boiler, 35kW

System's schematic diagram



European project SOLLET (2):
Germany, Dormagen

Wood pellet oven

Solar collectors

- *House for one family with 400m² heated living area*
- *10 KW wood pellet oven with air/water heat exchanger*
- *10 KW wood oven with air/water heat exchanger*
- *105m² collector area*
- *3000l water storage tank*
- *Gas heating back-up system*

House

Wood oven

European project SOLLET (3):
Germany, Cologne

House

- *House for with 140m² heated living area*
- *10KW wood pellet oven with air/water heat exchanger*
- *28m² collector area*
- *1000l water storage tank*

Wood pellet oven

Solar collectors

Combi system
France

Πηγή: IEA Task 26

Combi System : multi-apartment (AT)

Πηγή: GSWB

Combi System : Solar Village III (GR)

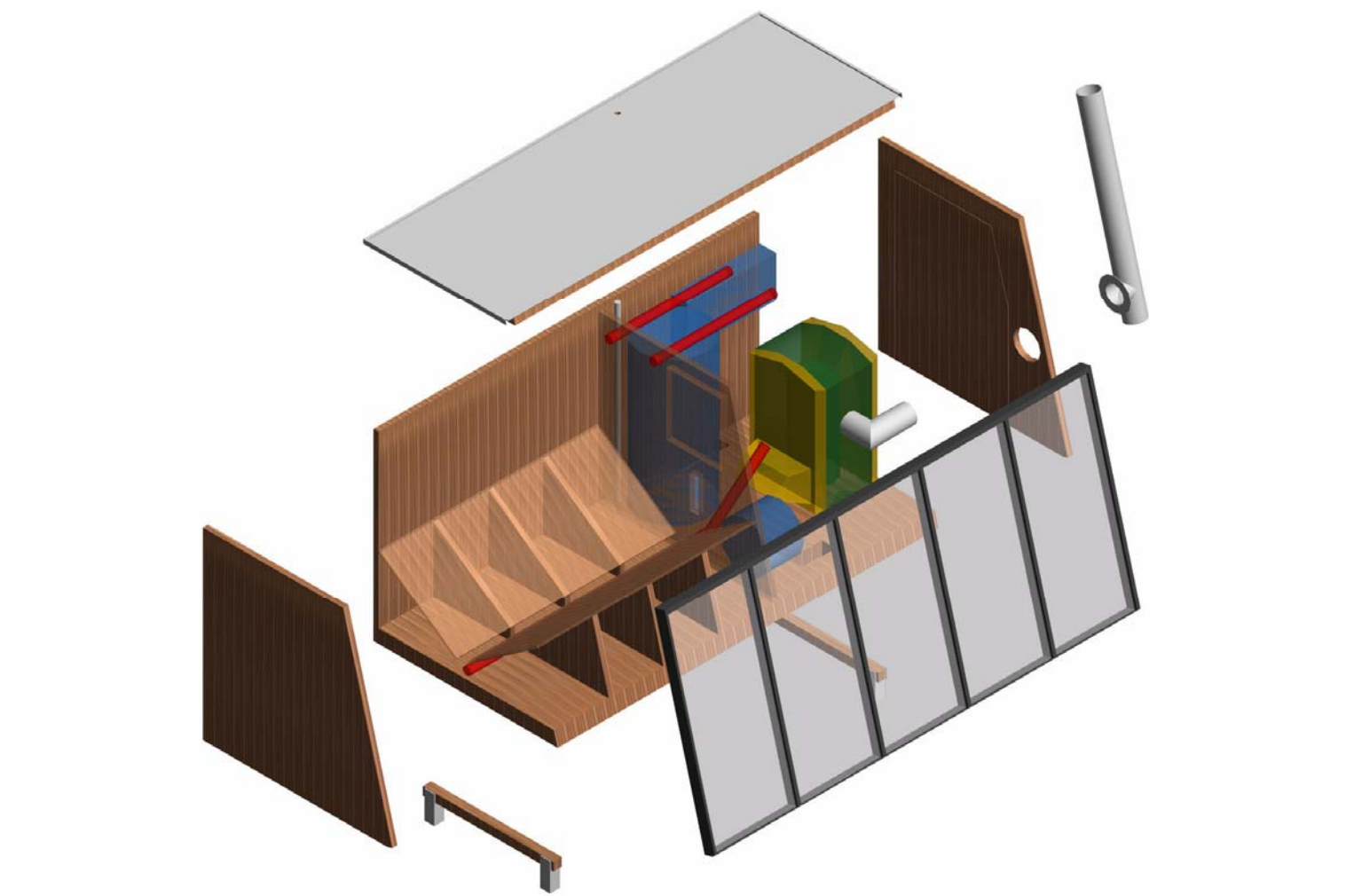
Commercial Systems

Καυστήρας Pellet

Πηγή: Buderus

Commercial Systems:
Plug n' play system

Commercial Systems:
Plug n’ play system



General Remarks - Comments

- The system can be combined with conventional heating devices - integration in any existing heating system.
- They can be combined with solar chillers (Combi+) for the cooling load coverage (use of un-needed energy during summer).
- Cost : ≈400€/m²
- Required collector field:20% of heated space for 40%-50% coverage (eg. 20m² flat plate collectors for 100m³ house)
- Special care must be taken on the system design and dimensioning (eg. the dimension of the expansion tank for stagnation).

Solar Cooling – Air conditioning

Chiller types, properties and examples

Solar Air Conditioning

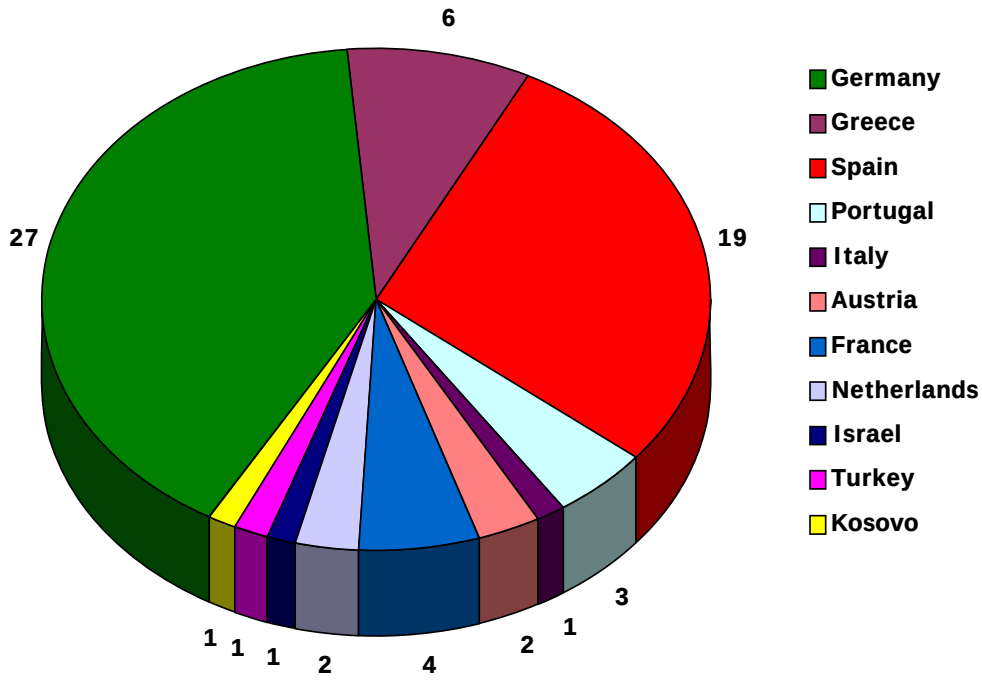
System that use the solar energy for space heating, cooling and DHW preparation.

Use of chillers that use hot water as primary energy supply.

- Closed circuits for chilled water production
- Open circuits for conditioned air

Solar Cooling systems (2004)

- 67 systems
- Total installed cooling power 6 MW
- Collecting surface: 16700 m^2

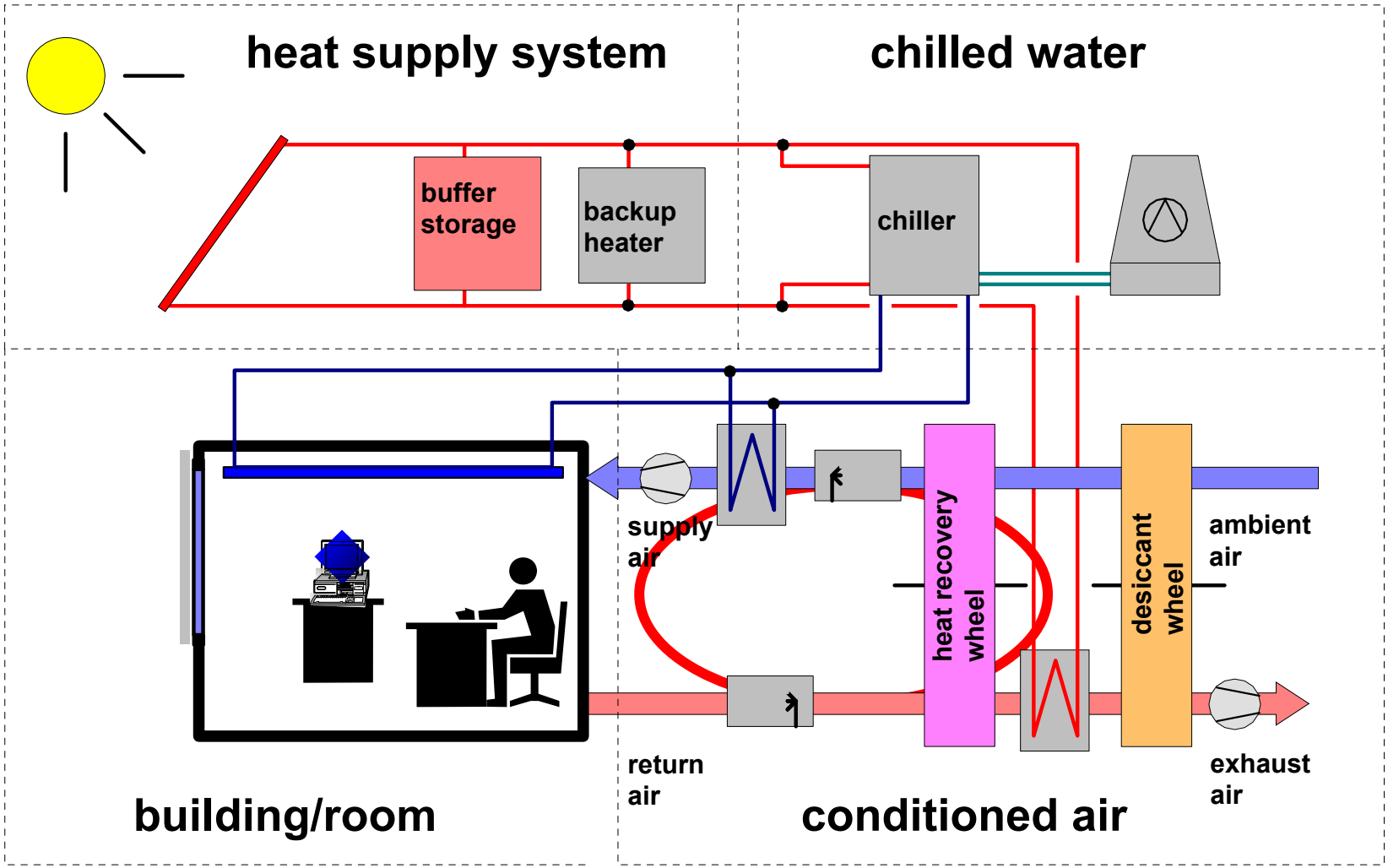


Source: IEA Task 25

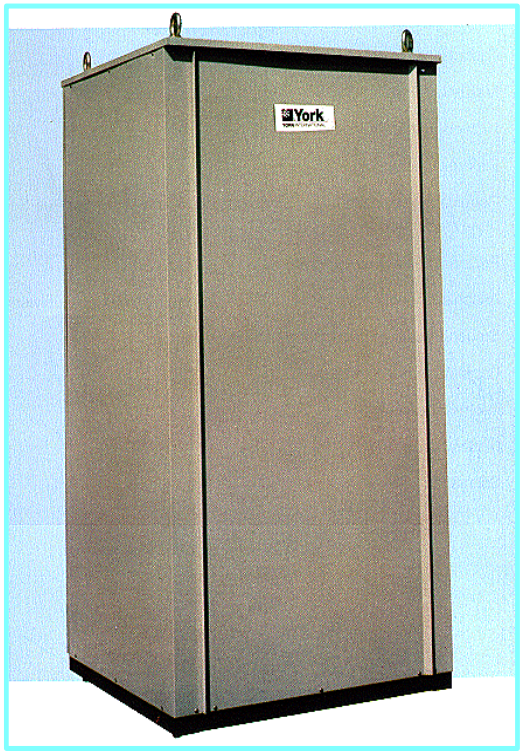
Solar cooling technologies: basic characteristics

Method	Closed cycle		Open cycle	
Refrigerant cycle	Closed refrigerant cycle		Refrigerant (water) is in contact with 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

Solar cooling configurations



Absorption chillers

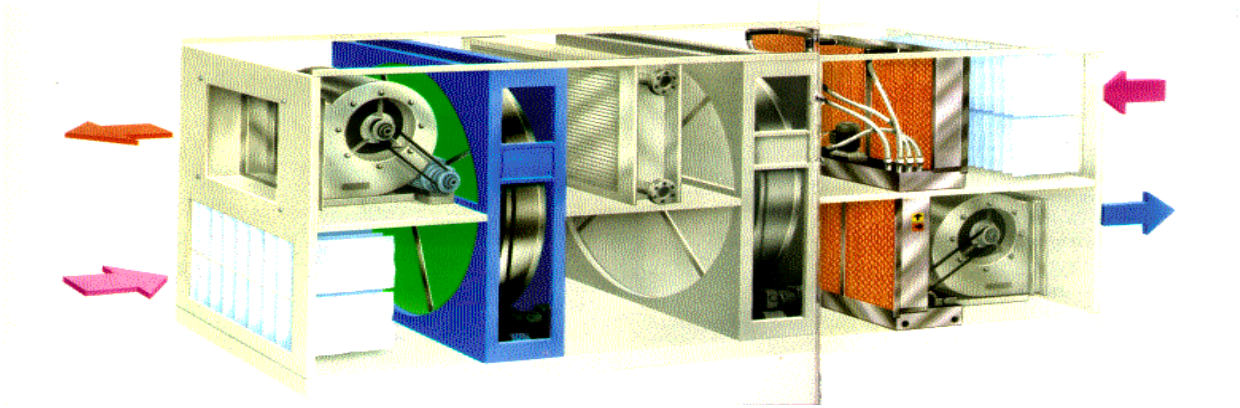


- 13 low power products available (<100 kW)
- 3 chillers from Greek manufacturer
- The chilled water can be used for air conditioning (evaporation) or direct space cooling (fan-coils, chilled ceilings,…)
- Smaller chiller: 4.5 kW
- Supply water temperature: 75°C - 100°C
- COP 0.68-0.78

Adsorption chillers

- The chilled water can be used for air conditioning (evaporation) or direct space cooling (fan-coils, chilled ceilings,…)
- Cooling power: 50 kW - 400 kW
- Supply water temperature > 55°C
- COP 0.65

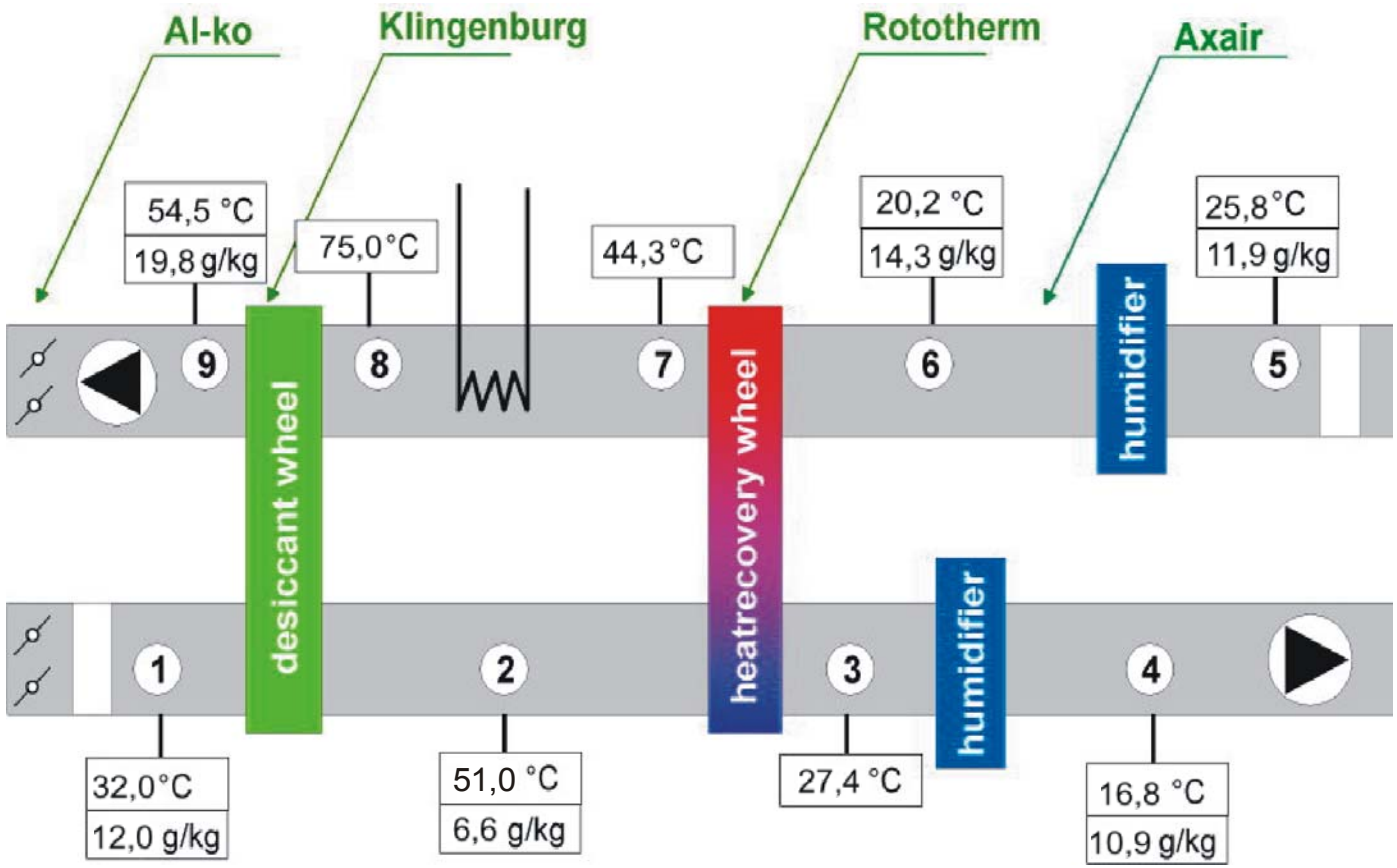
Desiccant Evaporative Cooling (DEC)



- Simple technology and low cost materials
- Parts available in the market
- About 6 desiccant wheel manufacturers worldwide
- Use of low water temperatures (down to 45°C)
- Chemical storage of energy and higher efficiencies (regeneration) with liquid desiccant (ClLi)
- ✘ Large space requirement

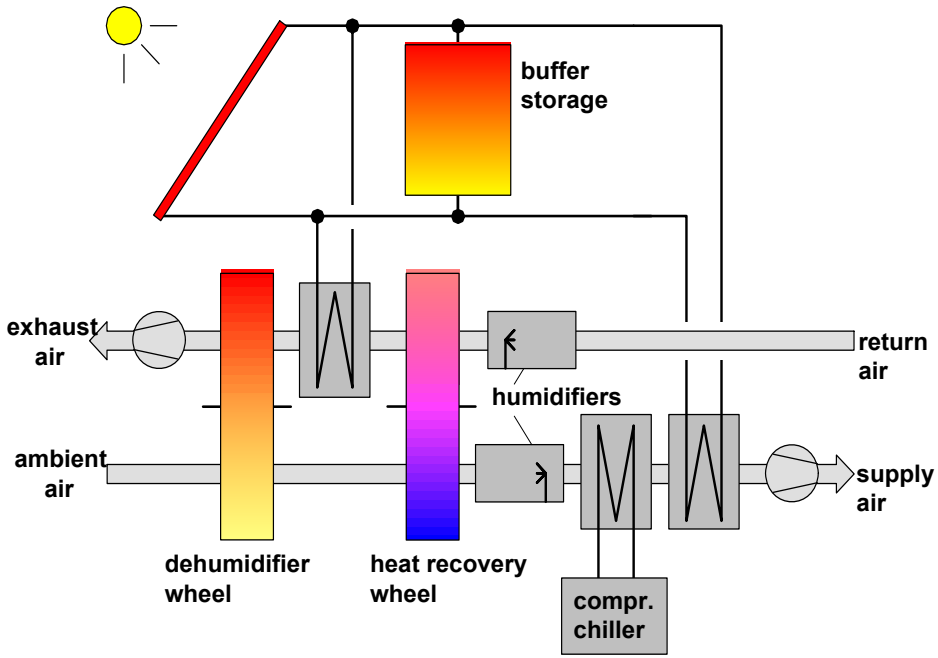
Source: Fraunhofer -ISE

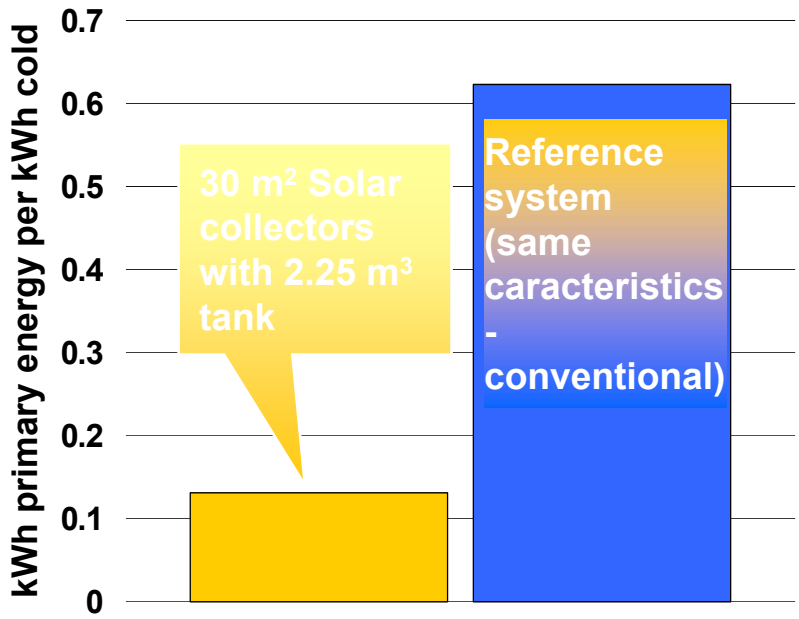
DEC: operation



Hybrid systems

Cooling with solar energy and compression chiller





DEC with integrated compression chiller in Palermo – Italy (240 m²)

Low power solar chillers

aosol energias renováveis

EAW

rotartica

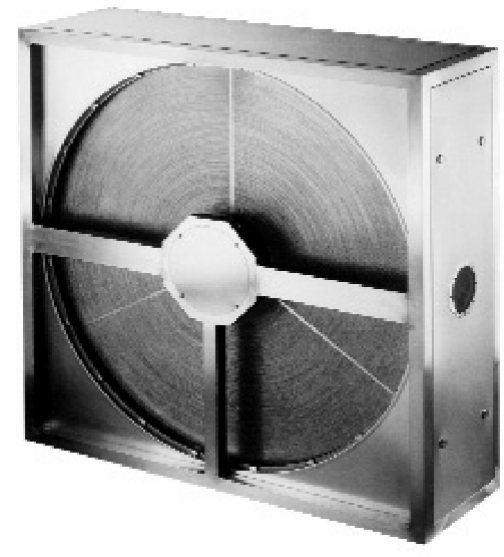
SorTech AG

PINK

ClimateWell

SK SonnenKlima GmbH

Solid DEC cooling system



Source: Fraunhofer -ISE

House with absorption chiller (4.5-10kW)

Source: Rotartica

Offices of Fraunhofer ISE – Liquid DEC

Source: Fraunhofer -ISE

“Photonio Project” – Oinofita Attiki – Largest Installation

Sarantis cosmetic factory

- Collector field:2664m²
- 2 adsorption chillers 700kWc
- Total cost: 1.409.000 €

Source:Sole s.a.

General observations

✓ Seasonal coincidence of high cooling needs and high solar energy

✘ Industry of small scale chillers is under development

✘ High cost for chillers up to 30kW (2000€/kW)

✓ Integration to existing systems. (use of Fan coils etc.)

✘ Many companies hesitate to export their products

✓ Solar chillers in "split unit" form are expected soon

✘ Cooling tower is required in most cases

✓ Can use geothermal borehole heat exchangers to reject energy instead of cooling tower

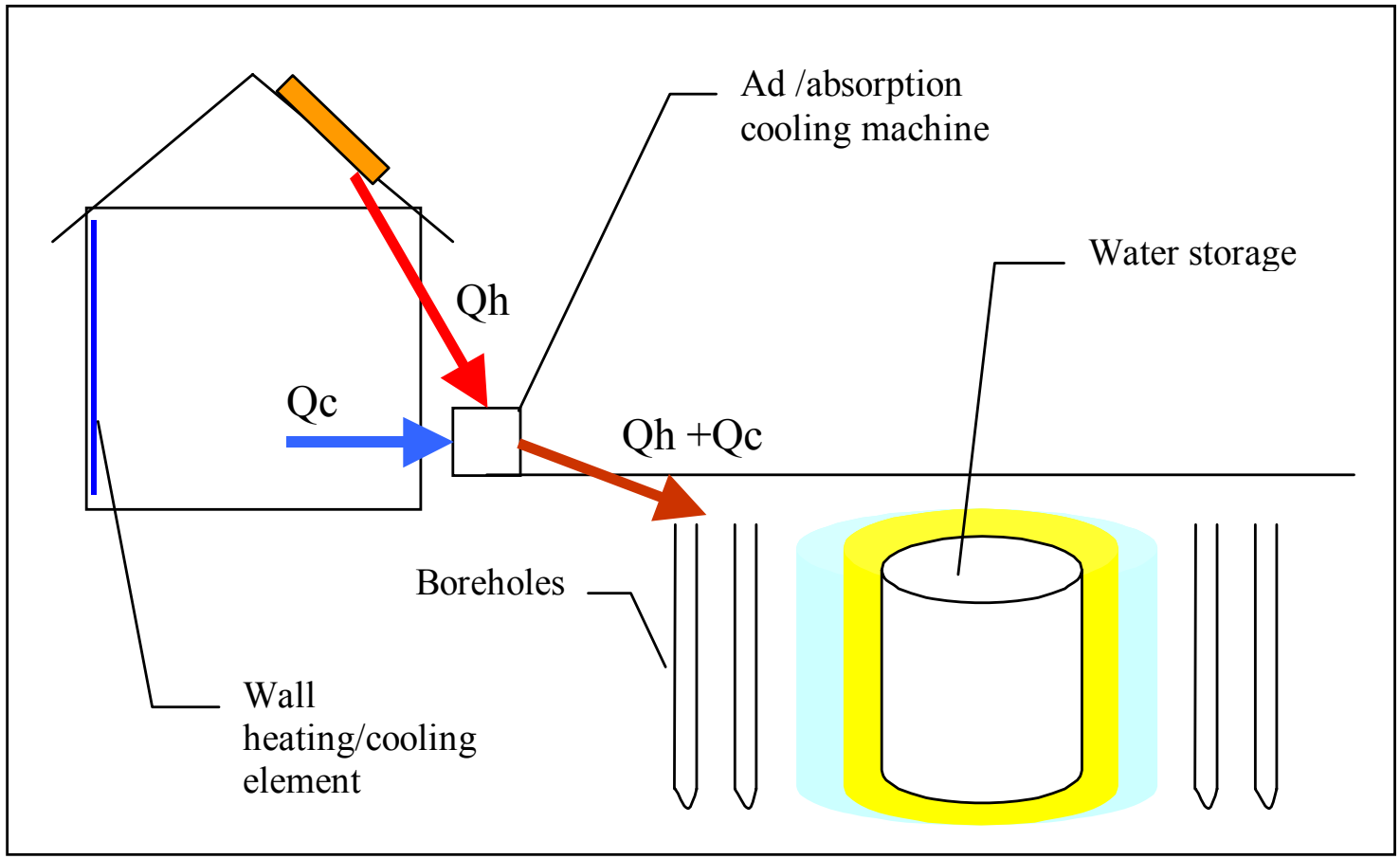
General collecting field dimensioning:

- 3m²/kWc for closed circuit systems
- 10m² per 1000m³/h for open circuit chillers

High-Combi

- *High fraction solar cooling and heating system with bi-seasonal storage*

European project High-Combi



High Solar fraction heating and cooling systems
(High-Combi, STREP FP6)

Thank you for your attention