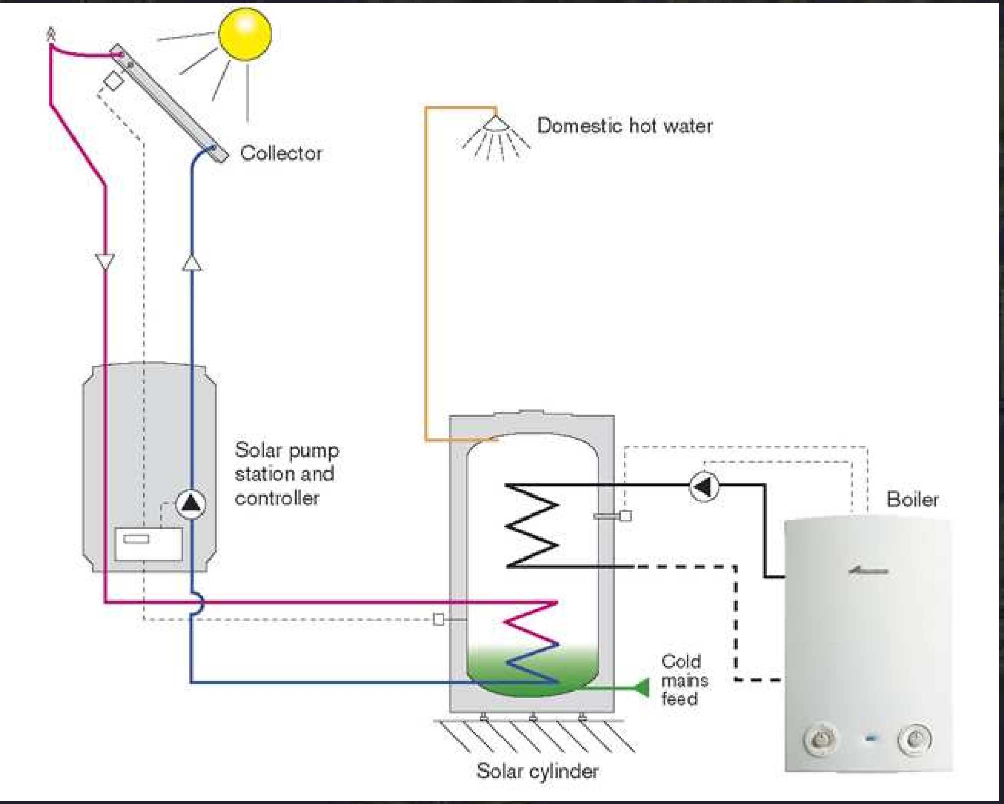
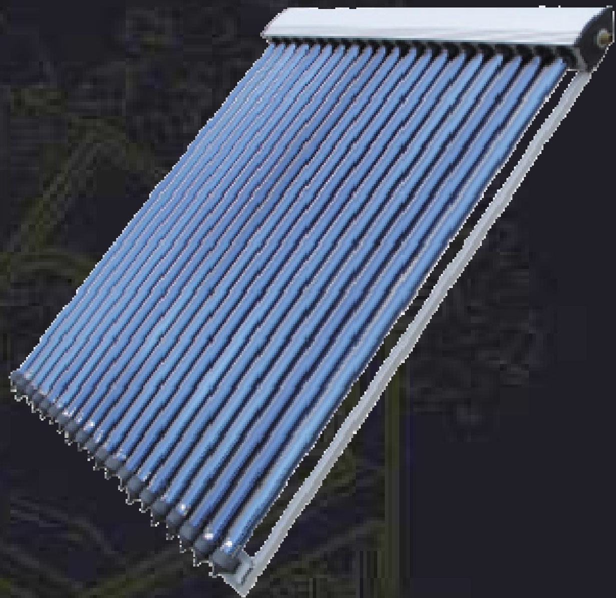
# LESSON 4:

# SOLAR THERMAL PANNELS

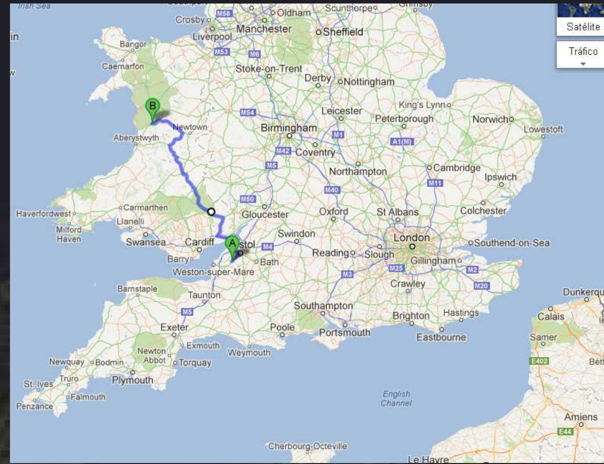


# Types of collectors

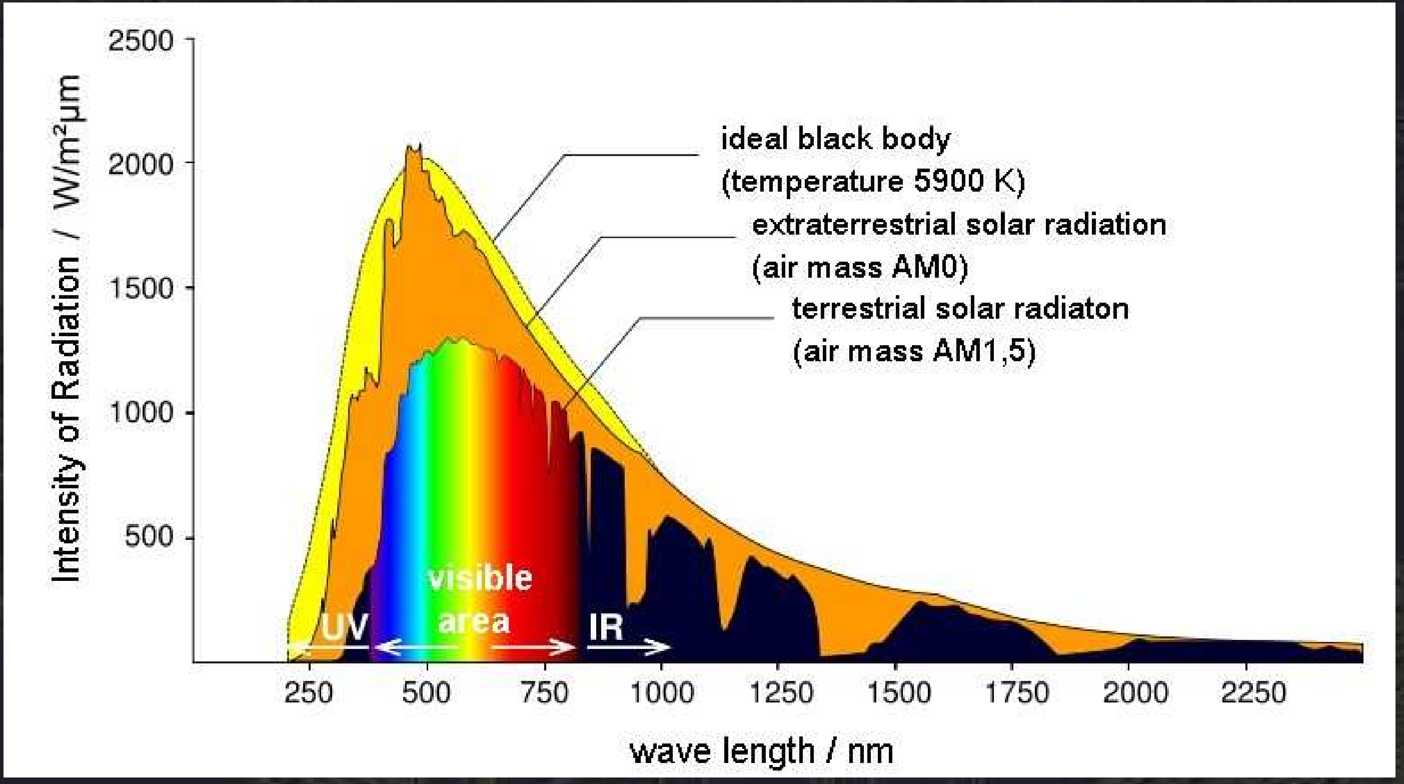
- uncovered (unglazed) collectors
- flat plate collectors
- evacuated tubular collectors



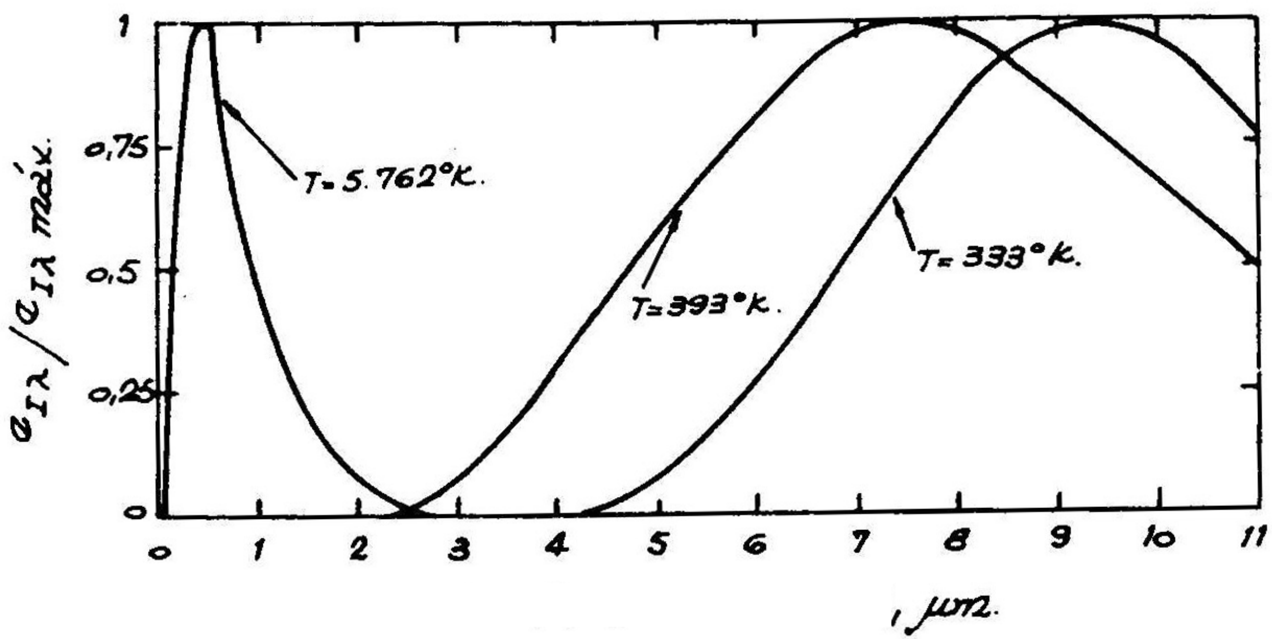
# SOLAR THERMAL ENERGY



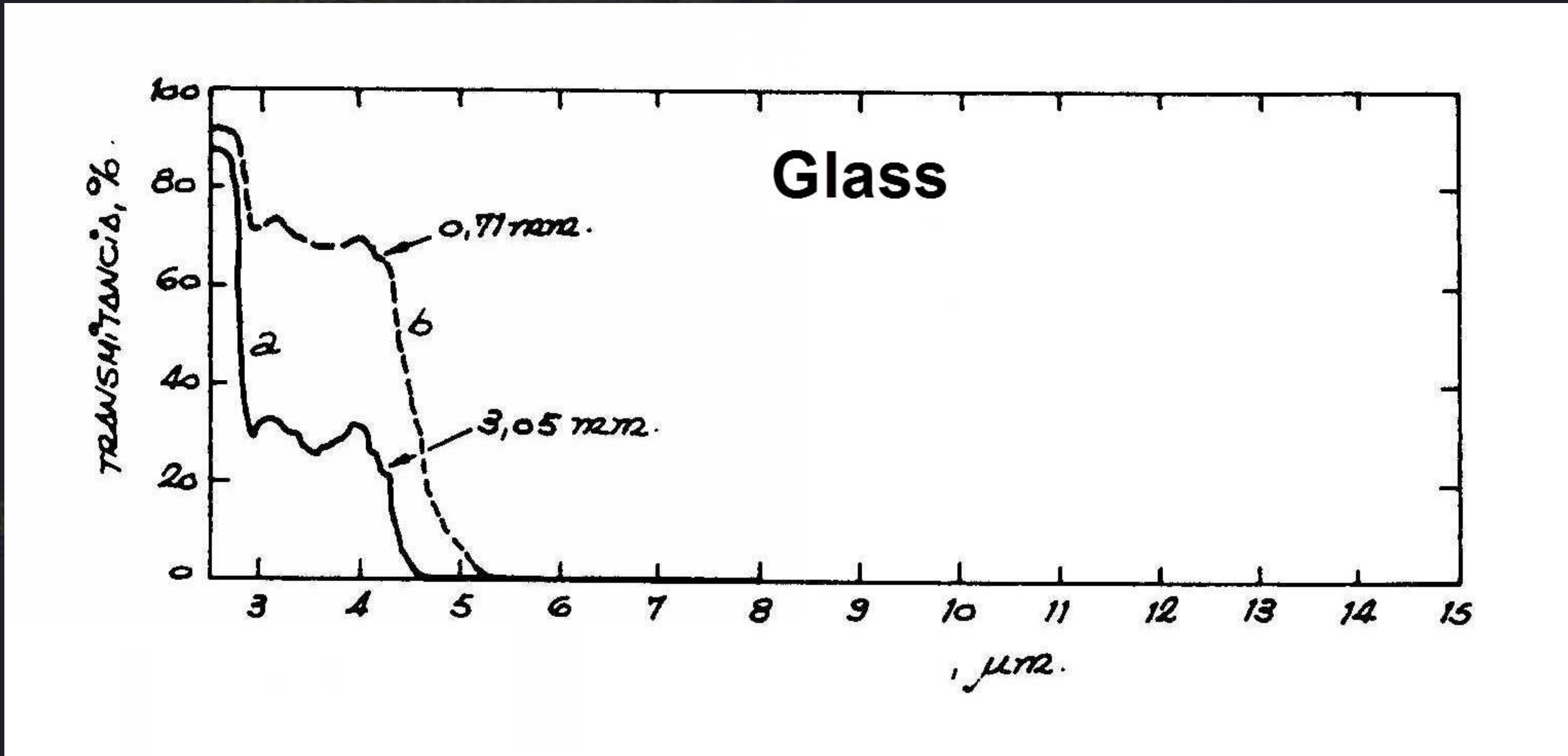

# GREENHOUSE EFECT



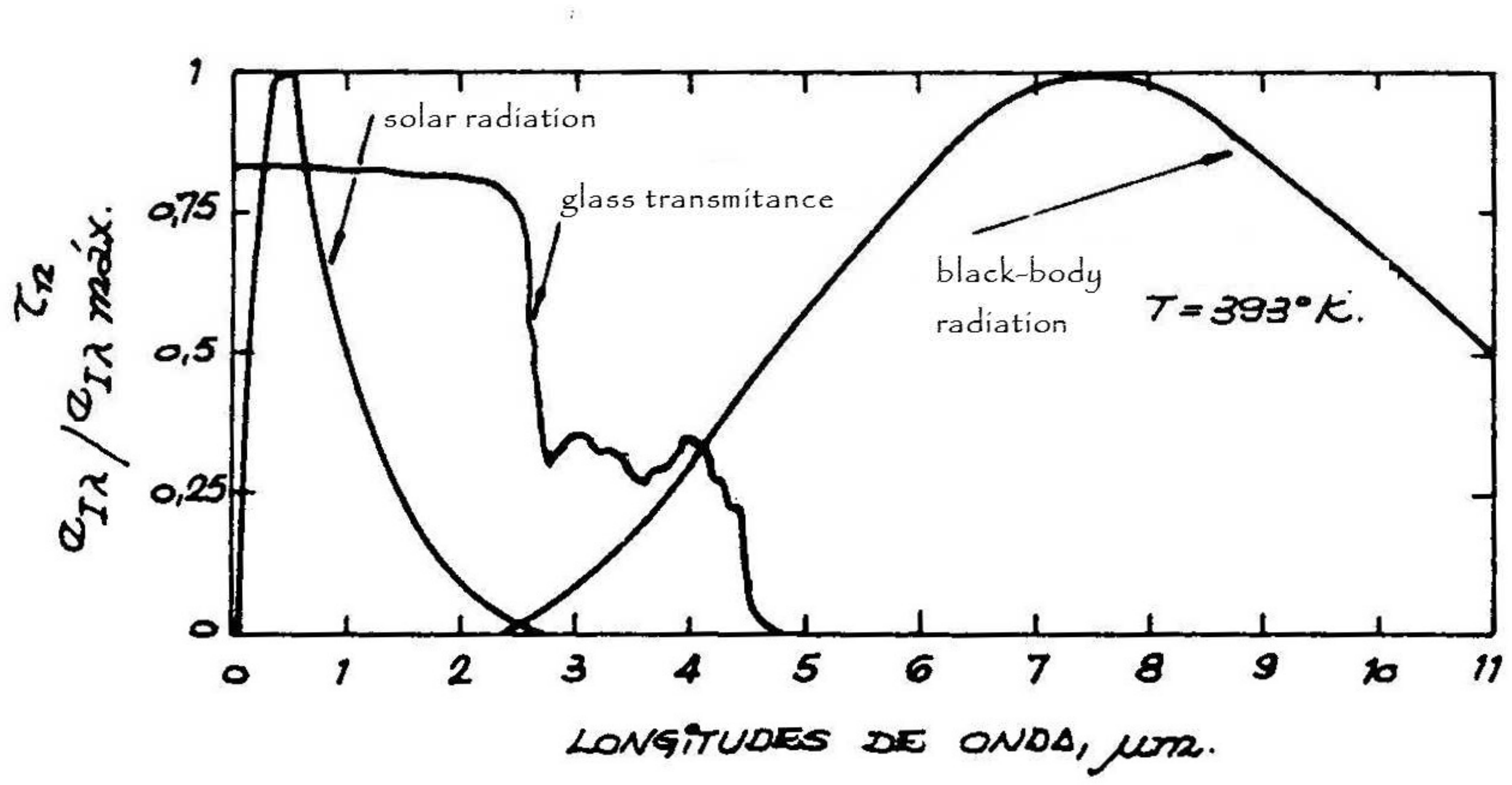
# GREENHOUSE EFECT




The wavelength of the emission is dependent on temperature.
The higher the temperature, the wavelength is smaller.

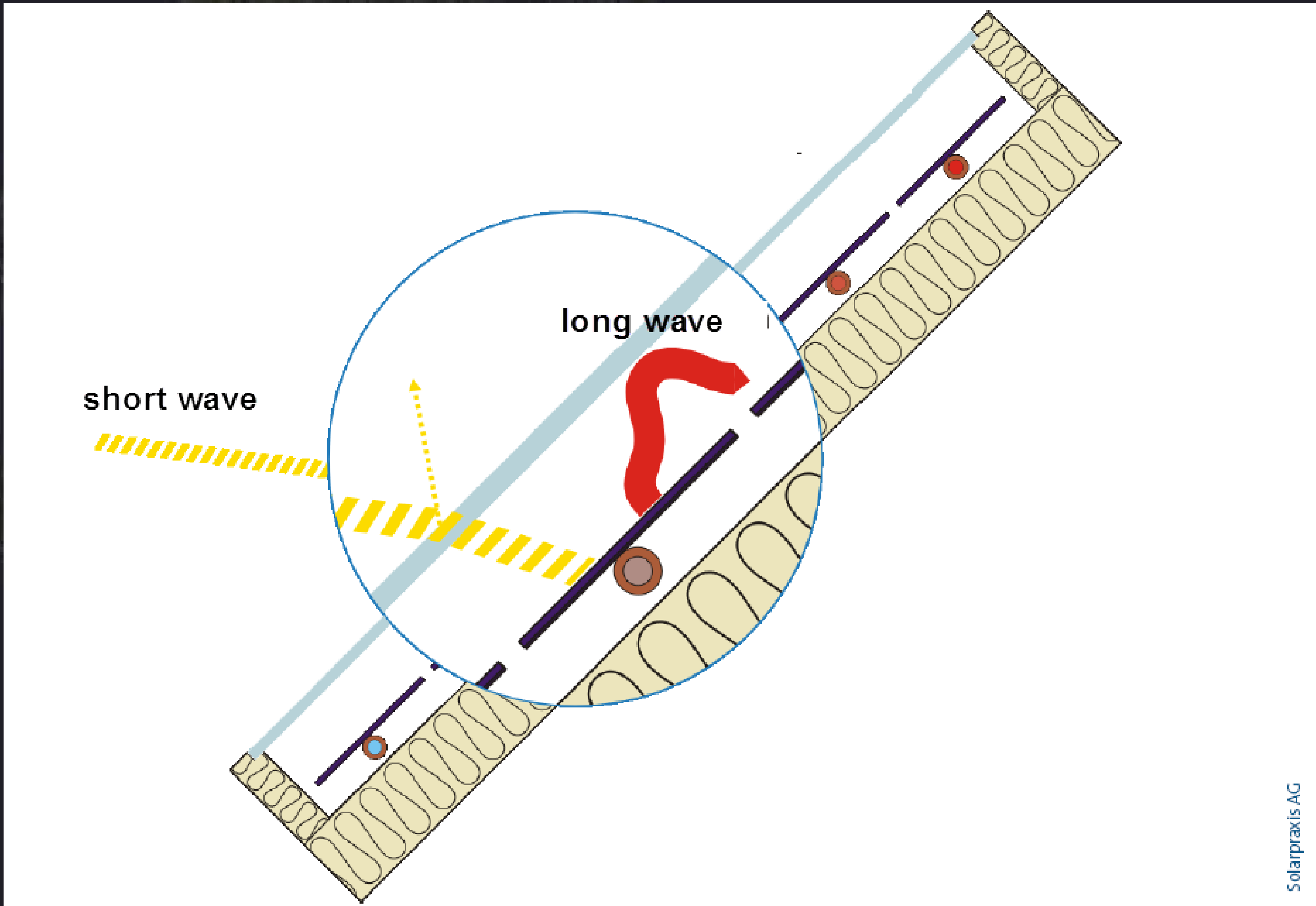



The glass is opaque to wavelengths greater than 5 μm

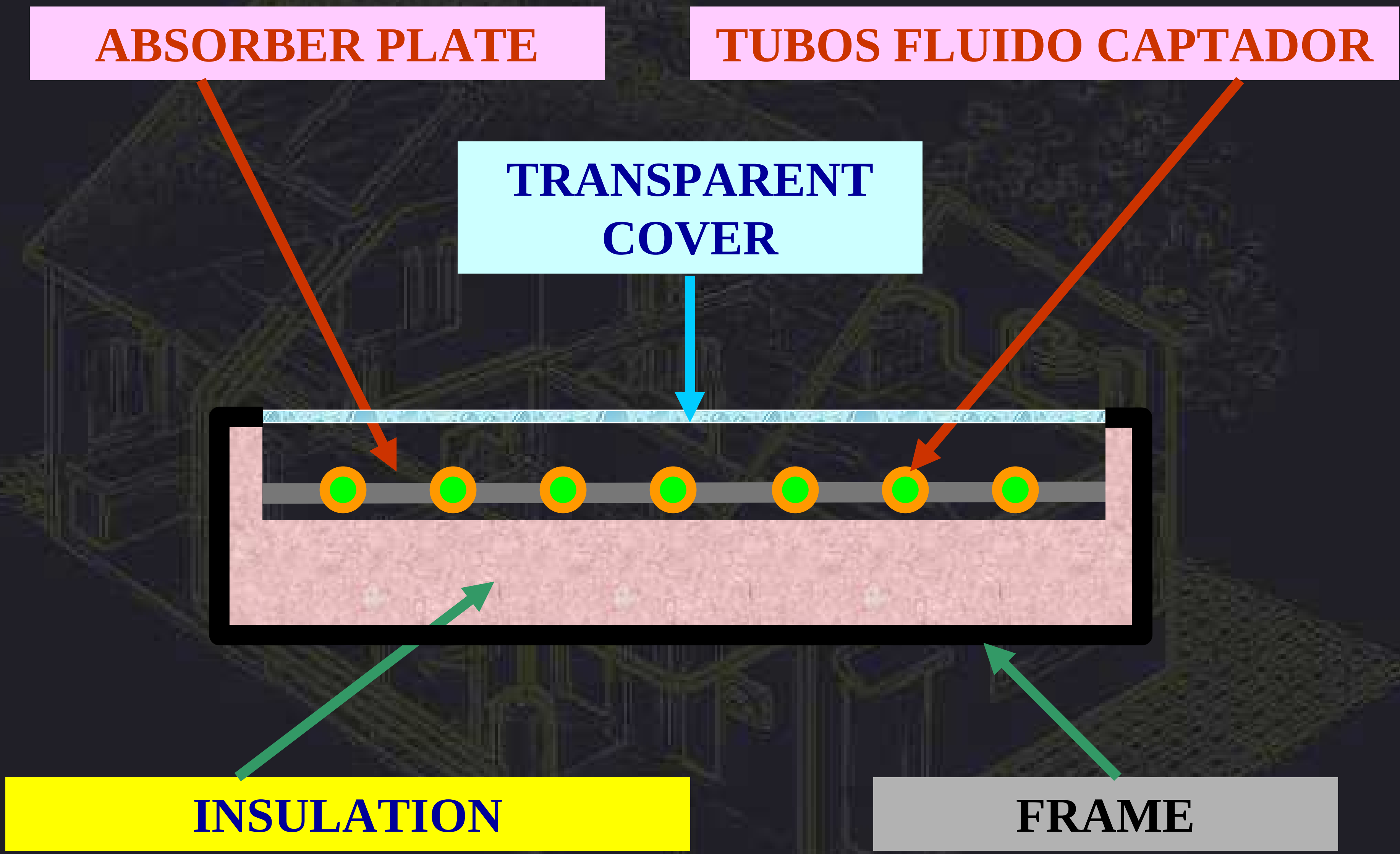



body radiation at low temperature can not pass the crystal

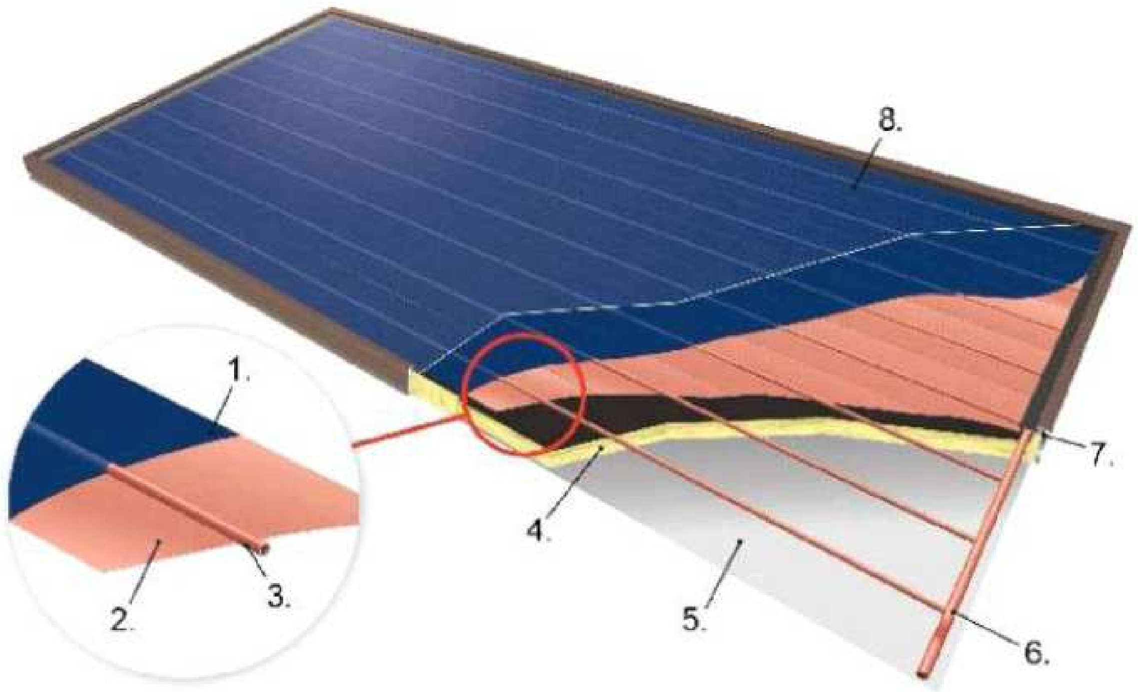
# SOLAR THERMAL ENERGY



# Flat plate collectors

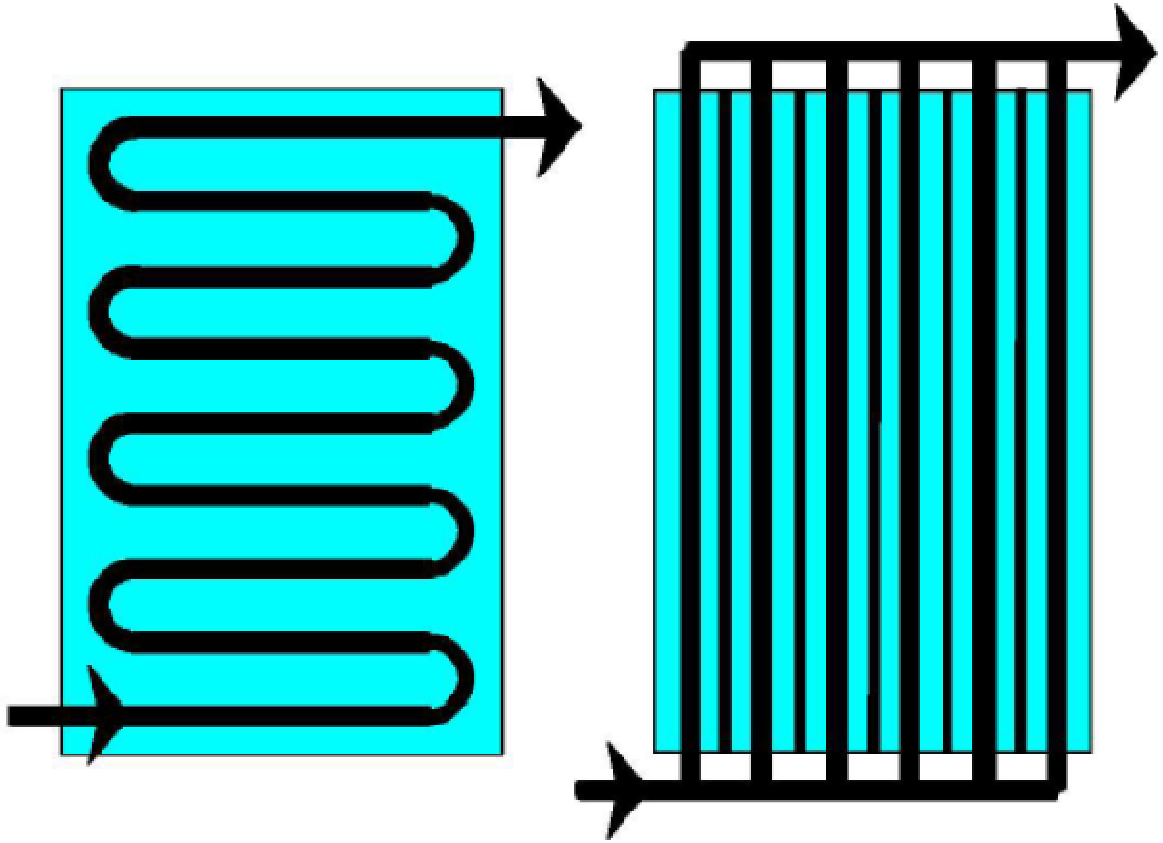

ABSORBER PLATE
TUBOS FLUIDO CAPTADOR
TRANSPARENT COVER
INSULATION
FRAME

# SOLAR THERMAL ENERGY



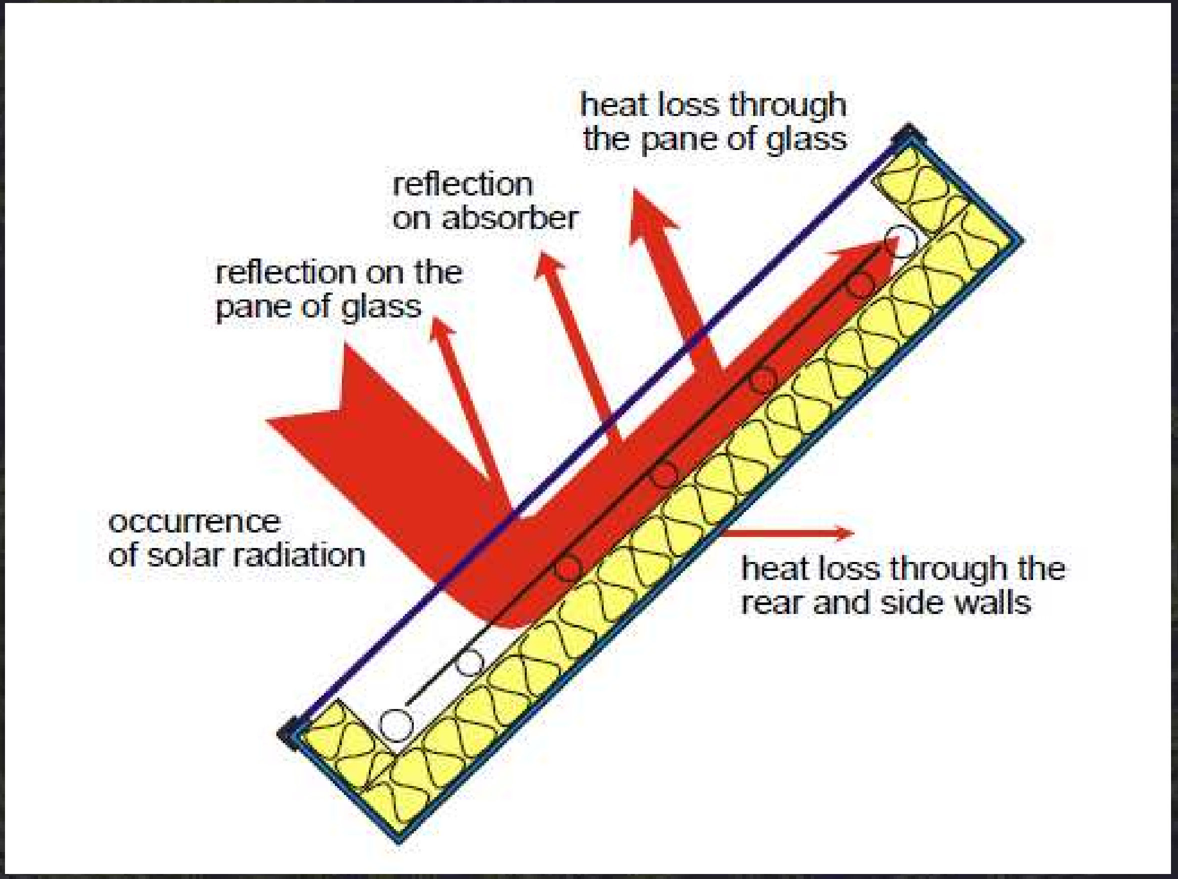

1. Selective Coating
2. Absorber
3. Tube
4. Insulation
5. Rear panel
6. Manifold
7. Frame
8. Transparent cover

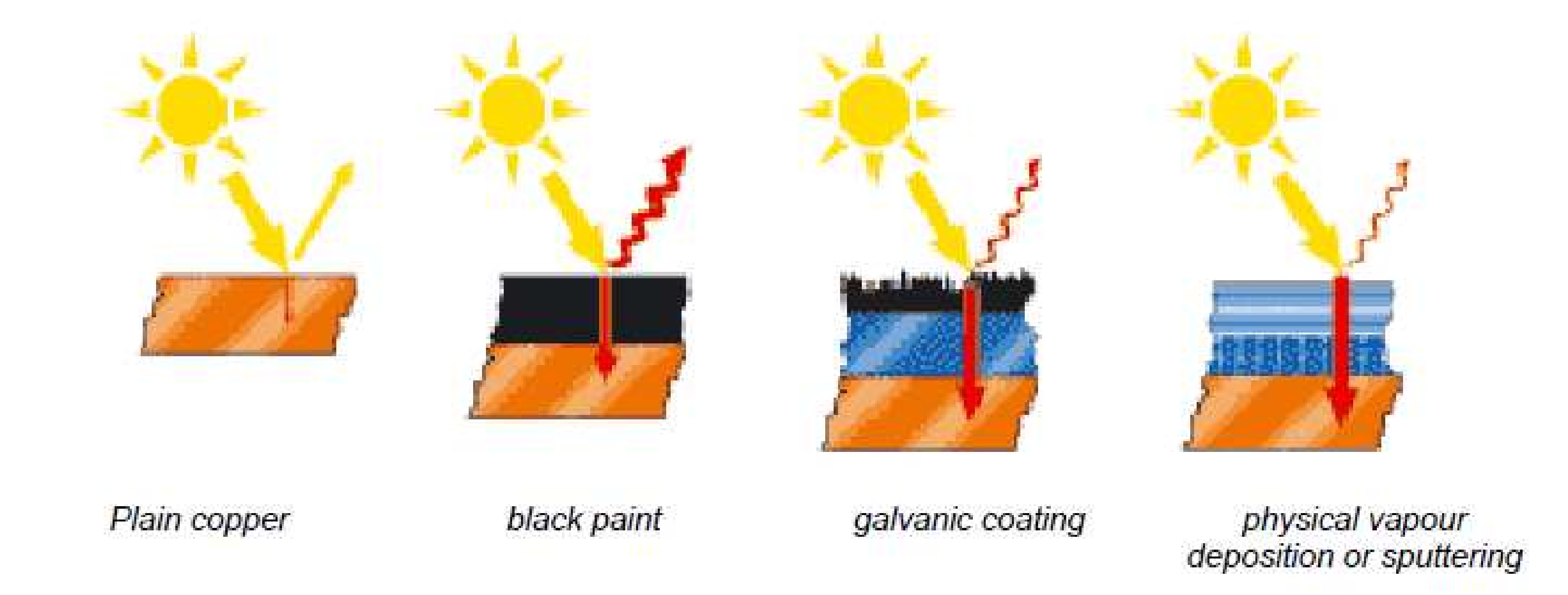
# SOLAR THERMAL ENERGY



Absorber with meander tubes (left) and a harp absorber (right)

# SOLAR THERMAL ENERGY





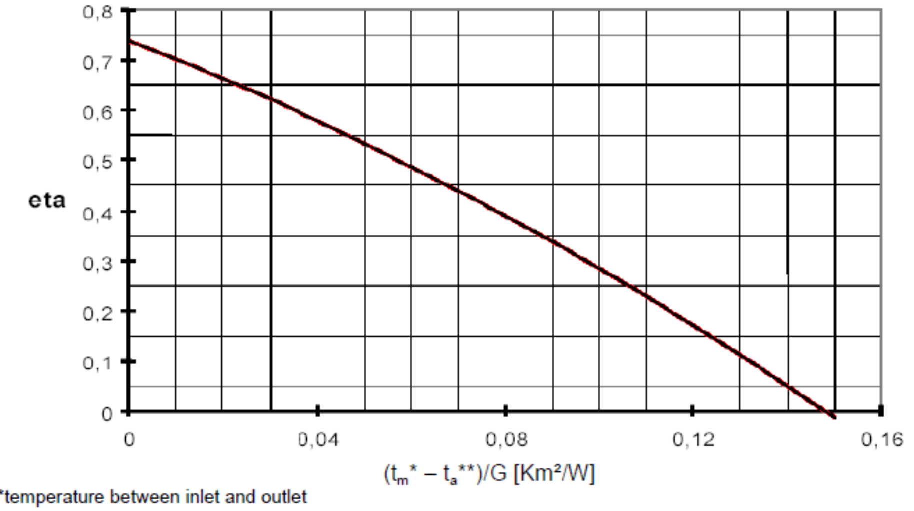

Absorber coatings with high absorbtance α in the solar spectral range (0.3 - 2.5 μm) and simultaneously a low emittance ε in the wavelength range 2.5 - 50μm are termed "selective coatings".

## PERFORMANCE CRITERIA OF SOLAR COLLECTORS

$$\mu = F_r(\tau\alpha) - U_L \frac{t_m - t_a}{I}$$

μ: efficiency
Fr: collector's heat removal factor
t: transmittance of the cover
ɑ: absorbtance of the absorber
Ul: overall heat loss coefficient of the collector
Tm: average temperature of the heat transfer fluid
Ta: ambient temperature
I: incident radiant energy

# Collector Efficiency Curve




*temperature between inlet and outlet
**ambient temperature

$$\eta = \eta_0 - a_1 \cdot \frac{(t_m - t_a)}{G} - a_2 \cdot \frac{(t_m - t_a)^2}{G}$$

| | | |
|---|---|---|
| $\eta_0$ | maximum efficiency (= efficiency at $t_m = t_a$) | |
| $a_1$ | linear heat loss coefficient | $\frac{W}{m^2 \cdot K}$ |
| $a_2$ | quadratic heat loss coefficient | $\frac{W}{m^2 \cdot K^2}$ |
| $t_m$ | average temperature of the heat transfer fluid | °C |
| $t_a$ | ambient temperature | °C |

$$\eta = \eta_0 - a_1 \cdot \frac{(t_m - t_a)}{G} - a_2 \cdot \frac{(t_m - t_a)^2}{G}$$

**Technical Specification**

| | |
|---|---|
| Zero Heat Loss Efficiency, $\eta_0$ | 73.4% |
| Primary Heat Loss Coefficient, $a_1$ | 1.529 W/m²K |
| Primary Heat Loss Coefficient, $a_2$ | 0.0166 W/m²K² |
| Incident Angle Modifier, $K_{T50°}$ | 1.37 |
| Instantaneous Efficiency**, $\eta_{0.05a}$ | 62.4% |
| Specific Output* | 850 kWh / m² / year |
| Stagnation Temperature | 200.3°C |
| Maximum Operating Pressure | 10 bar |
| Collector Frame and Manifold | Aluminium |
| Selective Absorber Coating | CerMet |
| Absorber Contact Sheet | Aluminium |
| Evacuated Tube | Borosilicate Glass 1800mm x 58mm (OD) x 47mm (ID) |
| Tube Spacing | 78mm |
| Testing & Certification | EN12975-2 & Solar Keymark Registration No. 011-7S722 R |

# SOLAR THERMAL ENERGY

| | |
|---|---|
| **Art. No.:** | **221 894** |
| **Description:** | **SchücoSol K** |

**Flat-plate collectors**

| | | | |
|---|---|---|---|
| Size (L x W x D): | | 2037 x 1137 x 80 mm | |
| Collector surface: | | 2.32 | $m^2$ |
| Weight: | | 44.0 | kg |
| Efficiency: | $\eta_o$ = | 79.9 | % |
| Coefficient of heat loss: | $k_1$ = | 3.97 | $W/m^2K$ |
| | $k_2$ = | 0.016 | $W/m^2K^2$ |
| Angle of radiation correction factor: | $k_{(50)}$ = | 0.95 | |
| Thermal output: | | 1.7 | kW |

**Absorber**

| | | | |
|---|---|---|---|
| Emission: | ε = | 5.0 | % |
| Absorption: | α = | 95.0 | % |
| Absorber surface: | | 2.15 | $m^2$ |
| Aperture surface: | | 2.14 | $m^2$ |
| Material: | | Copper | |
| Coating: | | Sunselect | |

**Hydraulics**

| | | |
|---|---|---|
| Heat transfer volume: | 1.54 | l |
| Minimum volume flow: (up to max. 5 collectors in series) | 2.50 | l/min |
| Pressure loss (2.5 l/min solar fluid): | 97.4 | mbar |
| Connection: | 12.0 | mm Cu pipe |
| Type of connector: | Clamping ring | |
| Operating pressure: | 3.2 | bar |
| Permissible operating excess pressure: | 10 | bar |
| Test pressure: | 20 | bar |
| Standstill temperature: | 209 | °C |
| Permissible flow temperature: | 120 | °C |

**Front cover**

| | | |
|---|---|---|
| Solar glazing: | Low-iron, high transparency | |
| Transmittance: | > 91.0 | % |
| Thickness: | 4.0 | mm |

**Housing**

| | |
|---|---|
| Material: | Aluminium Black (Anodised black; like RAL 9011, graphite black) |
| Gaskets: | EPDM/silicone |
| Thermal insulation: | 40 mm mineral wool |

## Technical Data

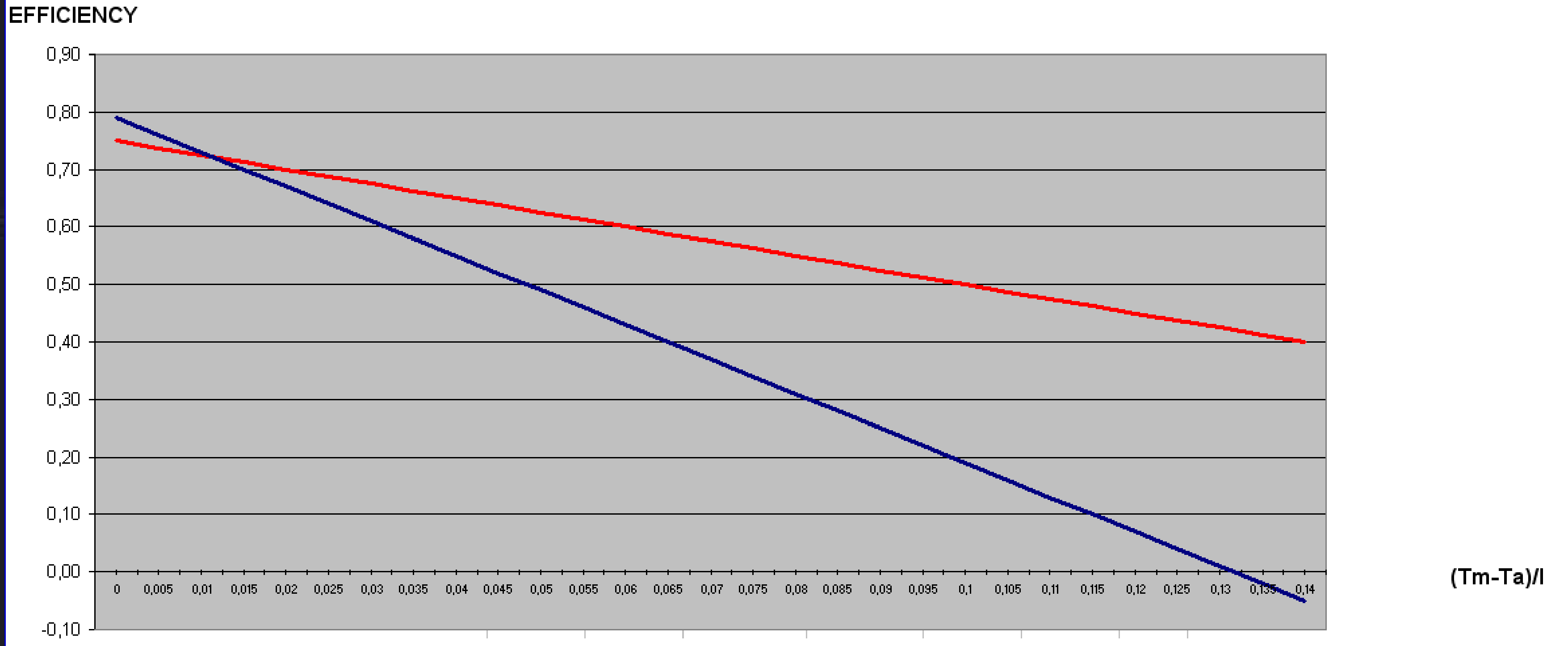
| Model - Vitosol 100-F | | SV1B |
|---|---|---|
| Total surface area | ft.² ($m^2$) | 27.0 (2.51) |
| Absorber surface area | ft.² ($m^2$) | 25.0 (2.32) |
| Aperture *1 | ft.² ($m^2$) | 25.1 (2.33) |
| Dimensions *2 | | |
| Width | inches | 41¾ |
| | mm | 1056 |
| Height | inches | 93¾ |
| | mm | 2380 |
| Depth | inches | 2¾ |
| | mm | 72 |
| Optical efficiency *3 | % | 75.4 |
| Heat loss coefficient $U_1$ | $W/(m^2 \cdot K)$ | 4.15 |
| $U_2$ | $W/(m^2 \cdot K^2)$ | 0.0114 |
| Thermal capacity | $kJ(m^2 \cdot K)$ | 4.5 |
| Weight | lb (kg) | 96.8 (43.9) |
| Fluid capacity | USG | 0.44 |
| (heat transfer medium) | L | 1.67 |
| Maximum working pressure *4 | psig | 87 |
| | bar | 6 |
| Maximum stagnation temperature *5 | °F (°C) | 395 (196) |
| Connection | inches | ¾ |
| | mm | 22 |
| Requirements for installation surface and anchorage | | Roof construction with adequate |

# SOLAR THERMAL ENERGY

A B C D E F G H I J K L M

| | | | | | |
|---|---|---|---|---|---|
| COLLECTOR 1 | MAXIMUM EFFICIENCY | 0,75 | | (Tm-Ta)/I | 0,040 |
| | LINEAR HEAT LOSS COEFFICIENT | 2,5 | | EFFICIENCY | **65%** |
| COLLECTOR 2 | MAXIMUM EFFICIENCY | 0,79 | | (Tm-Ta)/I | 0,040 |
| | LINEAR HEAT LOSS COEFFICIENT | 6 | | EFFICIENCY | **55%** |

| | | |
|---|---|---|
| AVERAGE TEMPERATURE | **45** | ºC |
| AMBIENT TEMPERATURE | **5** | ºC |
| RADIATION | **1000** | W/m2 |



# SOLAR THERMAL ENERGY

1. Calculate the collector efficiency, $\eta = 0.75$ to $2.5\,(tm-t) / I$
under the following conditions:
Ambient temperature 10 ° C
750 W/m2 radiation
Storage temperature 40 °C, 50 °C, 60 °C

2 Calculate the collector efficiency, $\eta = 0.75 - 5\,(tm-t) / I$
under the conditions of the previous exercise.

3. Calculate the collector efficiency, $\eta = 0.8 - 2.1\,(tm-t) / I$
under the following conditions:
Irradiation 800 W/m2
Storage temperature 45 ° C
Ambient temperature 0 ºC, 10 ºC, 20 ºC, 30 ºC

4. Calculate the collector efficiency, $\eta = 0.8 - 5.5\,(tm-t) / I$
under the conditions of the previous exercise

5. Calculate the collector efficiency $\eta = 0.8 - 7\,(tm-t) / I$
under the following conditions:
Storage temperature 45 ° C
Ambient temperature 10 ° C
Radiation 900 W/m2, 600 W/m2, 400 W/m2, 300 W/m2

# Area Definitions