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Solar thermal heating systems in European Union

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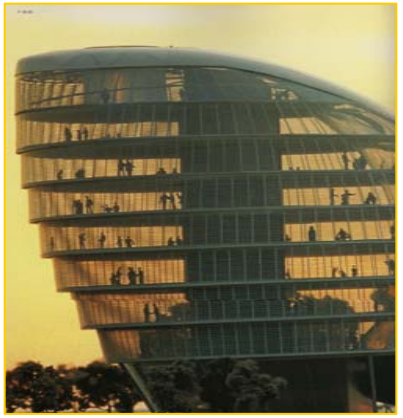
1. Primary energy demand

- **Energy consumption in commercial and residential buildings**:
  - 40% of Europe's energy bill.
  - 435 Mtoe in 2002.
- **Increased demand for air conditioning in buildings**:
  - Higher living and working standards
  - Adverse outdoor conditions in urban environments
  - Installed a/c has increased 5-fold in the last 20 years in Europe
  - Total a/c floor space: 30 million m^2 in 1980, over 150 million m^2 in 2000.
  - Annual energy use of room a/c was 6 TJ in 1990, estimated 160 TJ in 2010.
- **CO_2 emissions are expected to increase 20-fold from 1990 to 2010**, only in the EU



Solar thermal systems can help alleviate the problem!

Pool heating

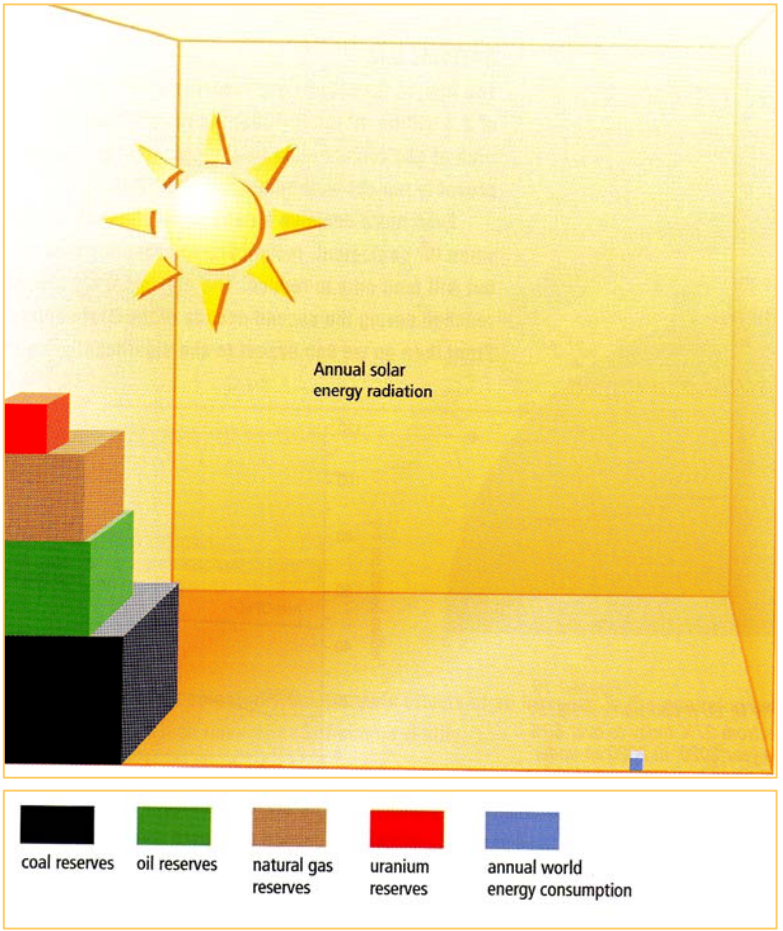
Domestic hot water

Space heating

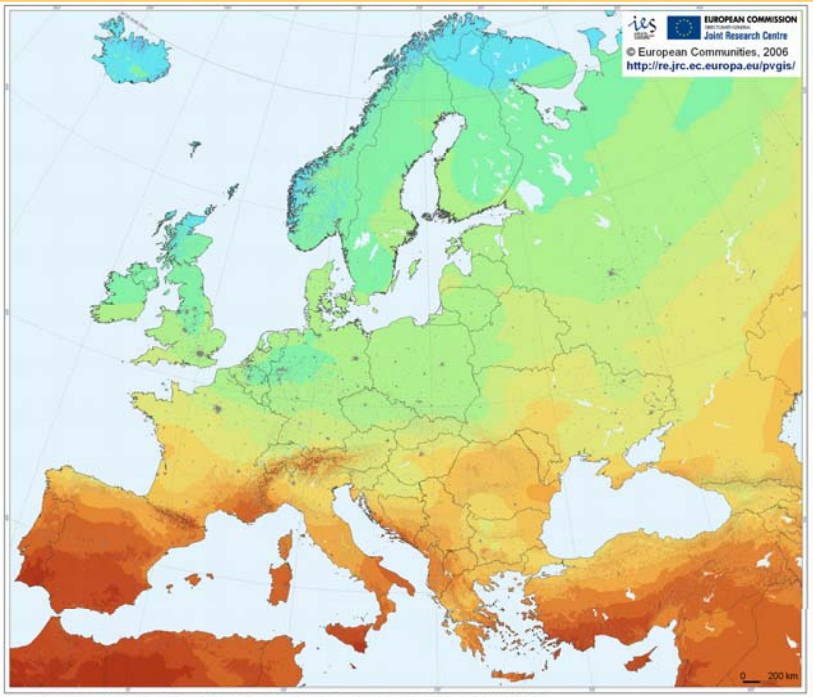
Space cooling

The solution : Solar Energy

- **Radiation** supply from sun carries a **5 billion year guarantee**
- Annually, **the sun provides 1.5*10^{18} kWh**, that is more than 10,000 times the energy that human race needs.

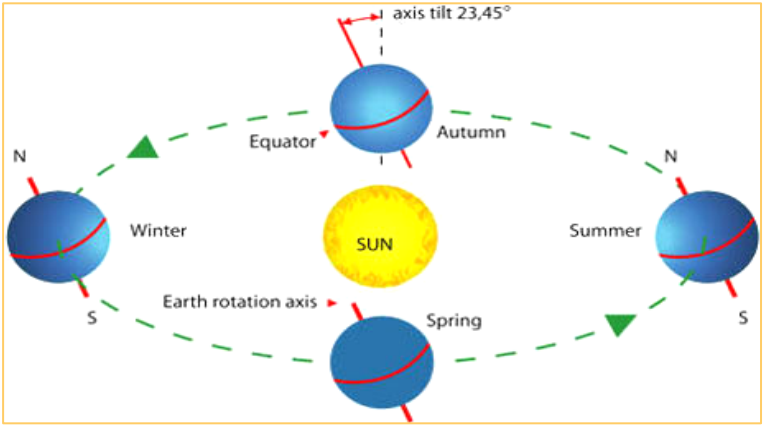


Source: *Planning & Installing Solar Thermal Systems: A guide for installers, architects & engineers*, EarthScan publications



Average annual solar irradiance is an important value for designing a solar plant. It depends on the geographical location, i.e. Saharan desert has 2.2 times higher radiation that Europe.

The **average solar irradiance is higher at lower latitudes**, since the rotation axis of the earth forms an angle of 23.45^0 with the perpendicular.



2. Solar Collectors Optimum Angle

Geographical location

- **Winter use**: geographical latitude of area + 15^0
- **Summer use**: geographical latitude of area - 15^0
- **Annual use**: collector angle = geographical latitude

RESULTS OF INCIDENT RADIATION ON COLLECTORS (FROM TSOL)
Place: Athens
Azimuth: 0

G Inclined, Specific[kWh/m²]
acording to collectors inclination (in degrees °)

From:	To:	0	10	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
1/ 1/	1/ 2/	66	80	91	96	100	104	107	109	111	112	113	112	111	109	107	104	100
1/ 2/	1/ 3/	75	84	91	93	96	97	99	99	99	99	98	96	94	91	88	84	80
1/ 3/	1/ 4/	104	112	116	118	119	119	119	118	116	114	111	108	104	99	94	89	83
1/ 4/	1/ 5/	146	151	152	152	151	149	147	143	139	134	129	123	116	108	101	92	84
1/ 5/	1/ 6/	182	183	181	178	175	170	165	159	153	145	137	128	119	109	100	90	79
1/ 6/	1/ 7/	200	200	195	191	185	180	173	166	158	149	139	128	118	108	96	85	75
1/ 7/	1/ 8/	213	214	210	205	199	194	187	180	171	162	151	139	128	117	105	91	80
1/ 8/	1/ 9/	200	206	206	204	202	199	194	188	182	174	165	155	144	132	121	109	96
1/ 9/	1/10/	156	168	176	179	180	181	180	178	175	171	166	161	154	146	138	128	118
1/10/	1/11/	106	120	130	134	138	140	142	143	142	142	140	137	134	130	125	119	113
1/11/	1/12/	66	77	86	90	94	96	99	100	101	102	102	101	99	97	95	92	88
1/12/	1/ 1/	53	63	72	76	79	82	85	87	88	89	89	89	88	87	85	83	80
	Sum YEAR	**1567**	**1658**	**1706**	**1716**	**1718**	**1711**	**1697**	**1670**	**1635**	**1593**	**1540**	**1477**	**1409**	**1334**	**1252**	**1165**	**1075**
hotels season:1/4 to 1/11		**1203**	**1242**	**1250**	**1243**	**1230**	**1213**	**1188**	**1157**	**1120**	**1077**	**1027**	**971**	**913**	**850**	**784**	**714**	**645**
heating season: 1/11 to 1/4		**364**	**416**	**456**	**473**	**488**	**498**	**509**	**513**	**515**	**516**	**513**	**506**	**496**	**484**	**468**	**450**	**430**
"winter": 1/12 to 1/3		194	227	254	265	275	283	291	295	298	300	300	297	293	287	280	270	260

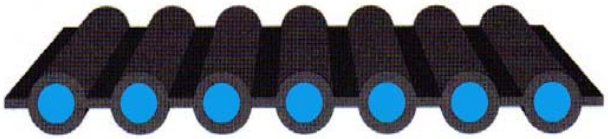
Unglazed collectors

Properties

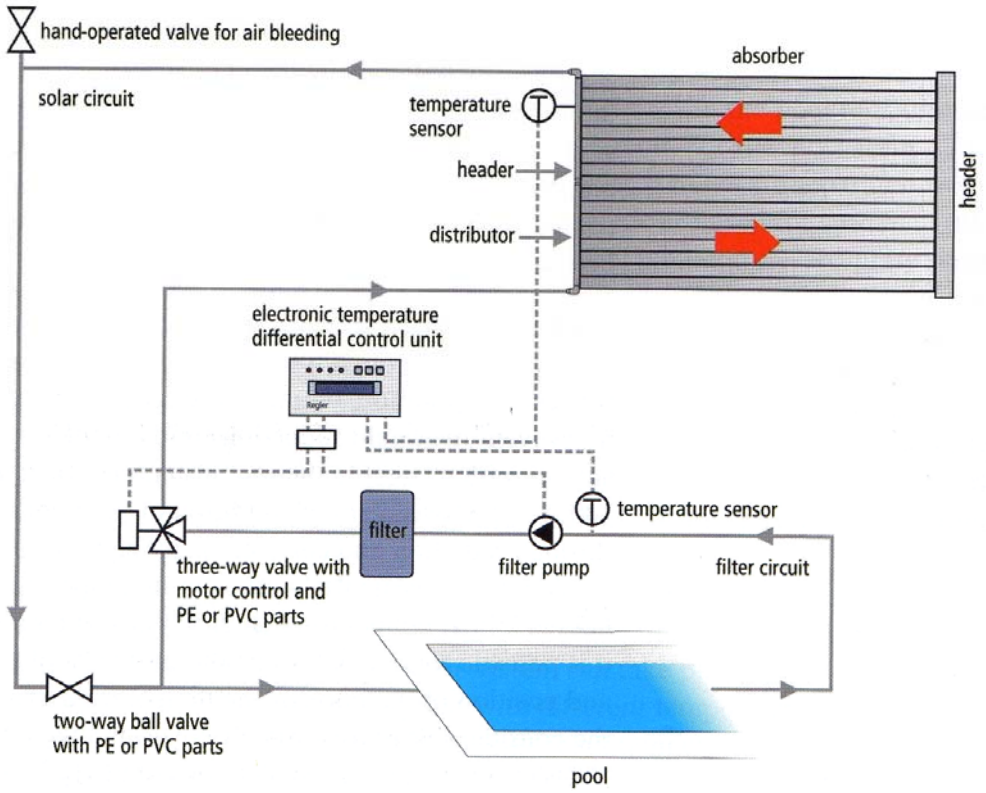
- No glazing, no insulation
- Low operation temperature
- Low cost, average payback time 1-5 years
- High thermal losses, low performance

Applications

- Pool heating only. Warm climates: to extend the swimming period from April-October.



unglazed collector, absorber



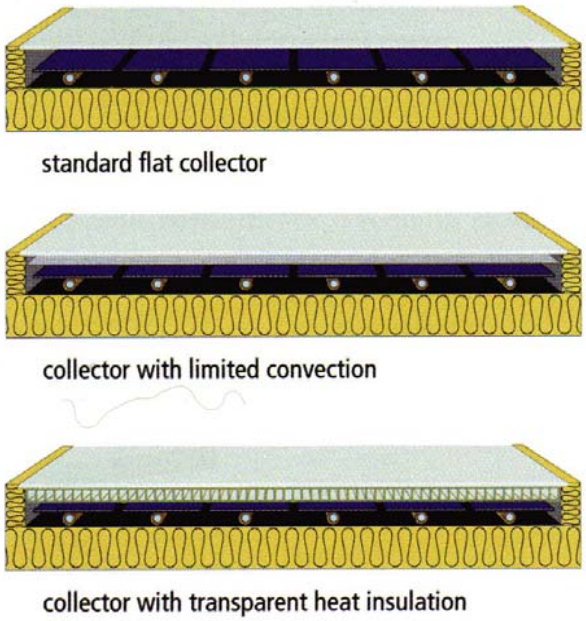
Flat plate collectors

Properties

- Middle cost: more expensive than unglazed, but cheaper than vacuum
- Higher operation temperature
- Thermal insulation on back & edges
- Fragile, heavier: 20-32 kg/m^2
- Transparent cover: black paint or spectral-selective coating (black chrome, black nickel, blue titanium)
- Spectral-selective coating: conversion of short-wave solar radiation into heat (light absorption capacity) is optimized, while thermal emissions are kept low. Absorption rate: 90-95%, emission rate 5-15%
- Stagnation temperature: 160-200^{0}C

Applications

- DHW
- Space heating
- Solar air conditioning (selective coating)



Collectors Comparison

Collector type	Cost	Performance (kWh/m²a)	Application
Unglazed	Low	300	Pool heating
Flat plate (black paint)	Middle	650	Pool heating, Hot water
Flat plate (selective coating)	Middle	700	Hot water, space heating, solar a/c

3. Solar Thermal Systems

The solar collector converts the light that penetrates its glass into heat. The generated heat flows then to the hot water store.

- **Thermosyphon**

No pumps, since gravity is used for liquid transport

- **Forced circulation**

Circulating pumps required, in Northern - Central Europe

- **Direct (drainback) system**

Direct circulation of domestic water through the collector, heat transfer medium: water. When the collector pump is switched off, the collector drains completely.

- **Indirect (filled) system**

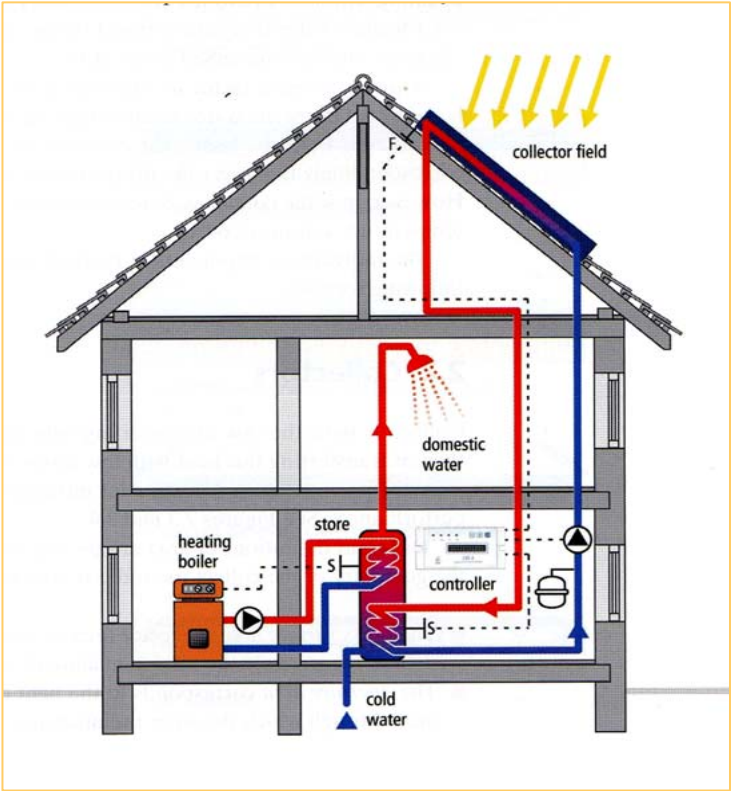
Solar circuit is separate from domestic water circuit, heat transfer medium: water-glycol. The collector circuit is partially or completely filled.

- **Open system**

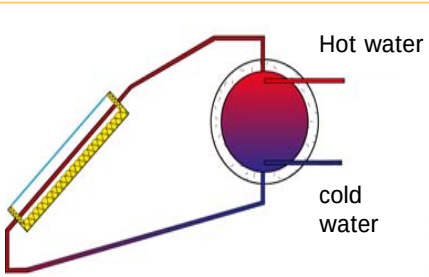
Open container at the highest point of solar circuit, which absorbs the volumetric expansion of the liquid caused by T changes

- **Closed system**

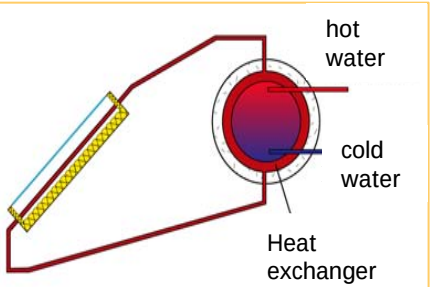
Operate at high pressures (1.5-10 bar), which influences the $T_{evaporation}$ of the liquid.



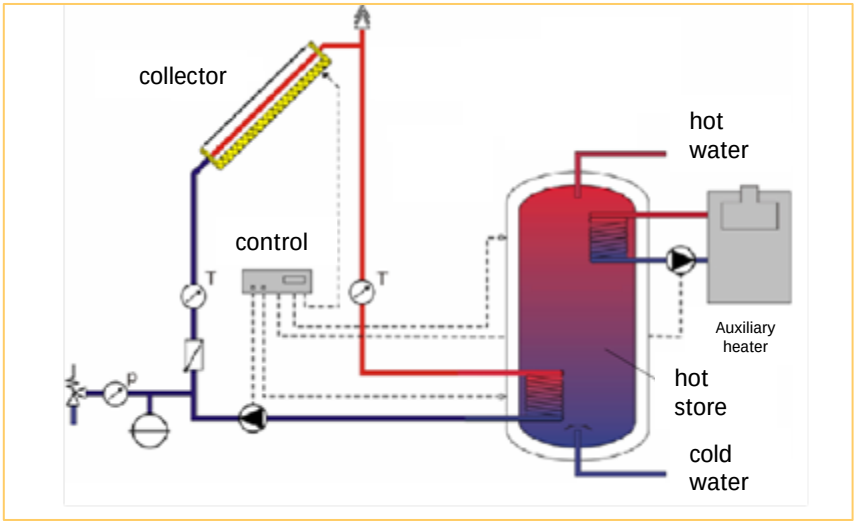
Thermosyphon direct



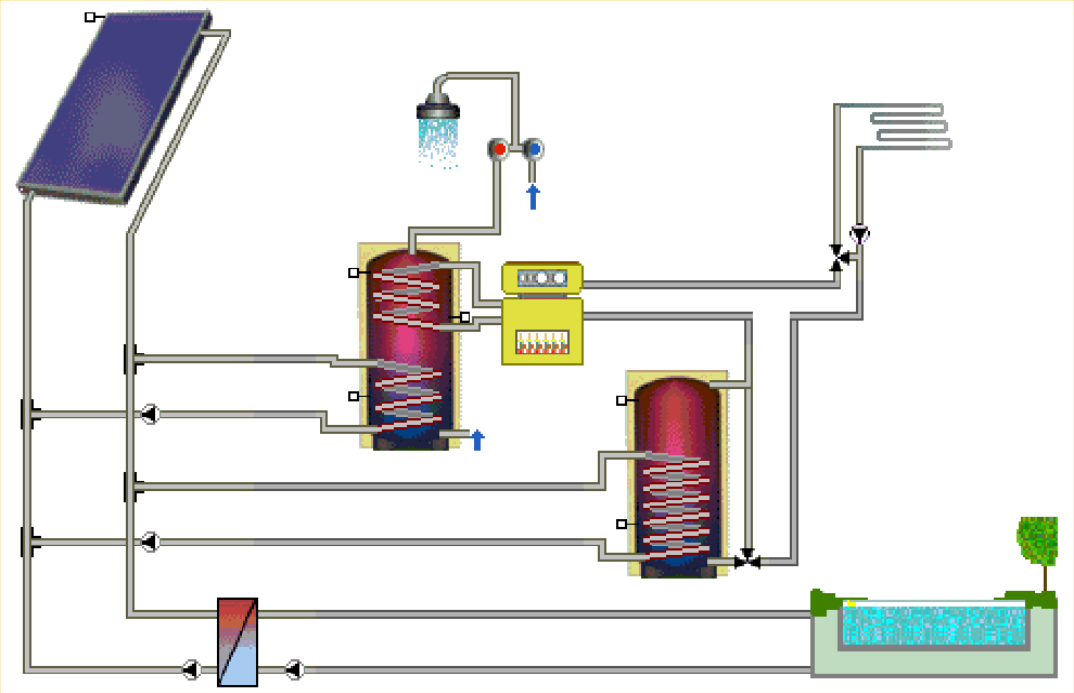
Thermosyphon Indirect

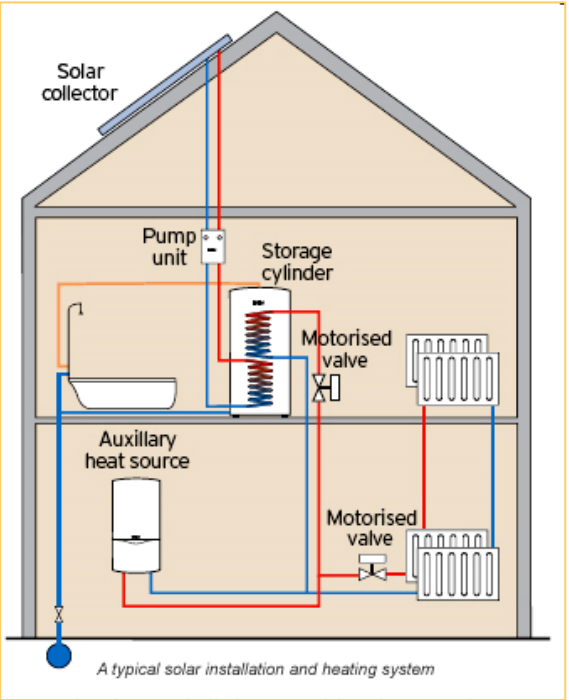


Forced circulation, indirect



Combi Systems





A typical solar installation and heating system

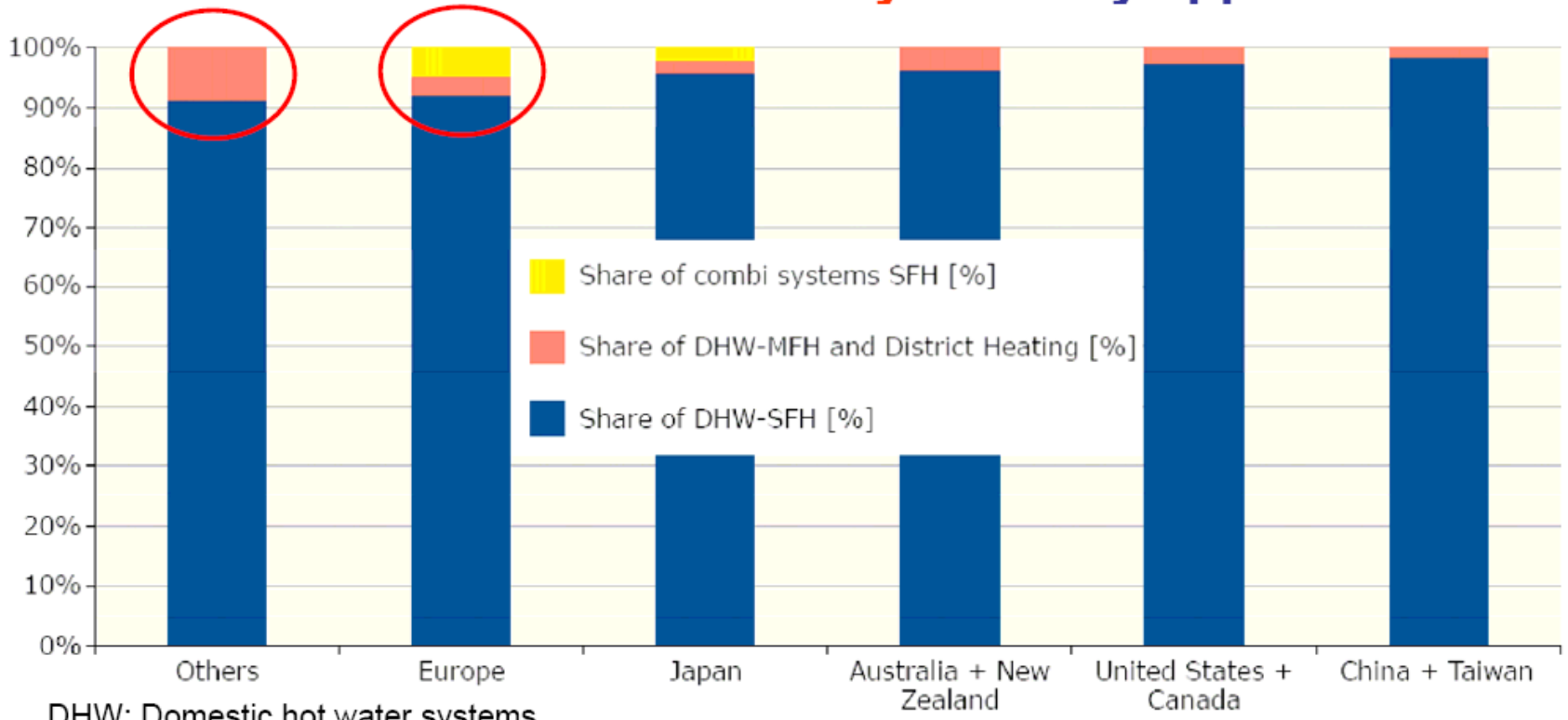
- Pool heating, hot water and space heating
- Integration into existing fan coil units
- High energy saving potential
- Required collectors: 20% of space for 40-50% covering
- 100% covering with solar collectors & biomass

Systems Cost

2008			
System	**Use**	**Cost (incl. installation)**	**Characteristics**
Pool heating	Pool heating	100 € /m^2 collector	Uncovered collectors, m^2 collector ≈ m^2 pool
Thermosyphon	Hot water	1,400 €	150 lt boiler, 2.5 m^2 flat plate collector
	Hot water	1,600 €	150 lt boiler, 2.5 m^2 selective flat plate
Combi	Hot water, Heating	500-750 € /m^2 collector	1000 lt boiler, 15 m^2 selective flat plate
	Professional: Pool heating, Hot water, heating & air-conditioning	400-650 € /m^2 collector	30.000 lt boiler, 500 m^2 selective flat plate

Global Sales

Distribution of solar thermal systems by application



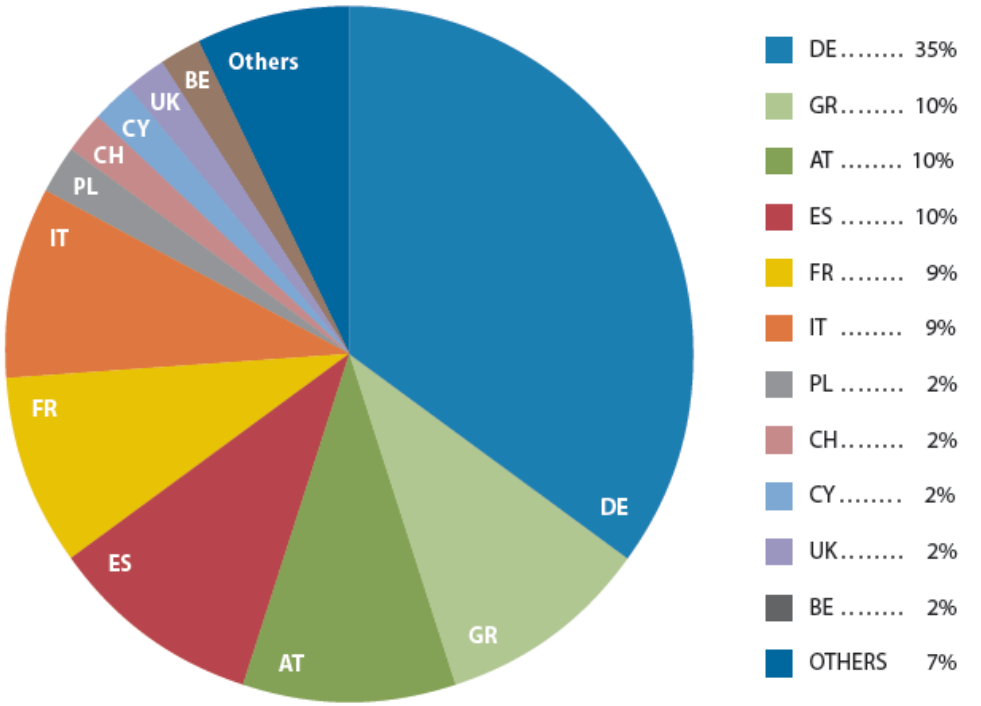
DHW: Domestic hot water systems
SFH: Single family houses
MFH Multi-family houses
Combisystems: Systems for DHW and space heating

Source: IEA-SHC, Solar Heat Worldwide Edition 2008, www.iea-shc.org

Others: Barbados, Brazil, India, Israel, Jordan, Mexico, Namibia, South Africa, Tunisia and Turkey

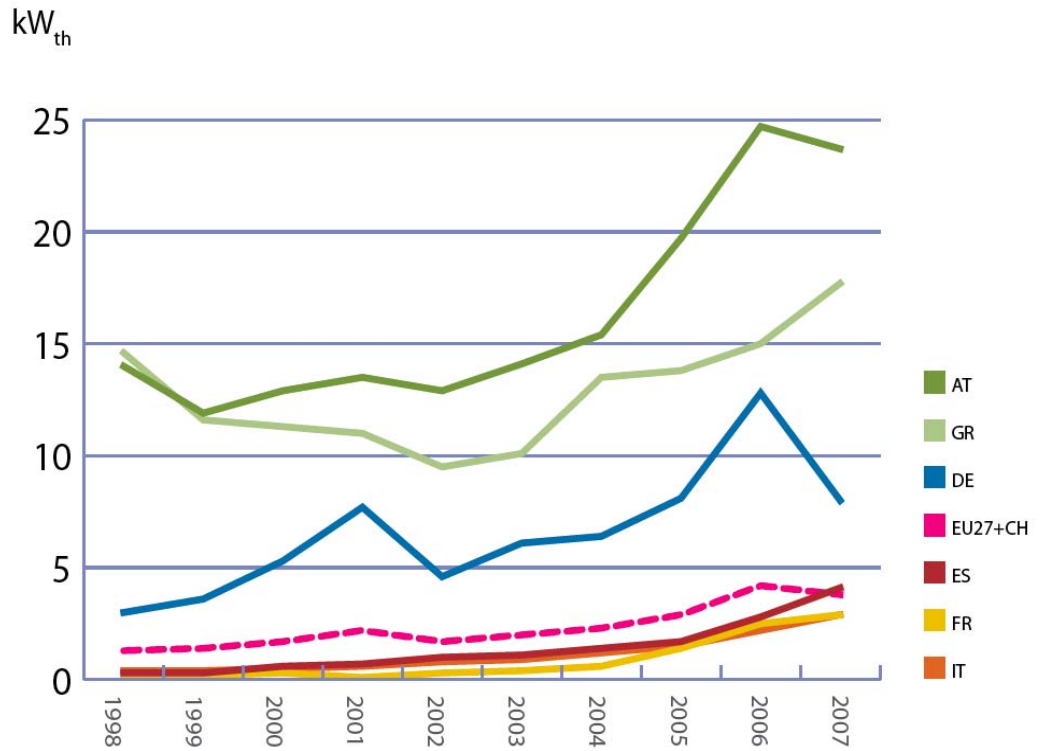
4. Solar Thermal Market in Europe, 2007

Breakdown per country, 2007



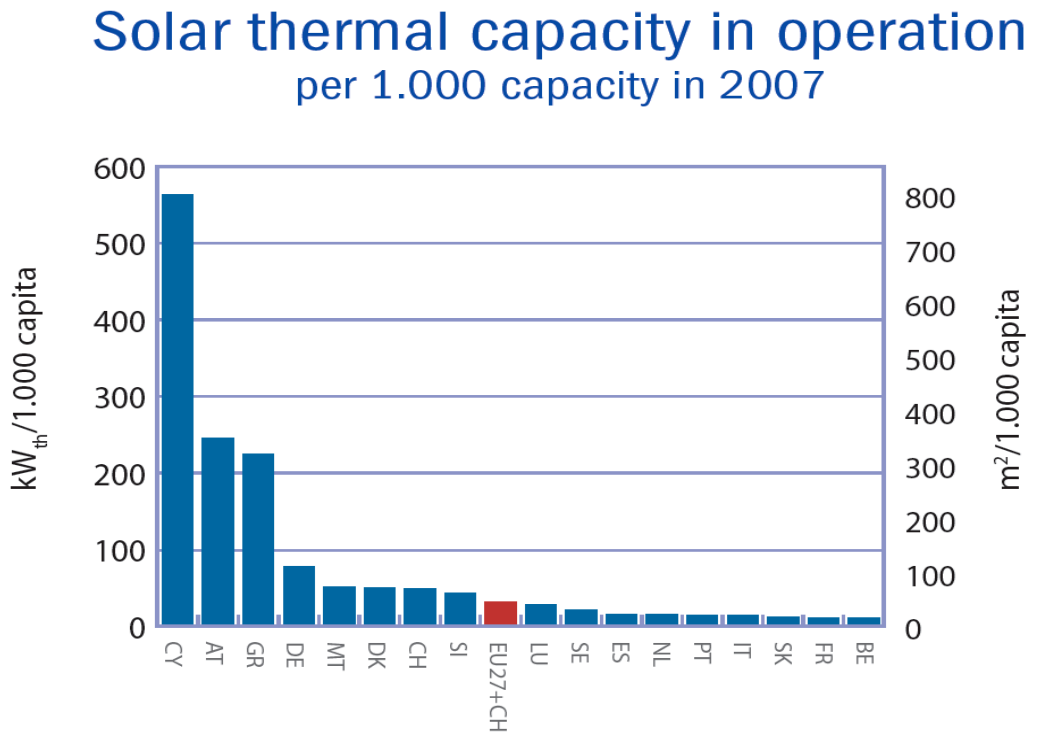
- Concentration in the European market is decreasing
- **5 countries account for ¾ of the total** – just a few years ago the same share was held by Germany, Austria and Greece only
- **Greece accounts for 9-10%** of European sales.

Newly Installed Capacity per Capita in Europe, 2007



- Big advance of **Austria: 23,7 kWth per 1.000 capita**, almost 3 times than Germany and more than 6 times than EU average (3,8 kWth per 1.000 capita)
- **Greece** has slowly and quietly increased its per capita market since 2002. Their **17,7 kWth per 1.000 capita** is 4,5 times as big as the Eu average.
- **France and Italy**: Strong growth in recent years, but only **2,9 kWth installed per 1.000 capita** each.

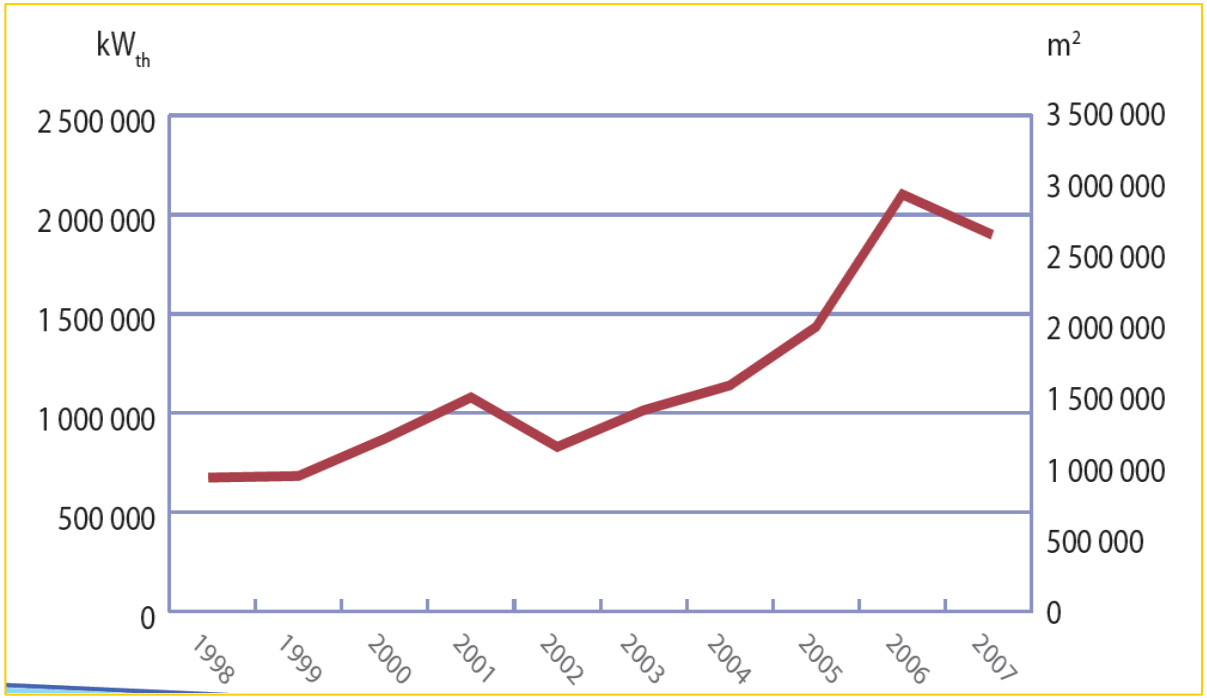
Solar Thermal Capacity in Operation, 2007



- **Cyprus is 1st: 562 kWth** in operation per 1.000 capita
- **Greece is 3rd**
- **EU average: 30,7 kWth** /1,000 capita.
- Austria shows the rest what is possible: 244 kWth/1.000 capita, 8 times the EU average

The figures relate to all installations built in the past and deemed to be still in operation (ESTIF assumes a life-time of 20 year for systems installed after 1989) and to today's size of the population.

Solar Collectors area in operation, 2007



- **2001: 12.3 million m²** glazed collectors in operation
  - 11,7% increase collector in operation
  - 13,6% increase new collector area
  - 1.6 million m² glazed collectors for pools
- **2007: 21.9 million m²** glazed collectors in operation

Conclusions/Remarks

- **Large market growth potential**

In Greece only 25% of the buildings are equipped with a solar thermal system (>90% of the owners are satisfied)

- **Seasonal storage**

For transferring the energy from low heating season to high heating season.

- **Solar Cooling**

Better utilization of solar energy throughout the year

Law modernization

solar thermal system project study compulsory for every large building

Financial incentives

to cover part of investment & construction costs

Thank you for your attention!

Centre for Renewable Energy Sources

Solar Thermal Department

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