SOLAR COLLECTORS

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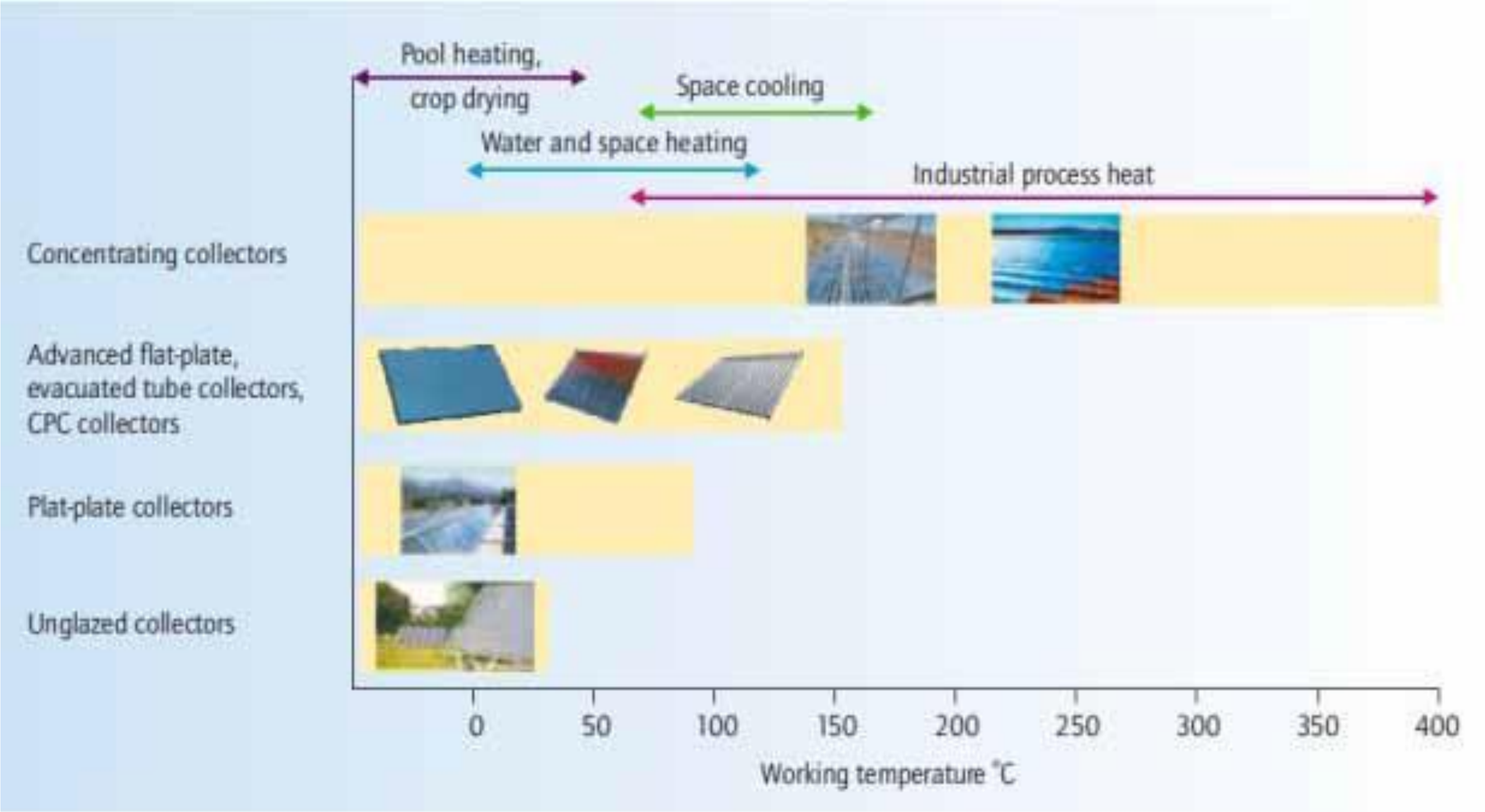
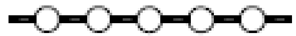
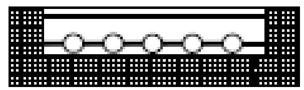
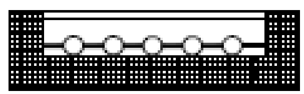
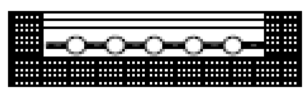
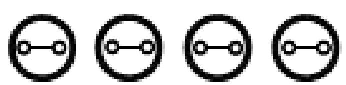
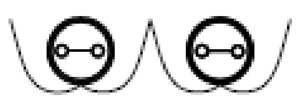
Working temperature of different types of solar thermal collectors

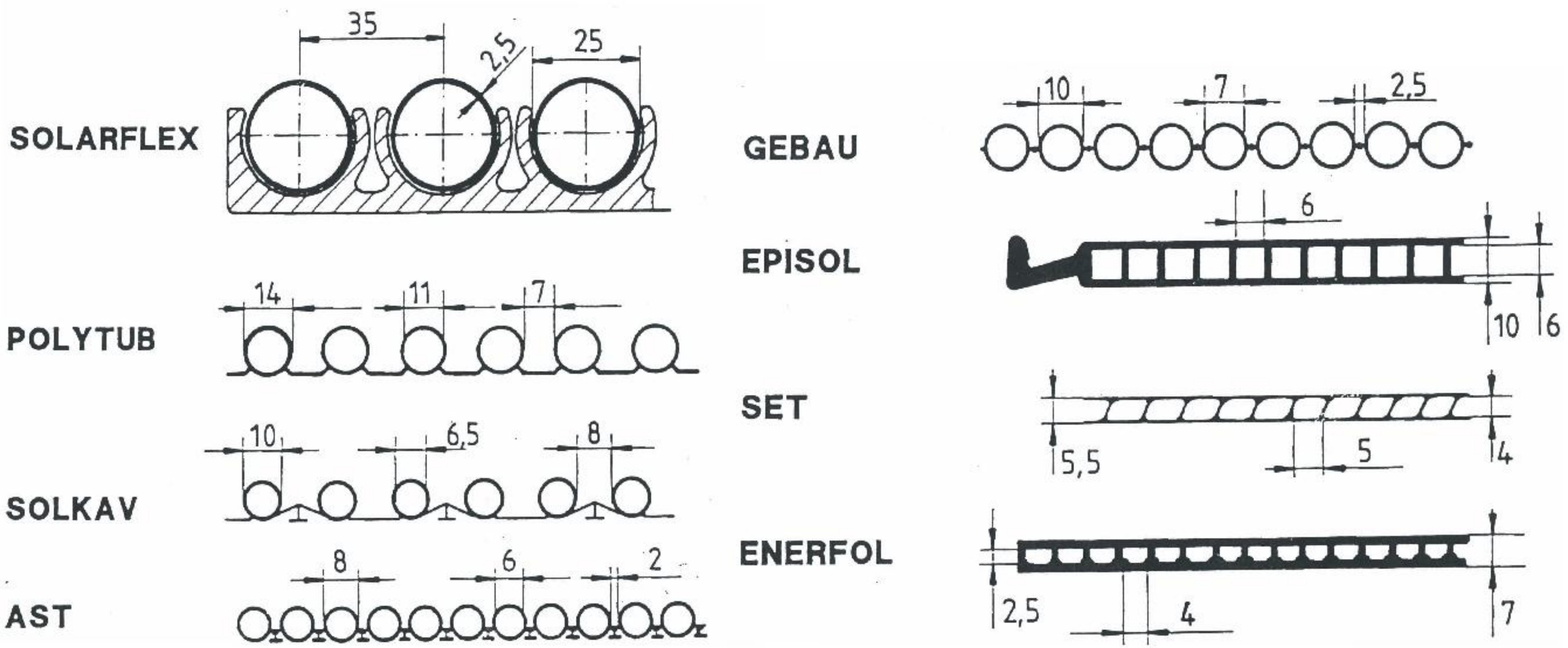


Source: ETP RHC, Strategic Research Priorities, 2013

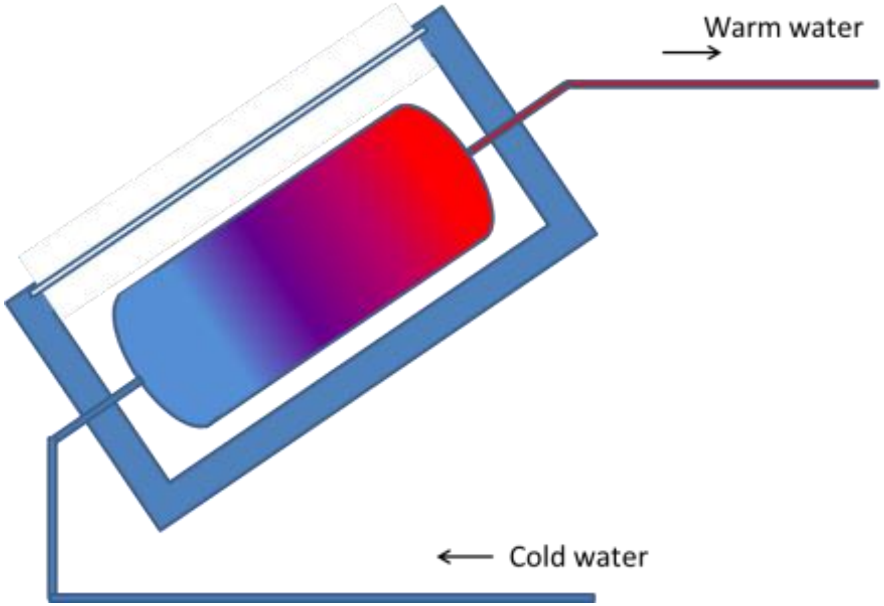
TYPES OF COLLECTORS

	principle	η_0 [ ]	U [W/m² K]	collector working temp.	appropriate application areas
simple absorber		0.90	20	15 – 30 °C	swimming pool
simple flat-plate collector with glass cover (FP)		0.80	4	30 – 80 °C	hot water
FP with selective surface (SS)		0.80	3	40 – 90 °C	hot water space heating
FP with double anti-reflective coated glazing and gas filling		0.80	2.5	50 – 100 °C	hot water space heating cooling
evacuated tube collector with SS (ETC)		0.65	2	90 – 130 °C	space heating cooling process heat
ETC with compound parabolic concentrator (CPC)		0.60	1	110 – 200 °C	space heating cooling process heat

Plastic Absorber



Integrated storage-collector

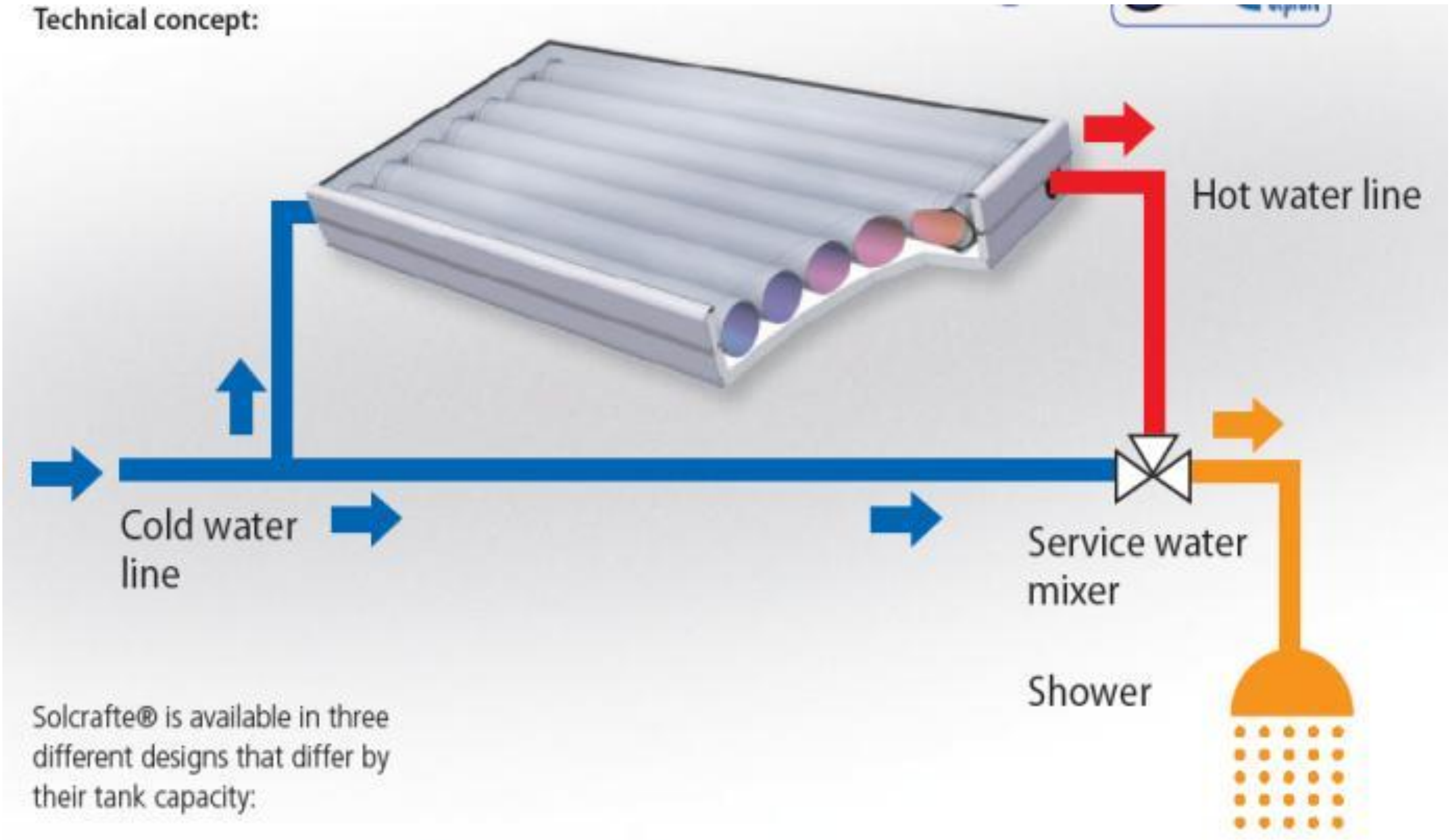


Cross-section trough a storage-collector

Integrated storage-collector

Source: KIOTO – Clear Energy

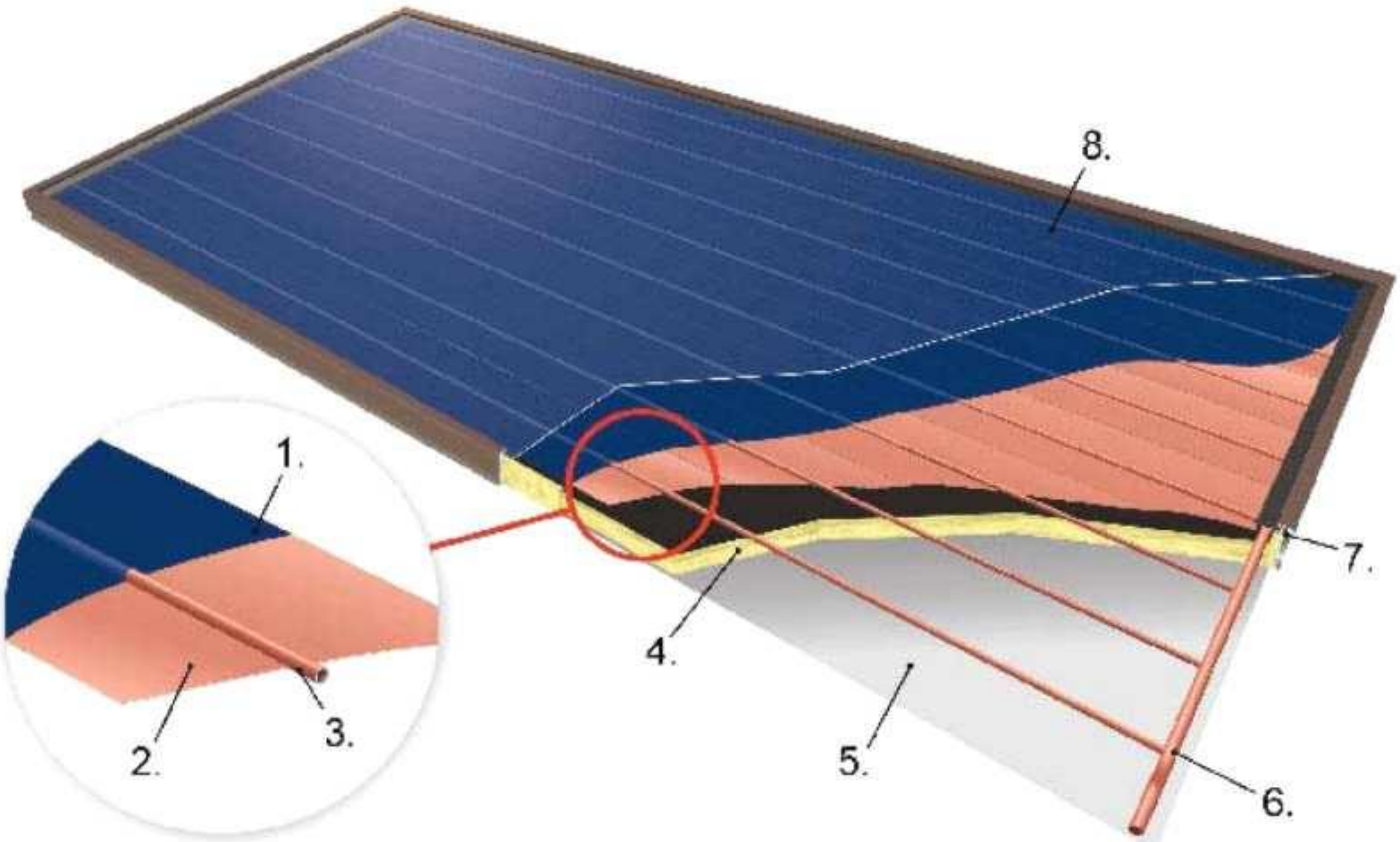
Technical concept of an integrated storage-collector



Source: KIOTO – Clear Energy

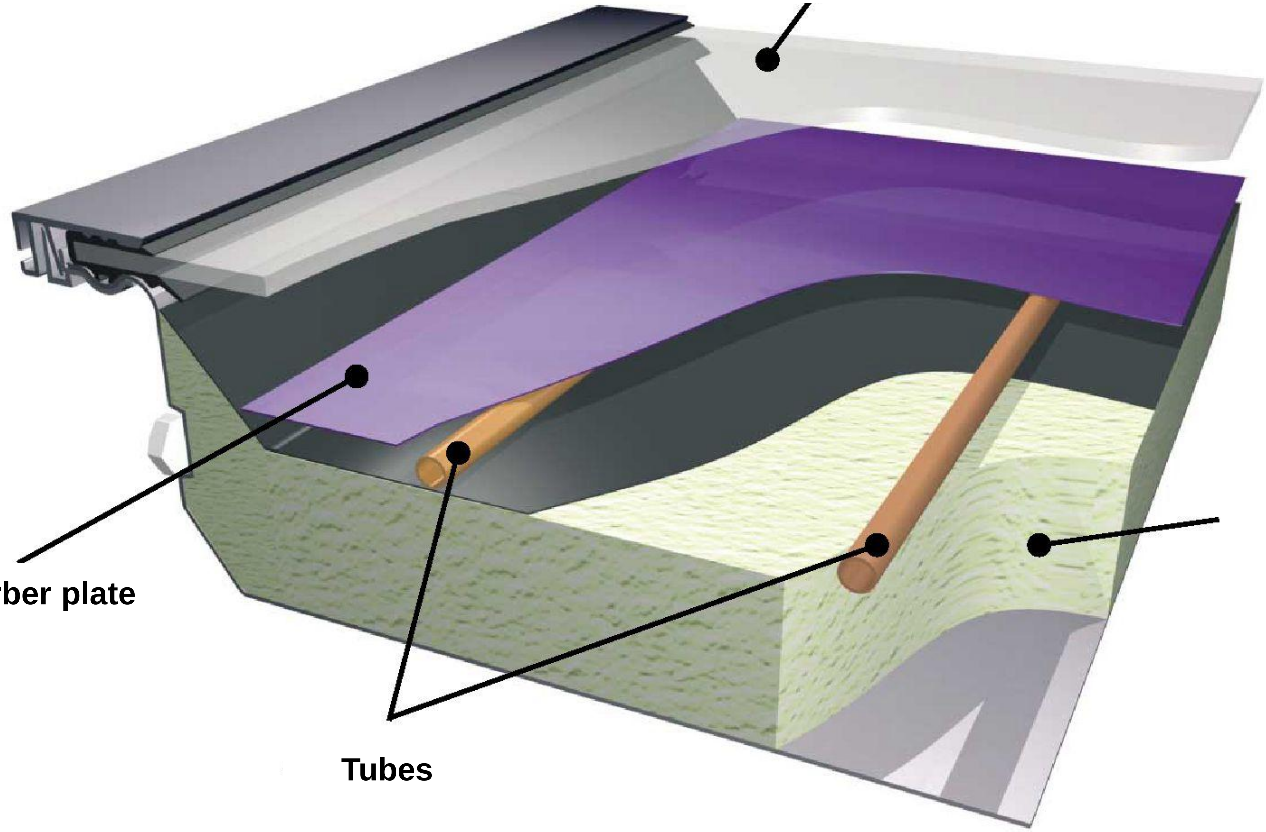
Flat plate collectors

FLAT-PLATE COLLECTOR



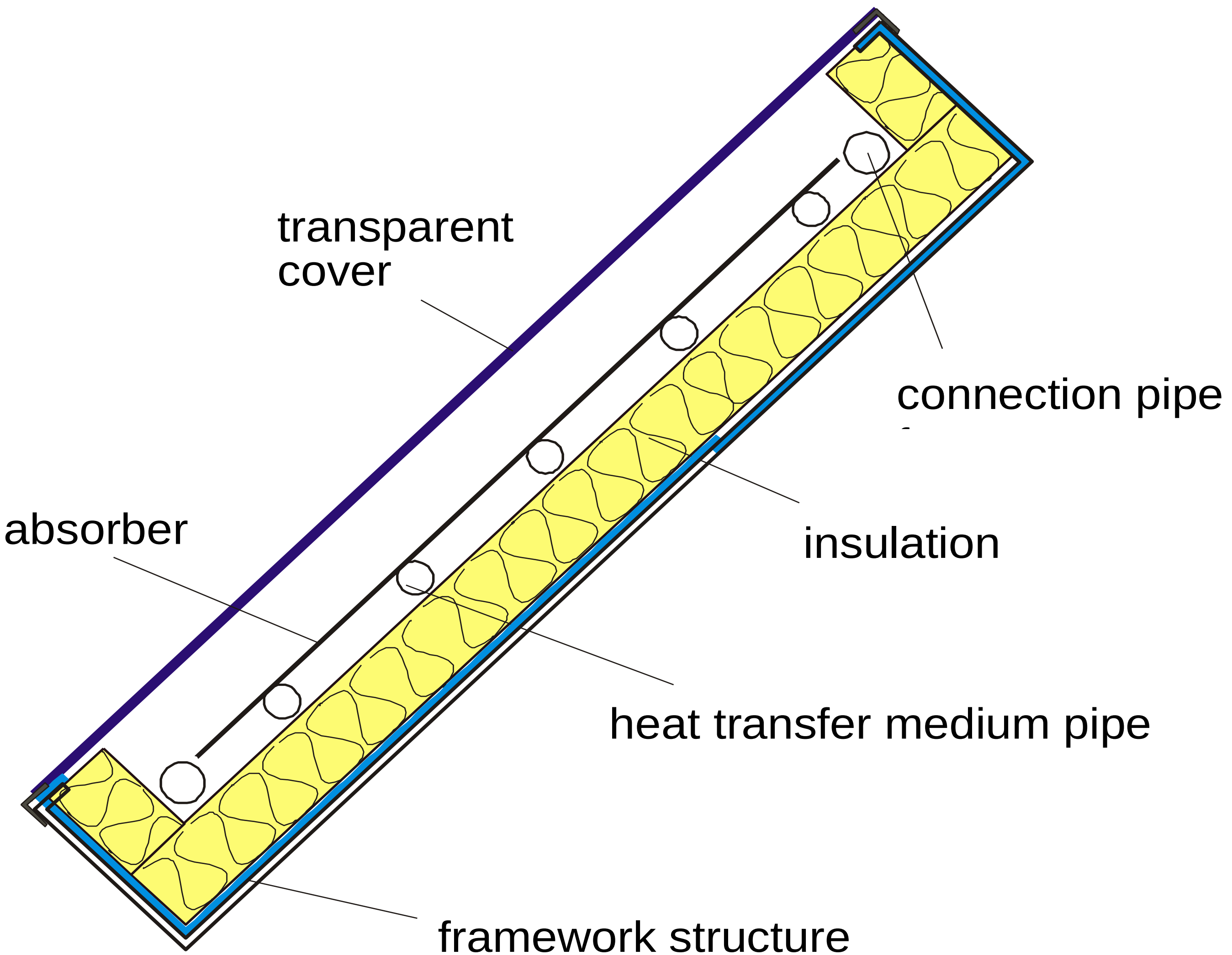
Source: IEA SHC Task 33

FLAT-PLATE COLLECTOR

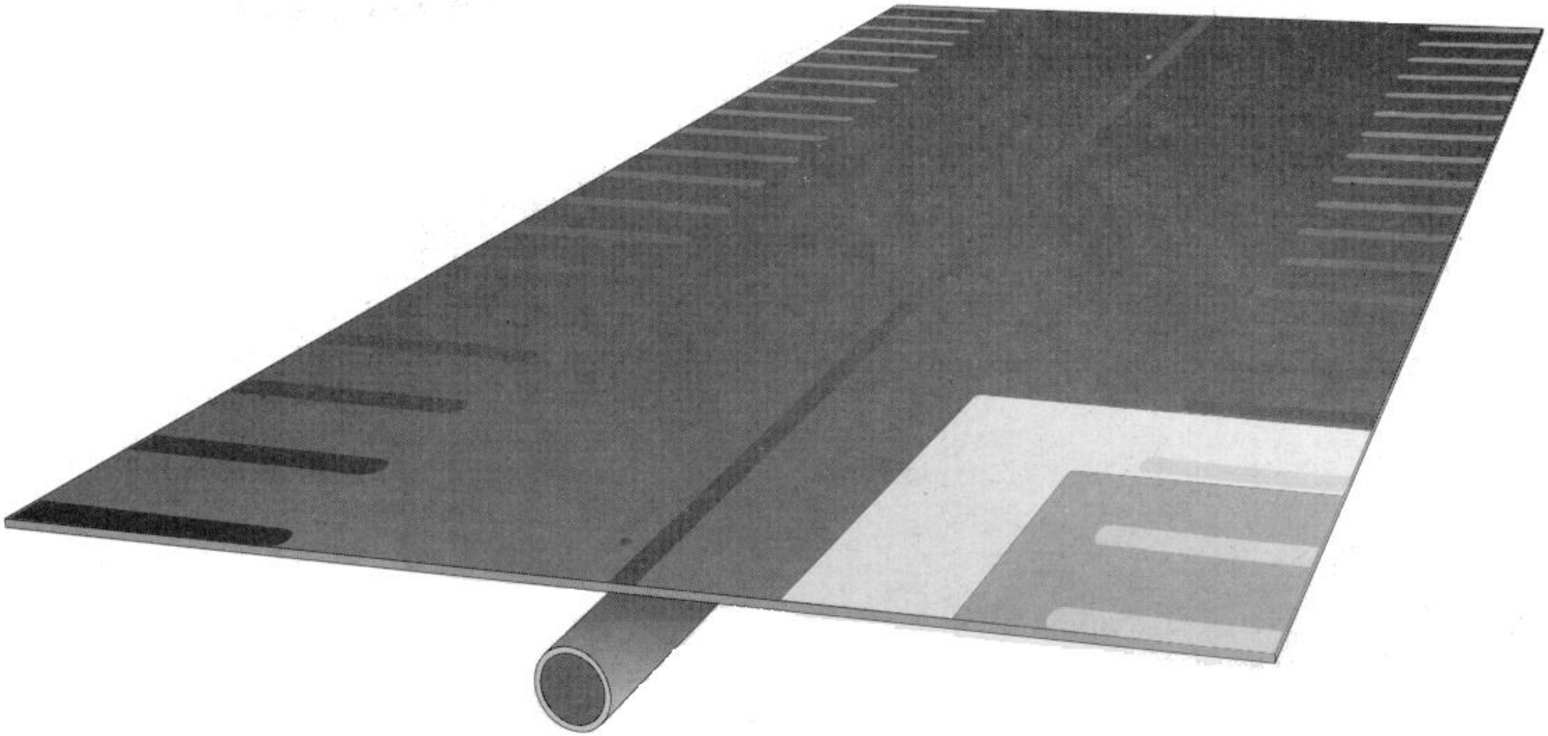


Source: Consolar

FLAT-PLATE COLLECTOR



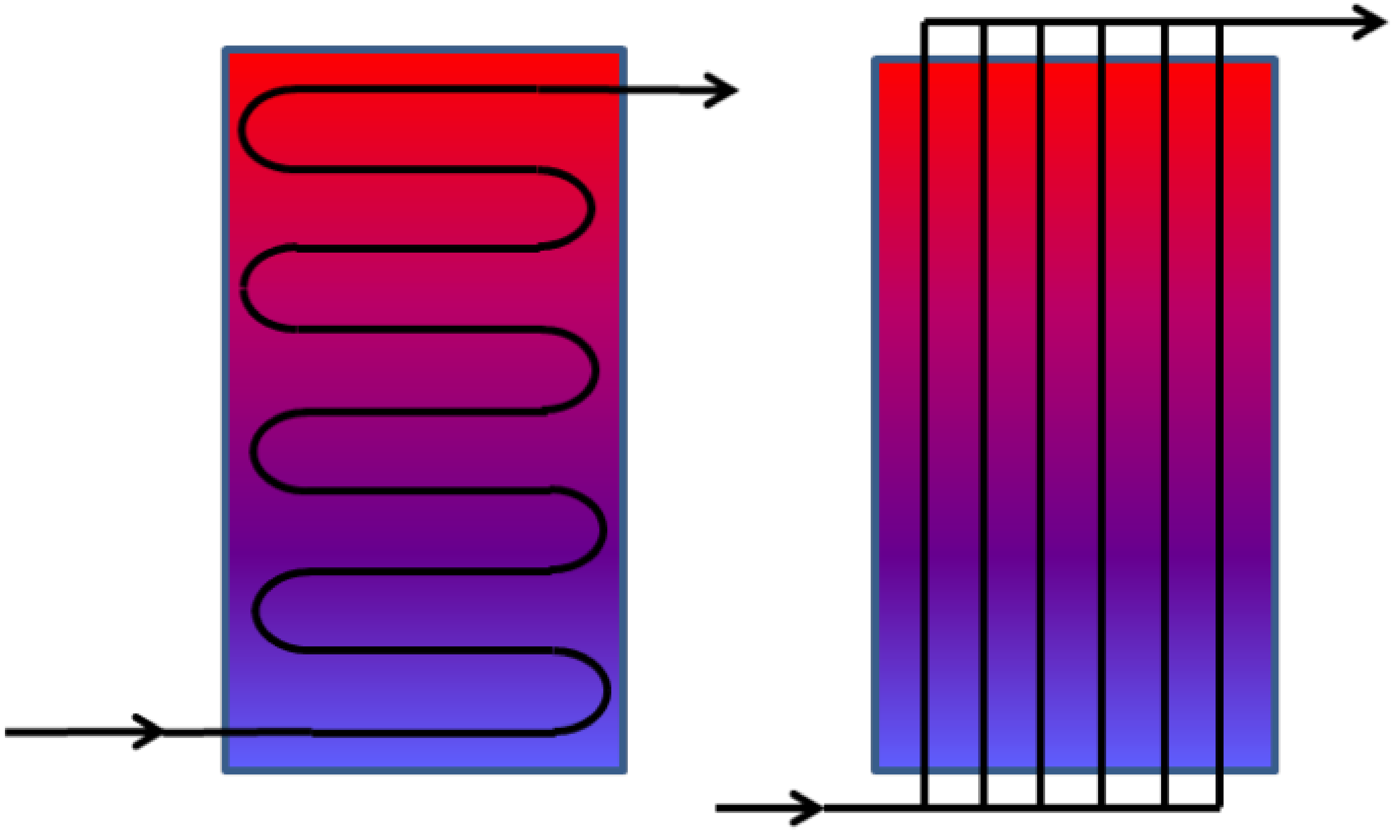
Strip absorber



Strip Absorber

Large-scale absorber consisting of one big copper sheet

Meander absorber and harp absorber



Aluminium Rollbond absorber with bionic channel structure

Absorber mit Fractherm®-Kanalstruktur, selektiv beschichtet

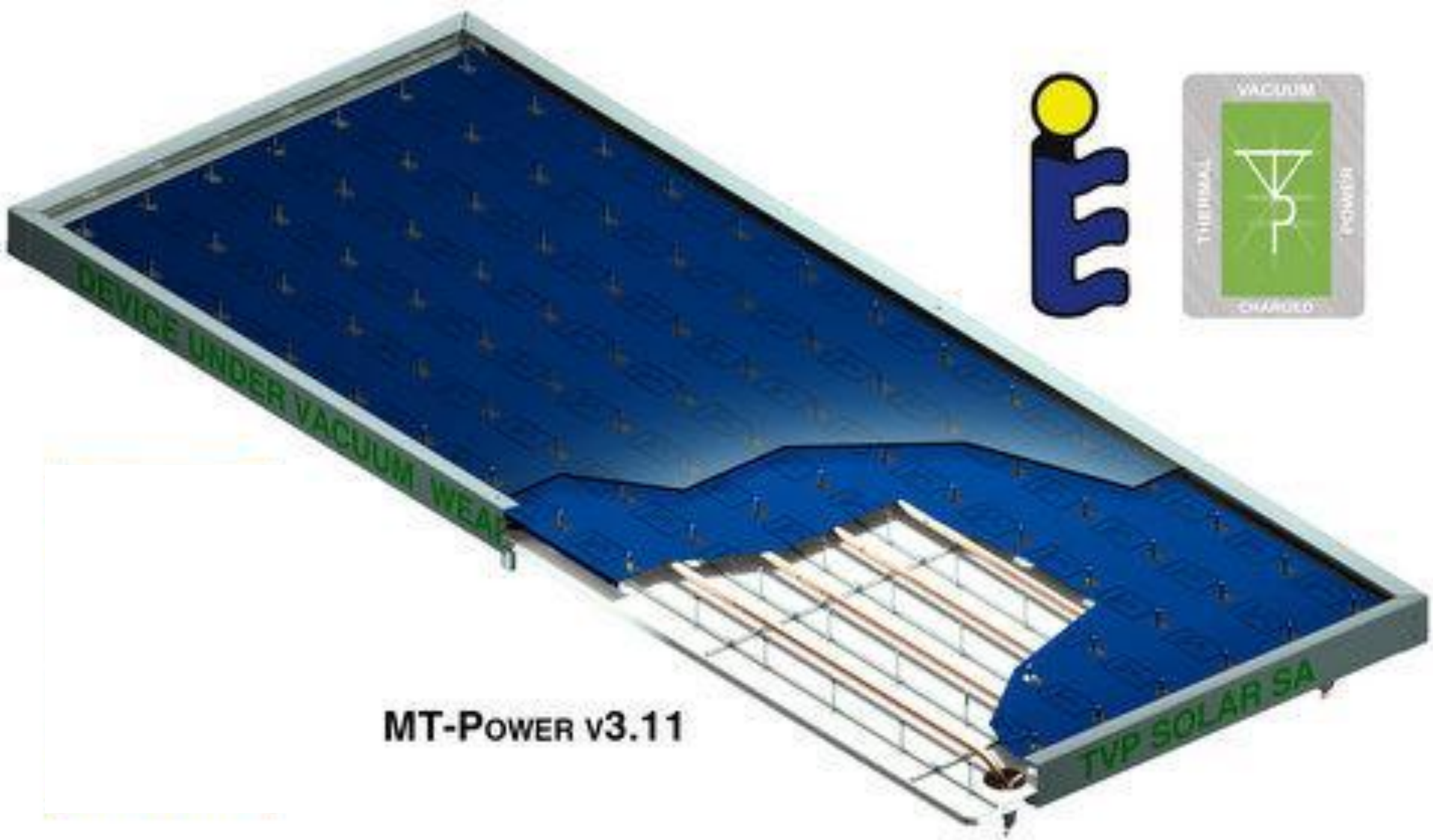
Source: Fraunhofer ISE

High Vacuum Flat-plate Collector - SBB

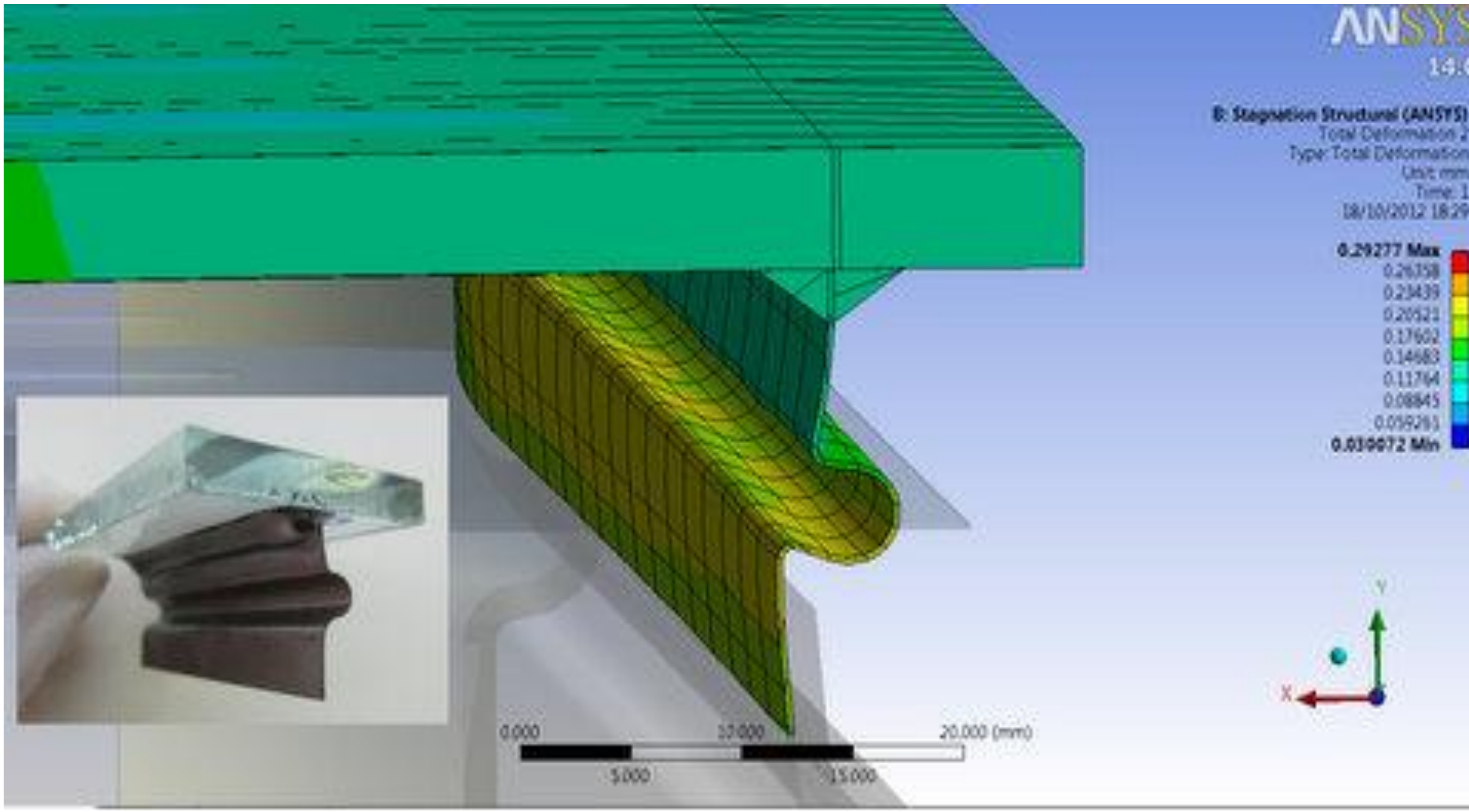
High Vacuum Flat-plate Collector – TVP (CH)

High vacuum flat-plate collector by TVP SOLAR in Masdar City (Abu-Dhabi, UAE)

TVP High Vacuum Flat-plate Collector with Solar KEYMARK certified up to 200°C



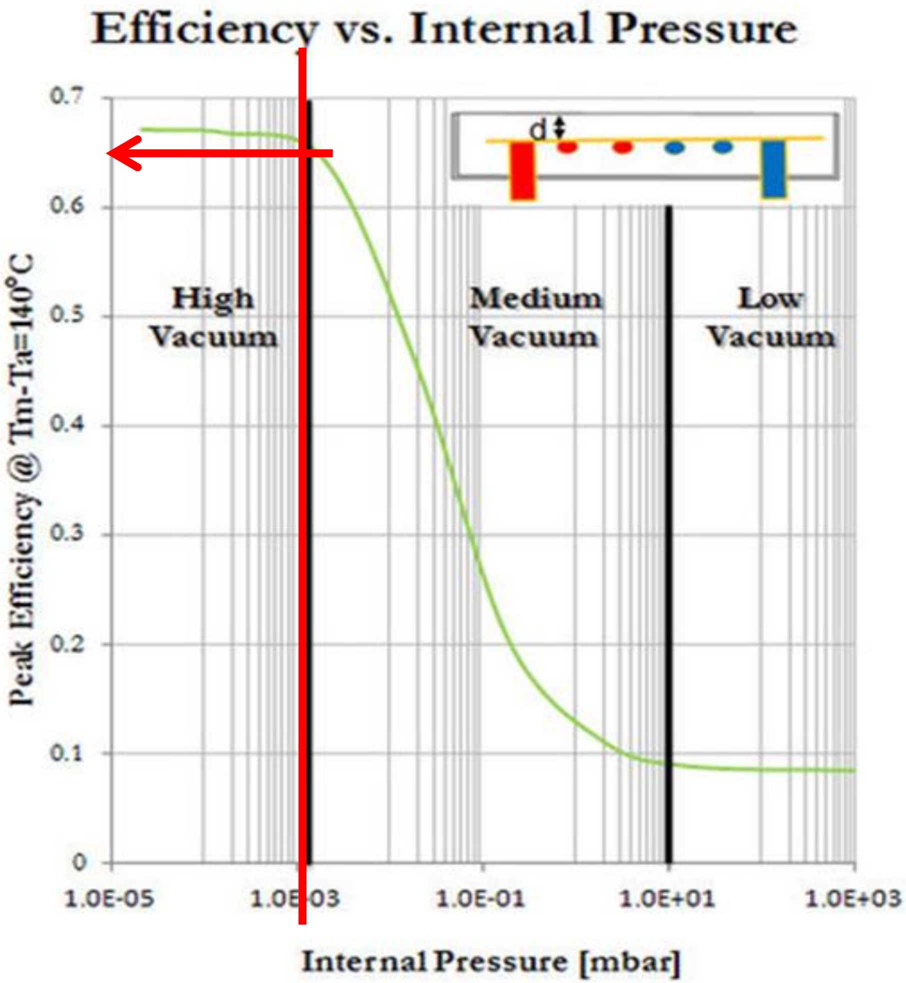
Glass-metal seal



Evacuated at almost 300°C during the manufacturing process

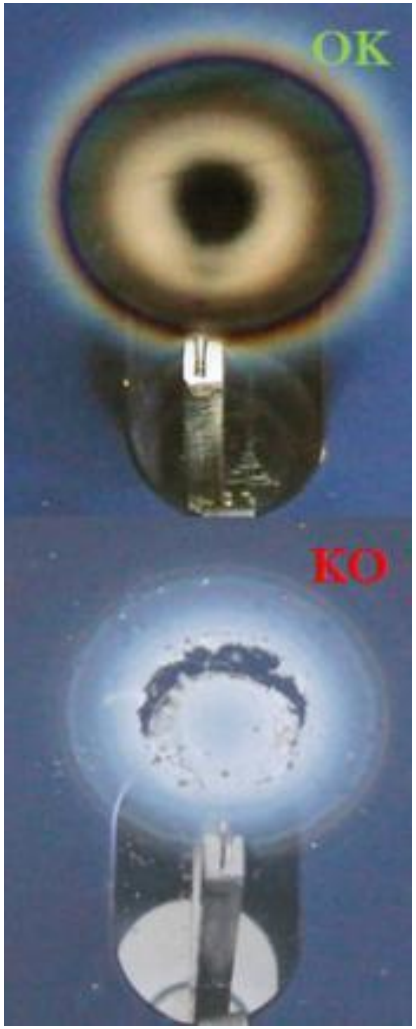
Source: TVP Solar SA

High Vacuum Flat-plate Collector – TVP



Peak efficiency operated at Tm-Ta=140°C as a function of internal pressure

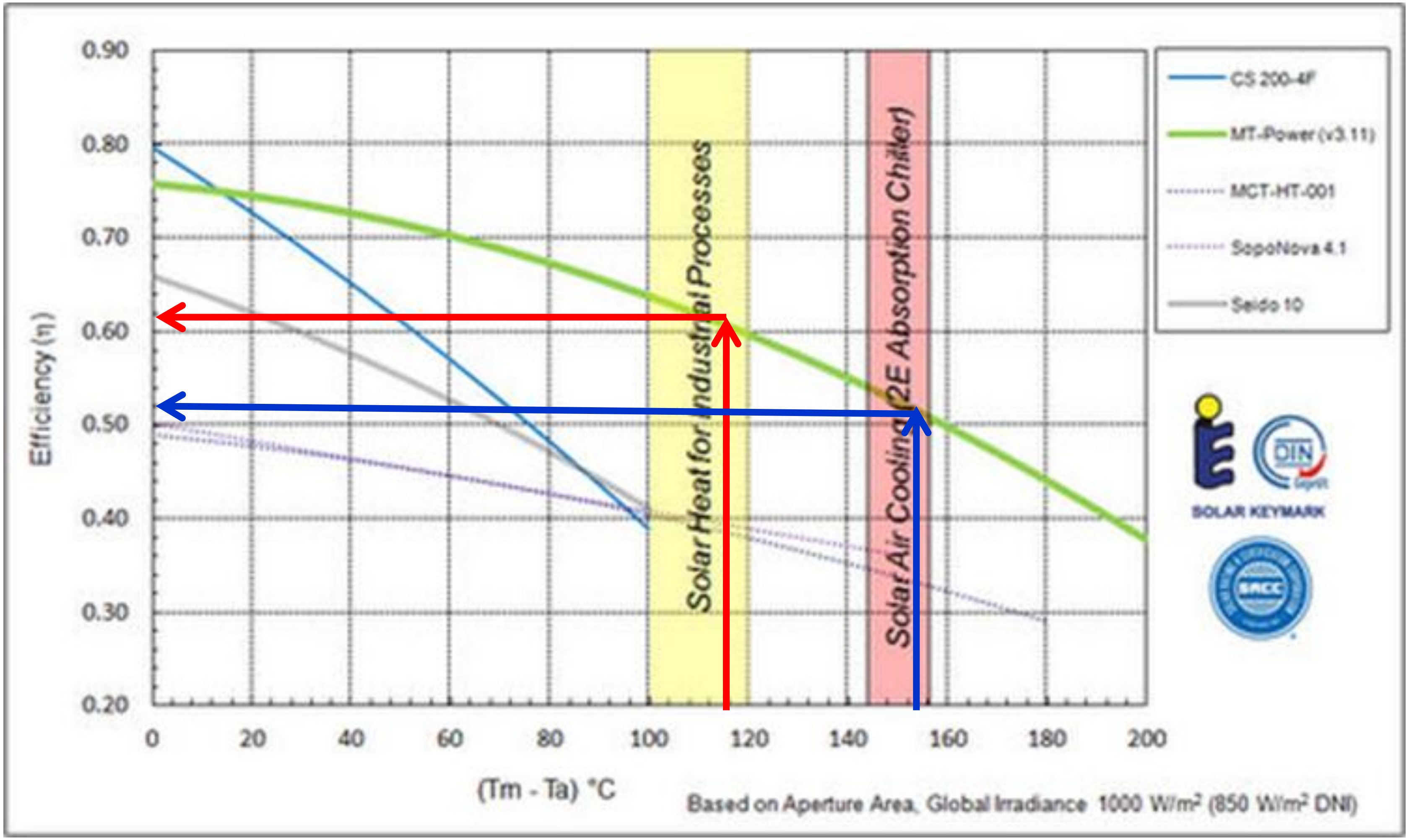
High Vacuum Flat-plate Collector – TVP



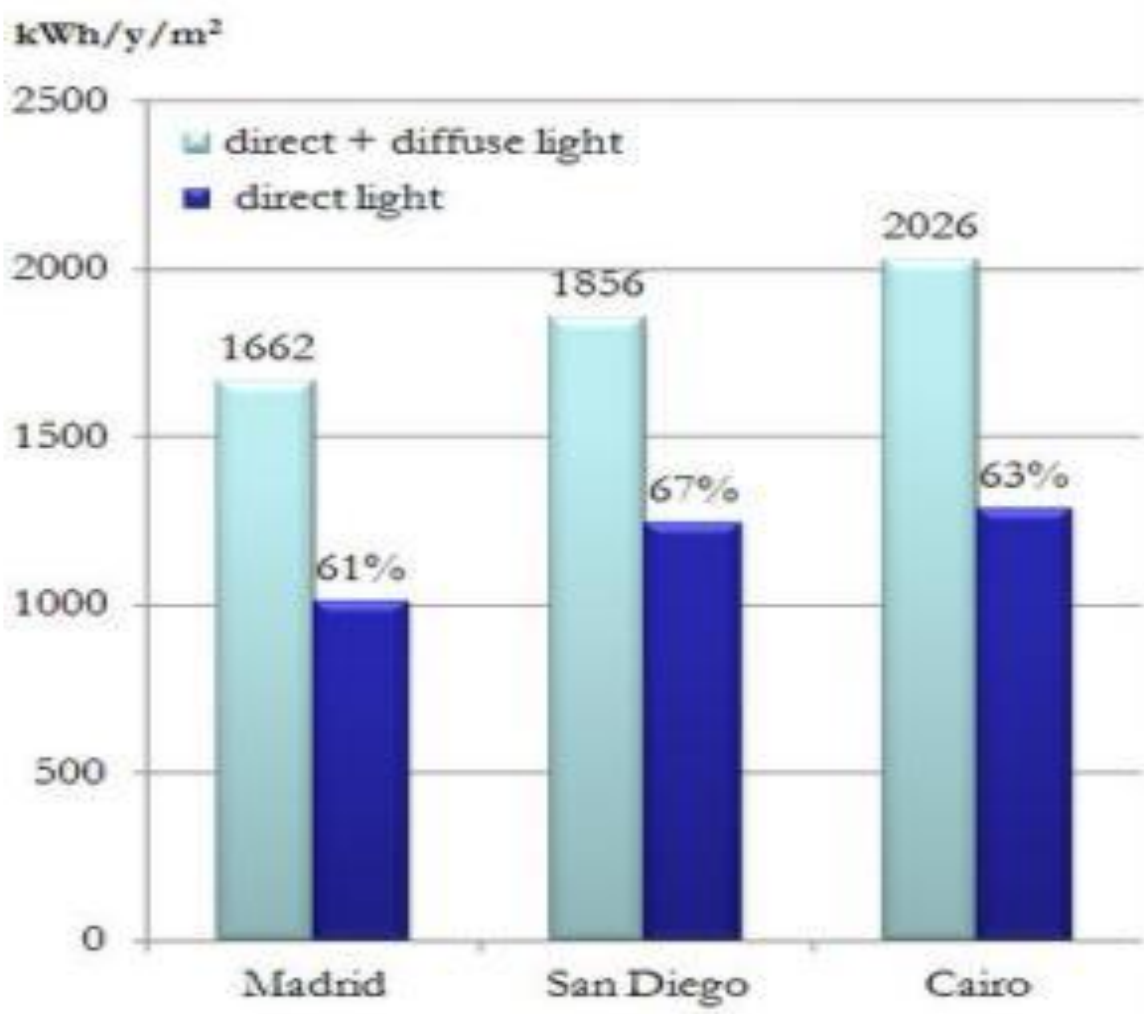
Vacuum check by a barium mirror spot. It turns from silver to white because of oxidation due to the residual gas inside the panel envelope if the vacuum is lost.

Source: TVP Solar SA

High Vacuum Flat-plate Collector – TVP (CH)



Direct and diffuse solar radiation available at selected locations worldwide

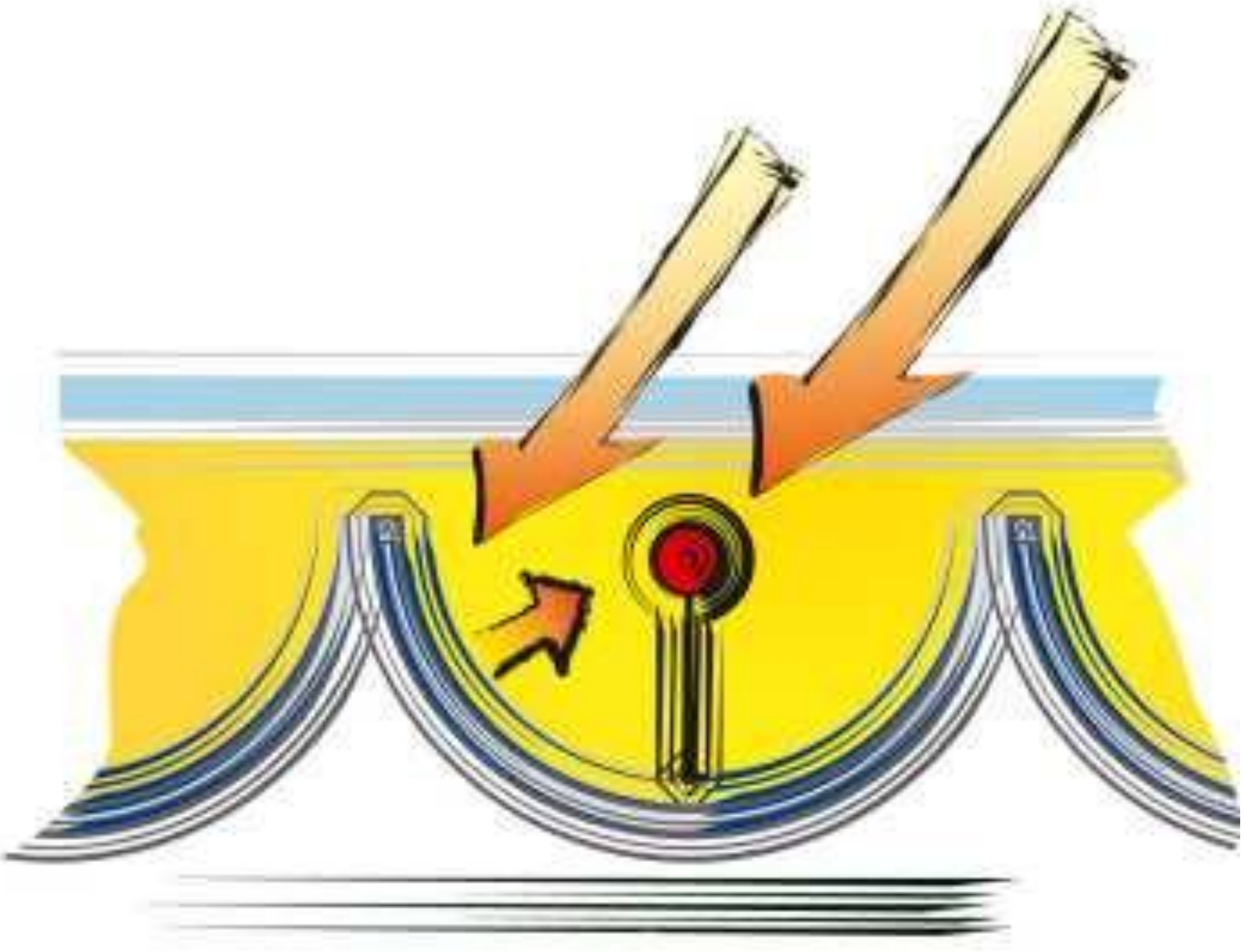


Source: METEONORM data

CPC - COLLECTOR

Source: Solarfocus

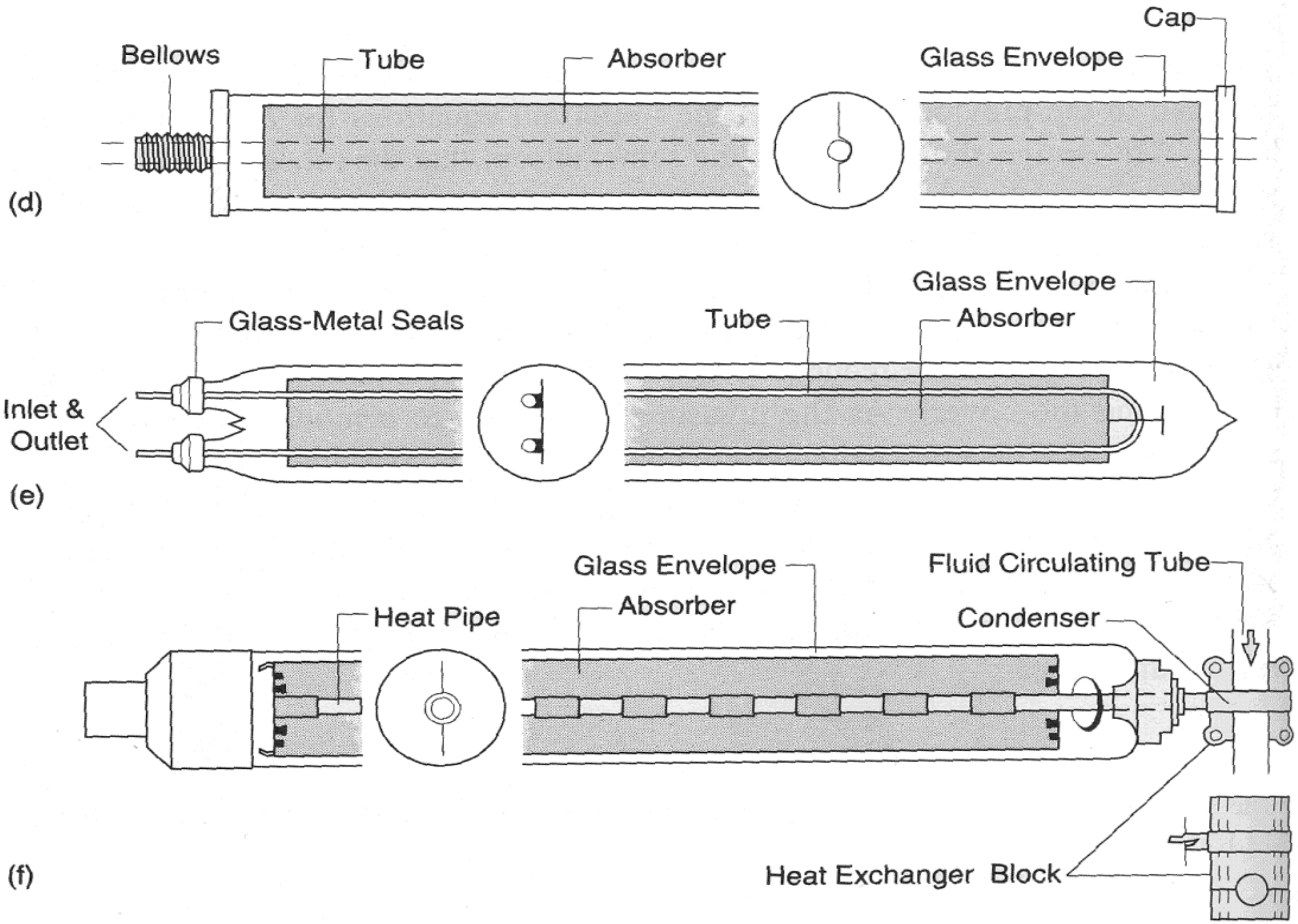
CPC - COLLECTOR



Source: Solarfocus

Evacuated Tube Collectors

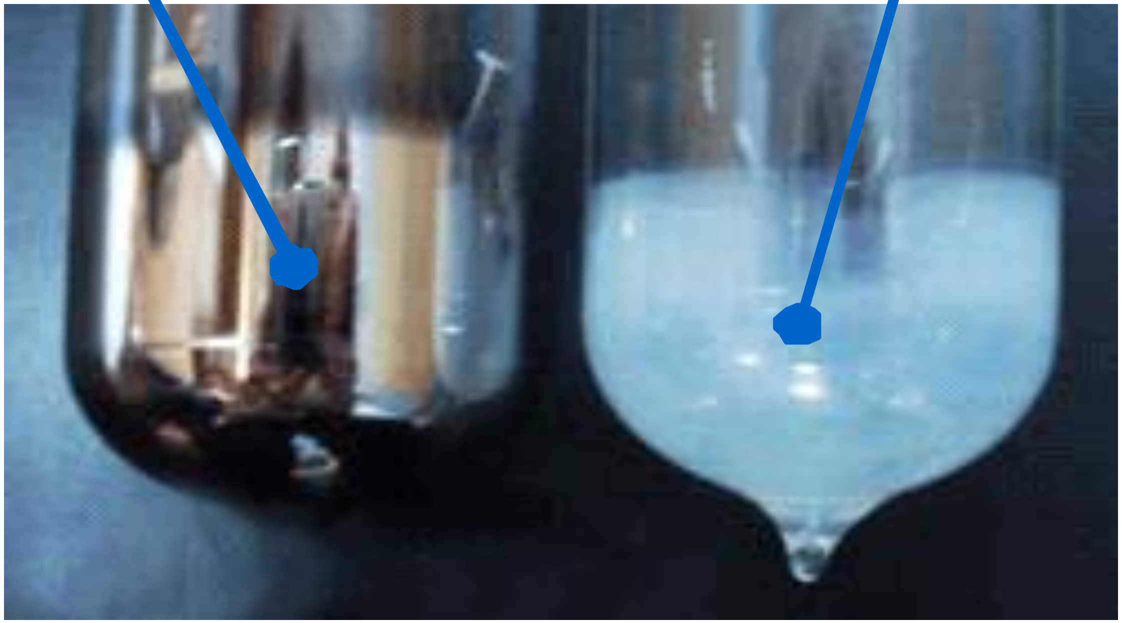
Evacuated Tube Collectors



Error–indication

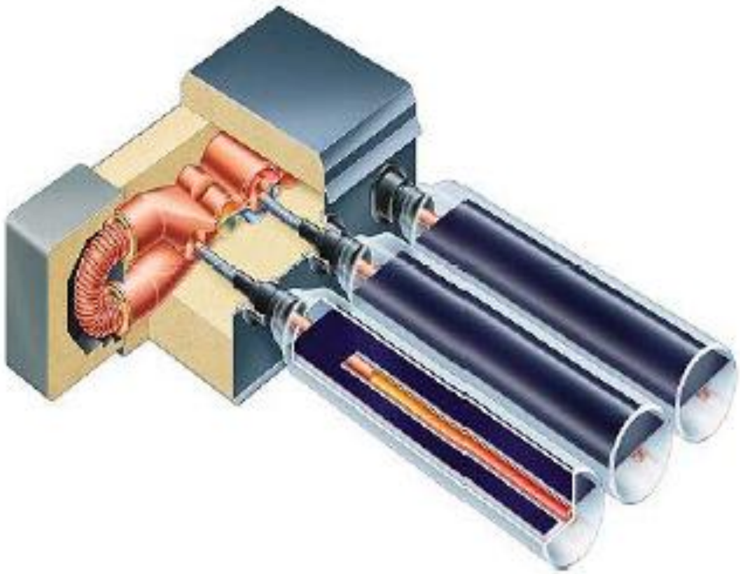
Vacuum present

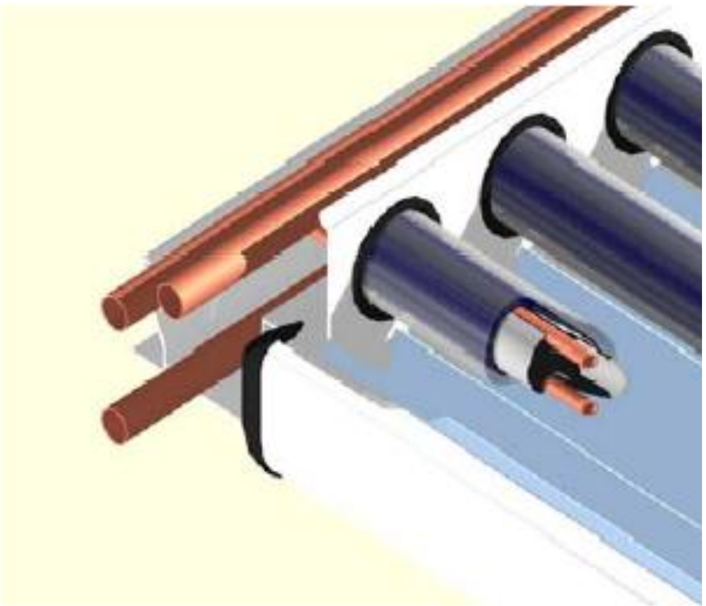
Vacuum faulty



(http://www.solardirect.com/ and http://www.solar-water-heater.com/product/trendsetter/basics.htm)

Evacuated Tube Collectors



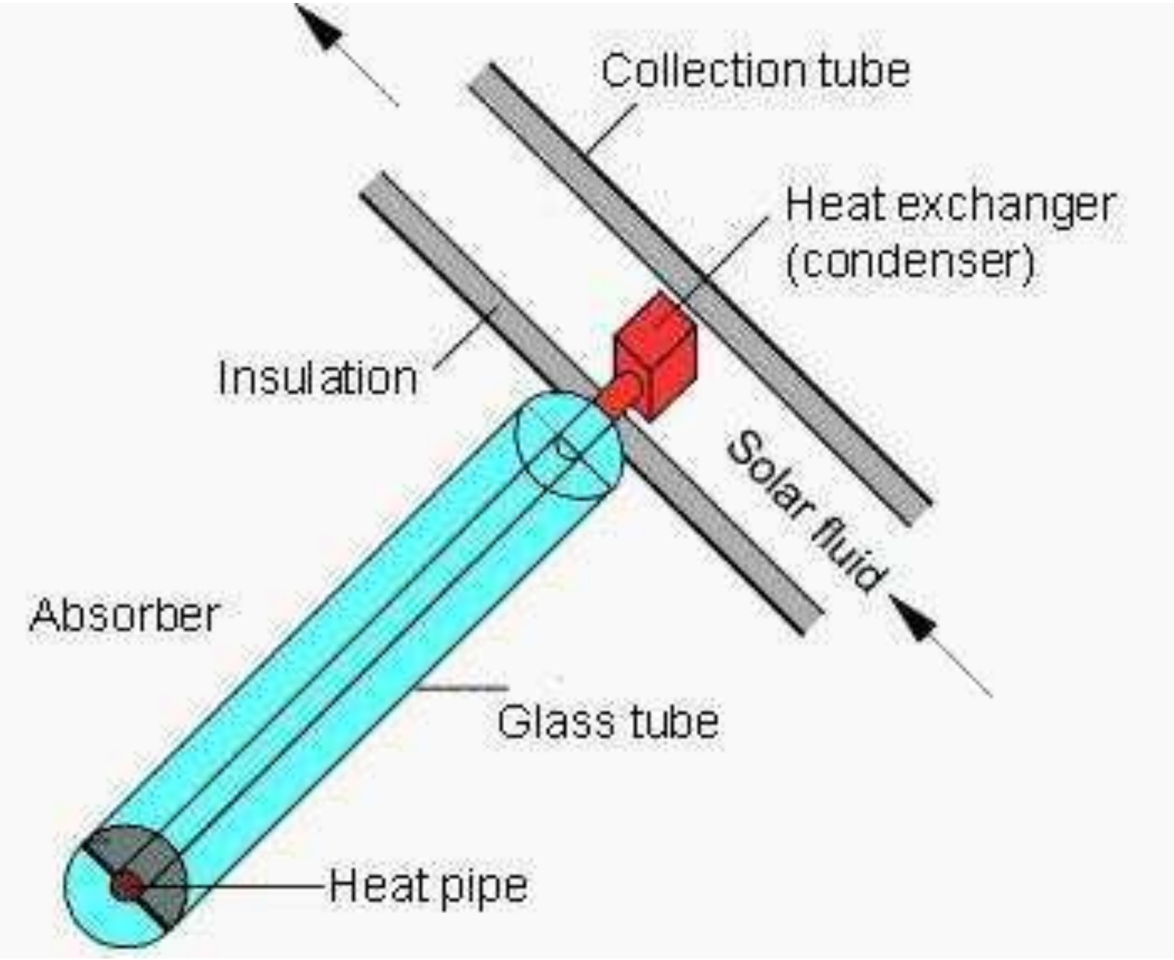


Heatpipe, Vitosol 300 (left) / Direct coupled Sydney Collector (right)

Evacuated Tube Collectors – Heat Pipe

Heat Pipe Principle

Heat Pipe Principle – Wet Connection



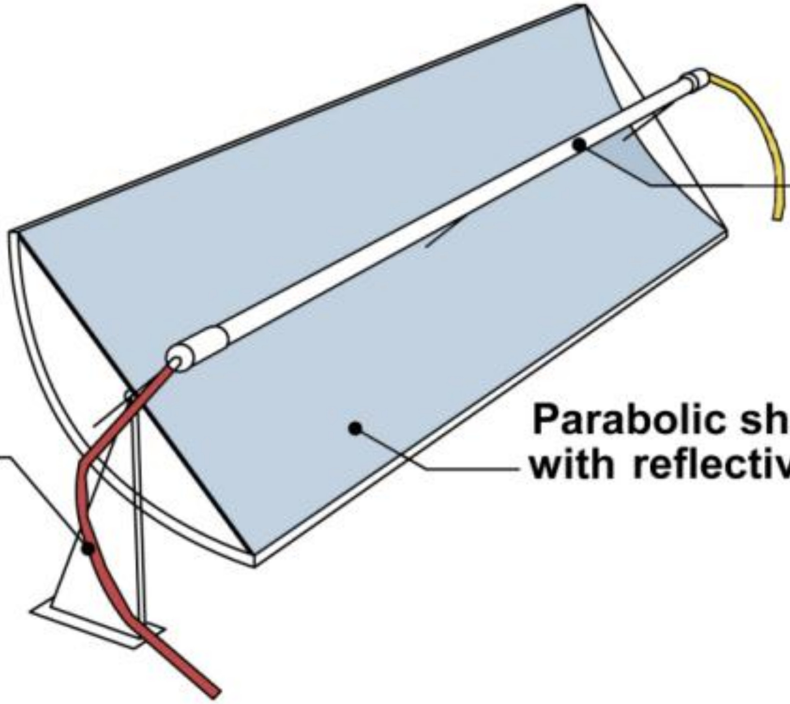
Thermosyphon system with evacuated tube collectors

Source: http://greenterrafirma.com/evacuated_tube_collector.html

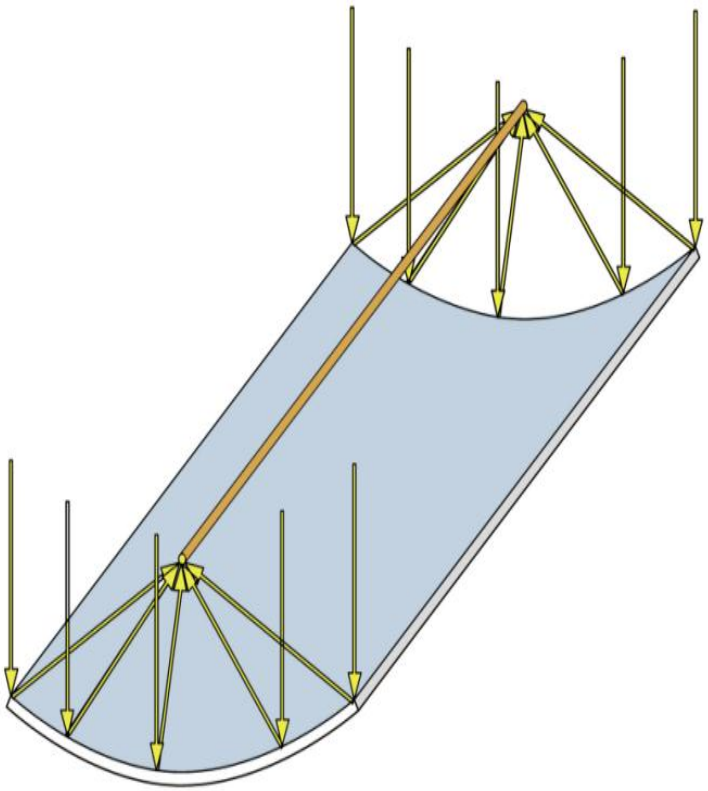
Evacuated Tube Collectors

Concentrating Collectors

Parabolic Trough Collector



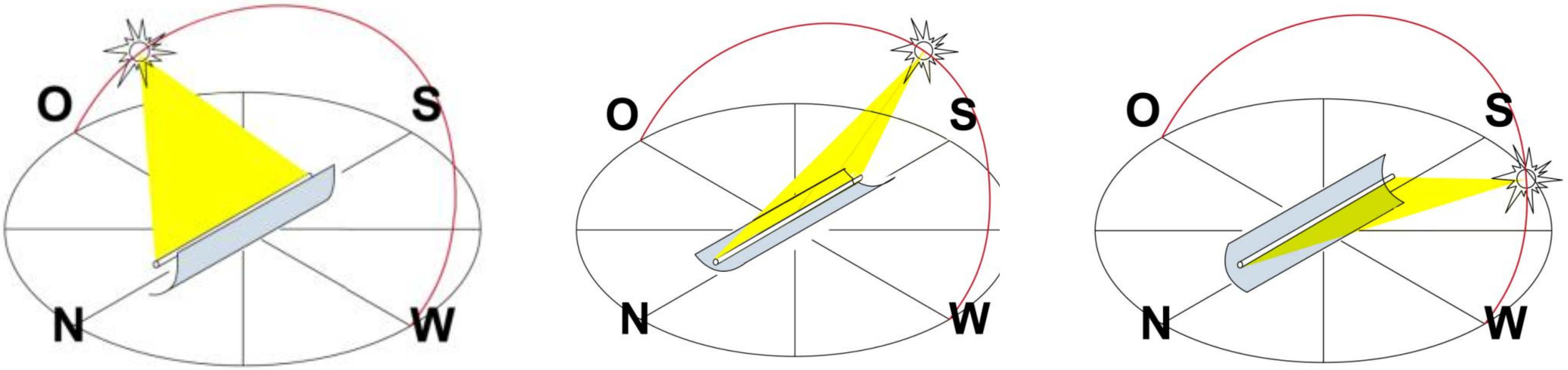
Working Principle - PTC



Parallel sun rays being concentrated onto the focal line of the collector

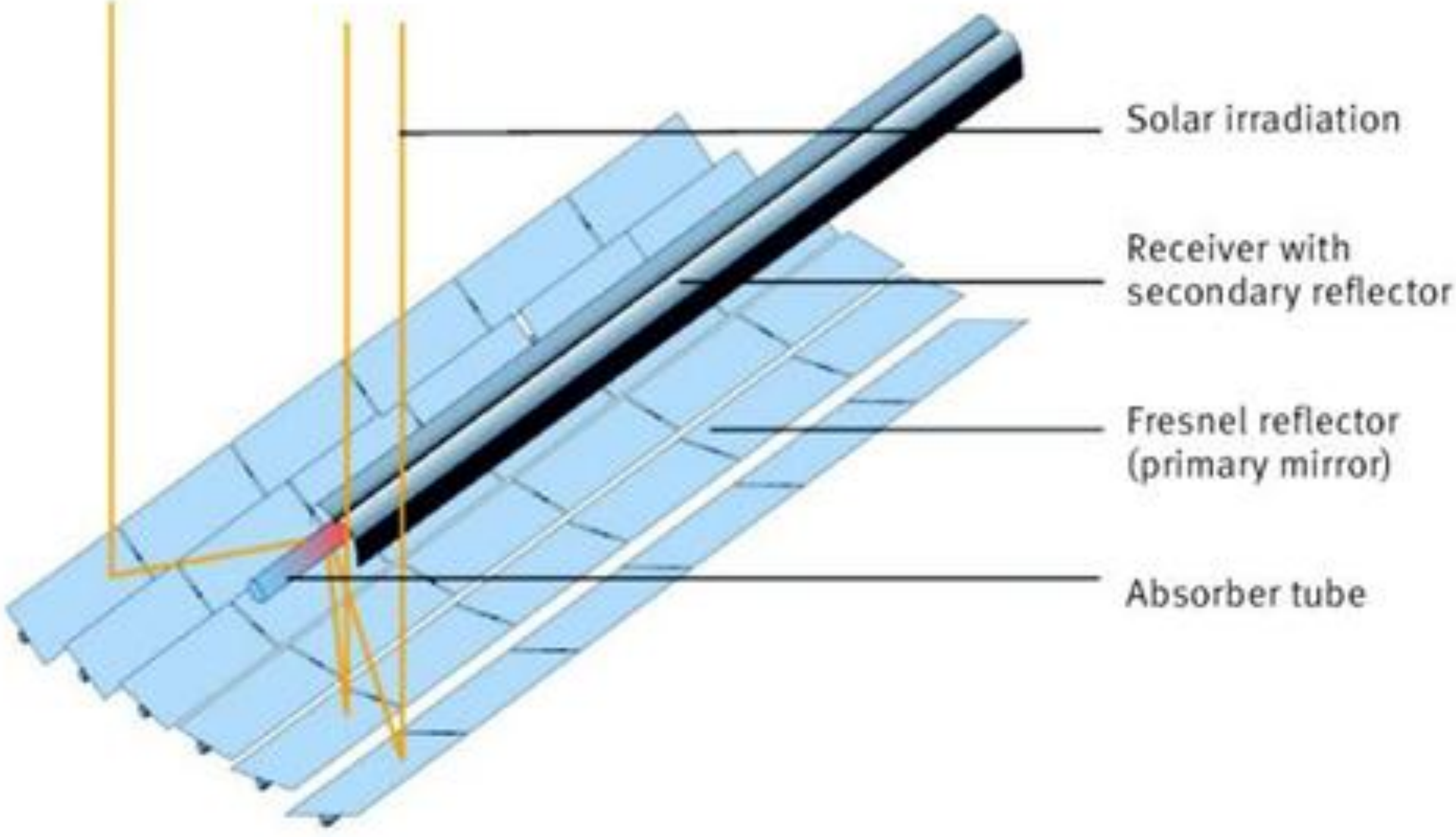
Small parabolic trough collector on the test rig of AEE INTEC

Tracking of the sun



Collector axis oriented north-south

Linear concentrating fresnel collector

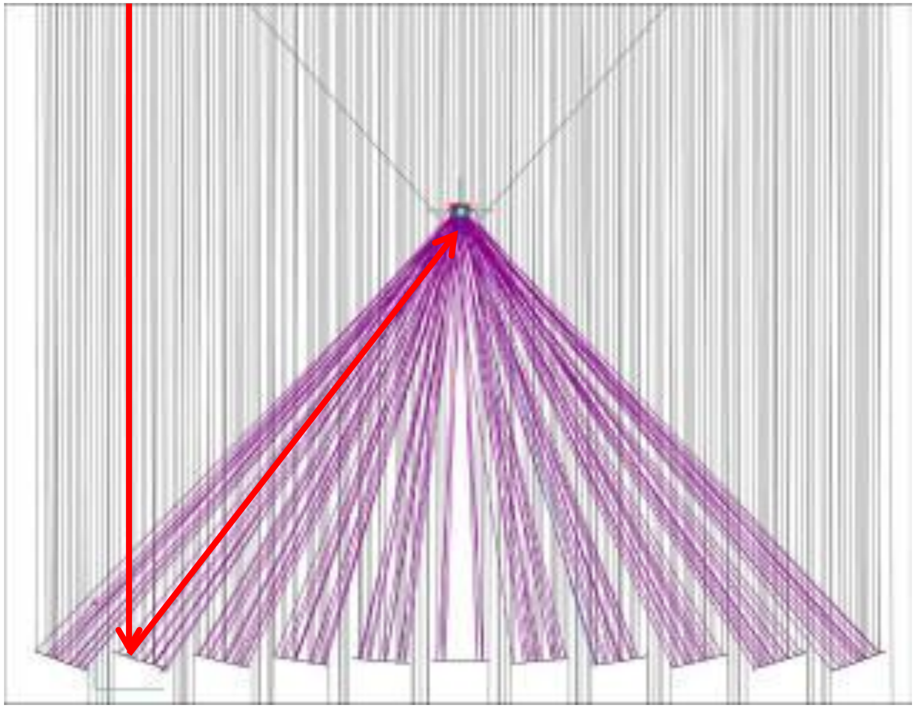


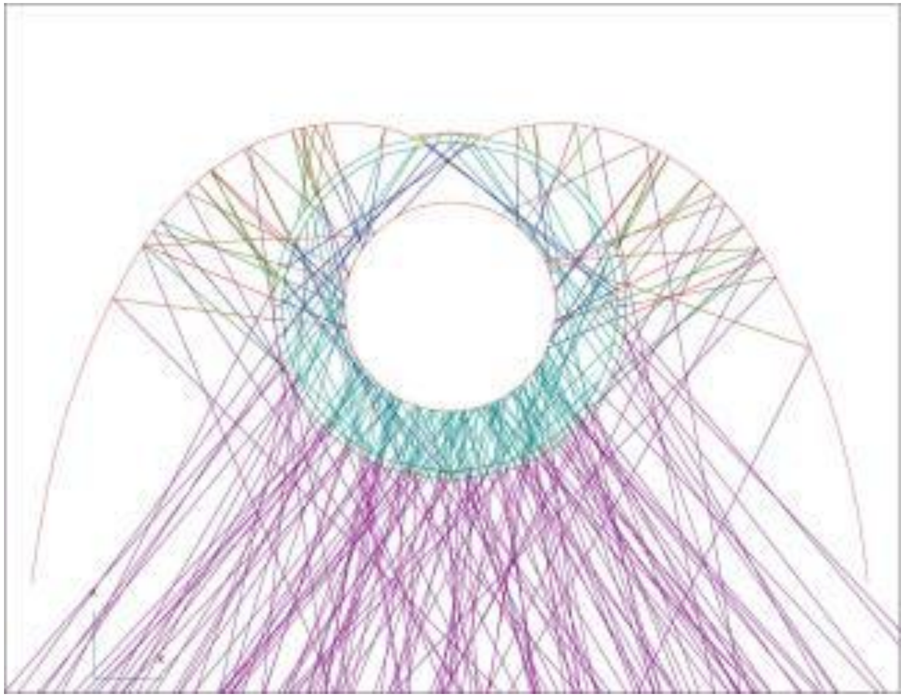
Source: W. Weiss and M. Rommel: Process heat collectors, IEA SHC Task 33

Solar cooling system with Fresnel concentrator collectors for a show-case football stadium in Doha, Qatar

Source: Industrial Solar

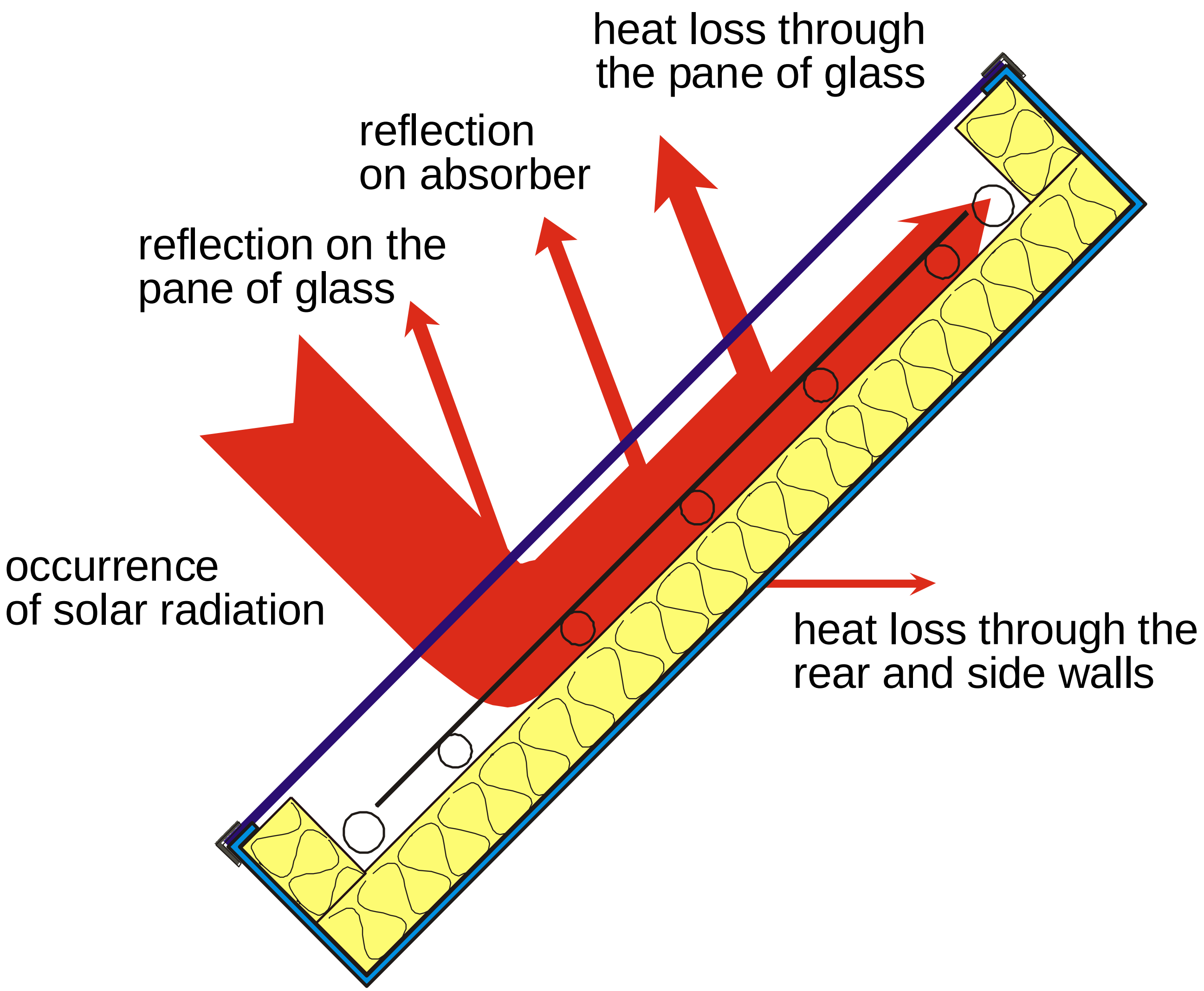
WORKING PRINCIPLE



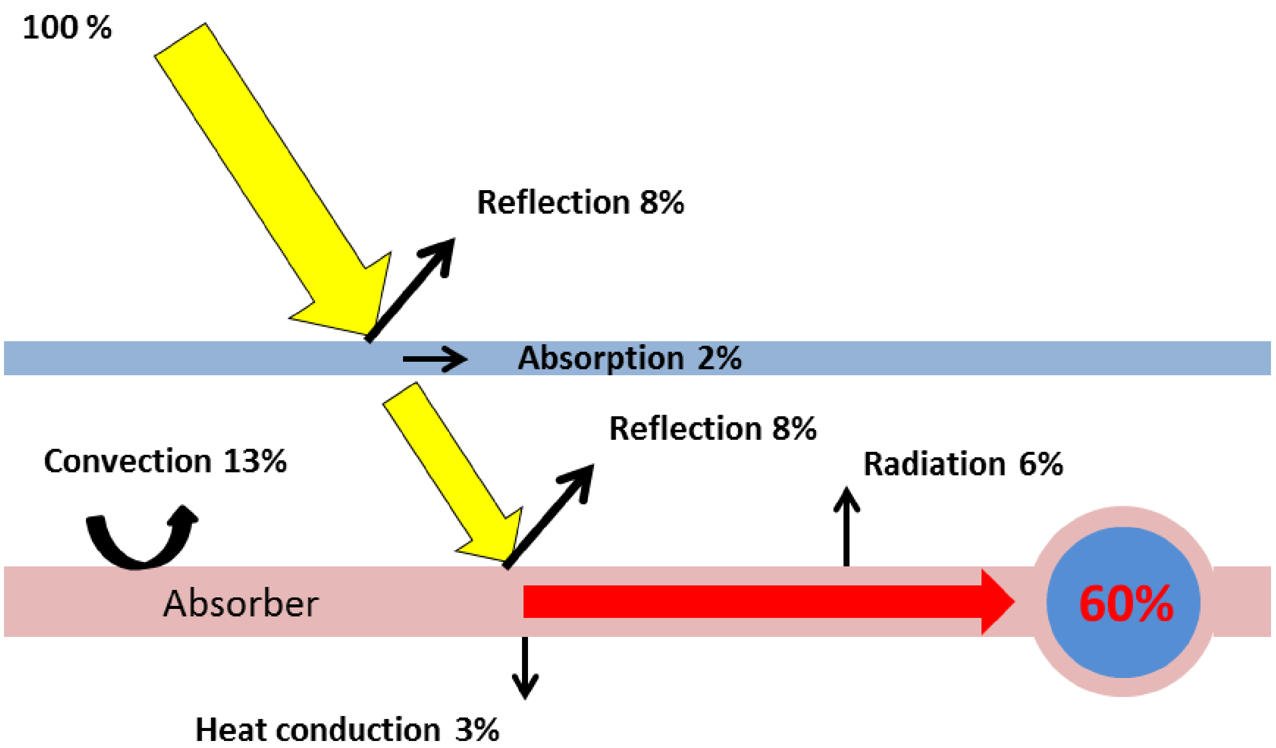


Raytracing with vertical irradiation.
Left: cross section of the whole collector
Right: cross section of the receiver with secondary concentrator

Physical Processes inside a Flat-Plate Collector



Losses of a basic Flat-plate Collector



Source: Source: Wagner & Co.

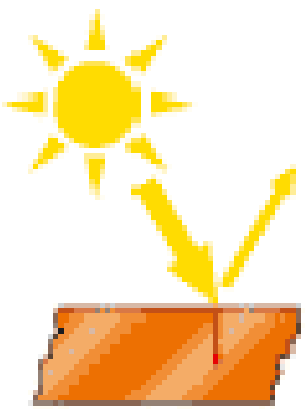
COLLECTOR MATERIALS

ABSORBER MATERIALS
THERMAL CONDUCTIVITY

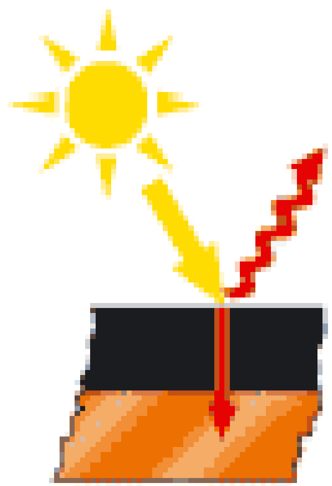
absorber material	thermal conductivity [W/mK]
steel	50
aluminium	210
copper	380

ABSORBER COATING

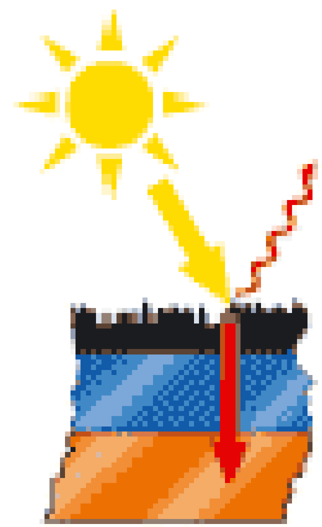
Selective coating:	$0 \leq \varepsilon < 0.2, \alpha > 0.9$
Partially selective coating:	$0.2 \leq \varepsilon < 0.5, \alpha > 0.9$
Non selective coating:	$0.5 \leq \varepsilon < 1.0, \alpha > 0.9$



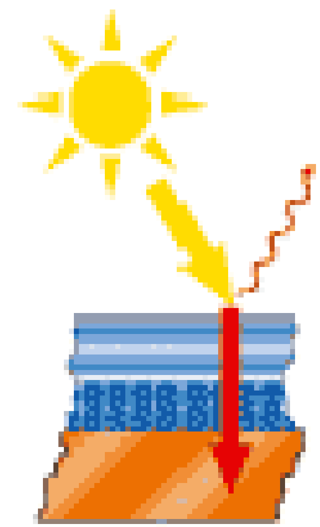
Plain copper



black paint



galvanic coating



physical vapour deposition or sputtering

ABSORBER COATING

Source:Alanod-Sunselect / ESTIF

ABSORBER COATING

Video: TiNOX High Selective Coating.flv

TRANSPARENT COVER MATERIALS

Cover	Thickness [mm]	Weight [kg/m²]	Solar transmittance
Standard glass *)	4	10	0.84
Standard glass, tempered	4	10	0.84
Iron free glass, tempered	3.2	8	0.91
Antireflective coated glass	3.2	8	0.95**
PMMA, ducted plate	16	5.0	0.77
PMMA, double ducted plate	16	5.6	0.72

*) Danger of breaking determined by high collector temperatures
**additional costs low and worthwhile

INSULATING MATERIALS

insulating material	**max. allowable temperature** [°]	**density** [kg/m³]	**conductivity** [W/mK] at 20°C
Mineral wool	> 200	60 - 200	0.040
Glass wool	> 200	30 - 100	0.040
Glass wool	> 200	130 - 150	0.048
Polyurethane foam	< 130	30 - 80	0.030
Polystyrol foam	< 80	30 - 50	0.034

Characteristic Values of Flat-plate and Evacuated Tube Collectors

$$\dot{Q}_{coll} = F_R(\tau\alpha)G - F_R U_L \Delta T$$

Qcoll is the energy collected per unit collector area per unit time

FR is the collector's heat removal factor

τ is the transmittance of the cover

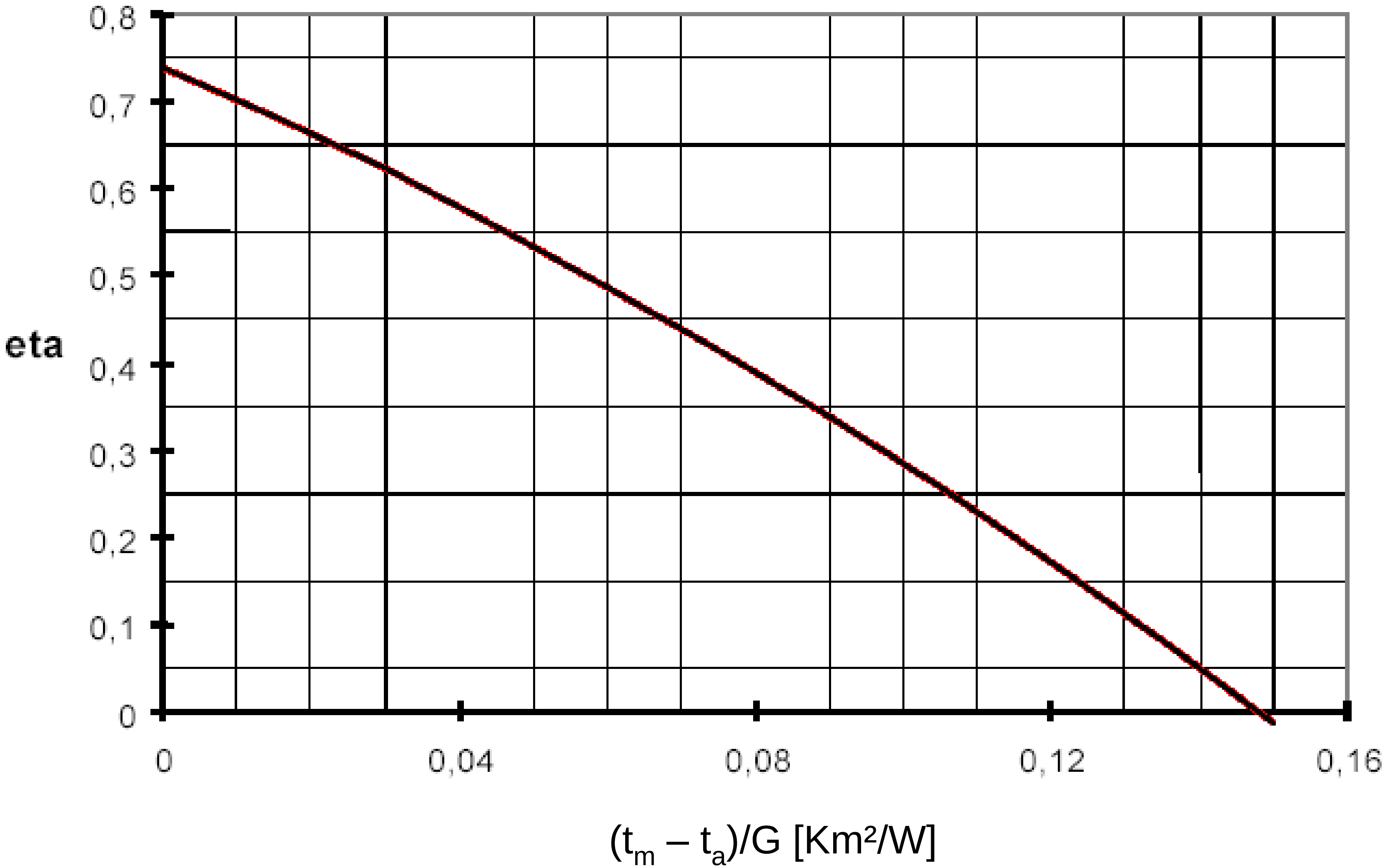
α is the shortwave absorptivity of the absorber

G is the global incident solar radiation on the collector

UL is the overall heat loss coefficient of the collector

T is the temperature differential between the heat transfer fluid entering the collector and the ambient temperature outside the collector.

Collector Efficiency Curve



Collector Efficiency

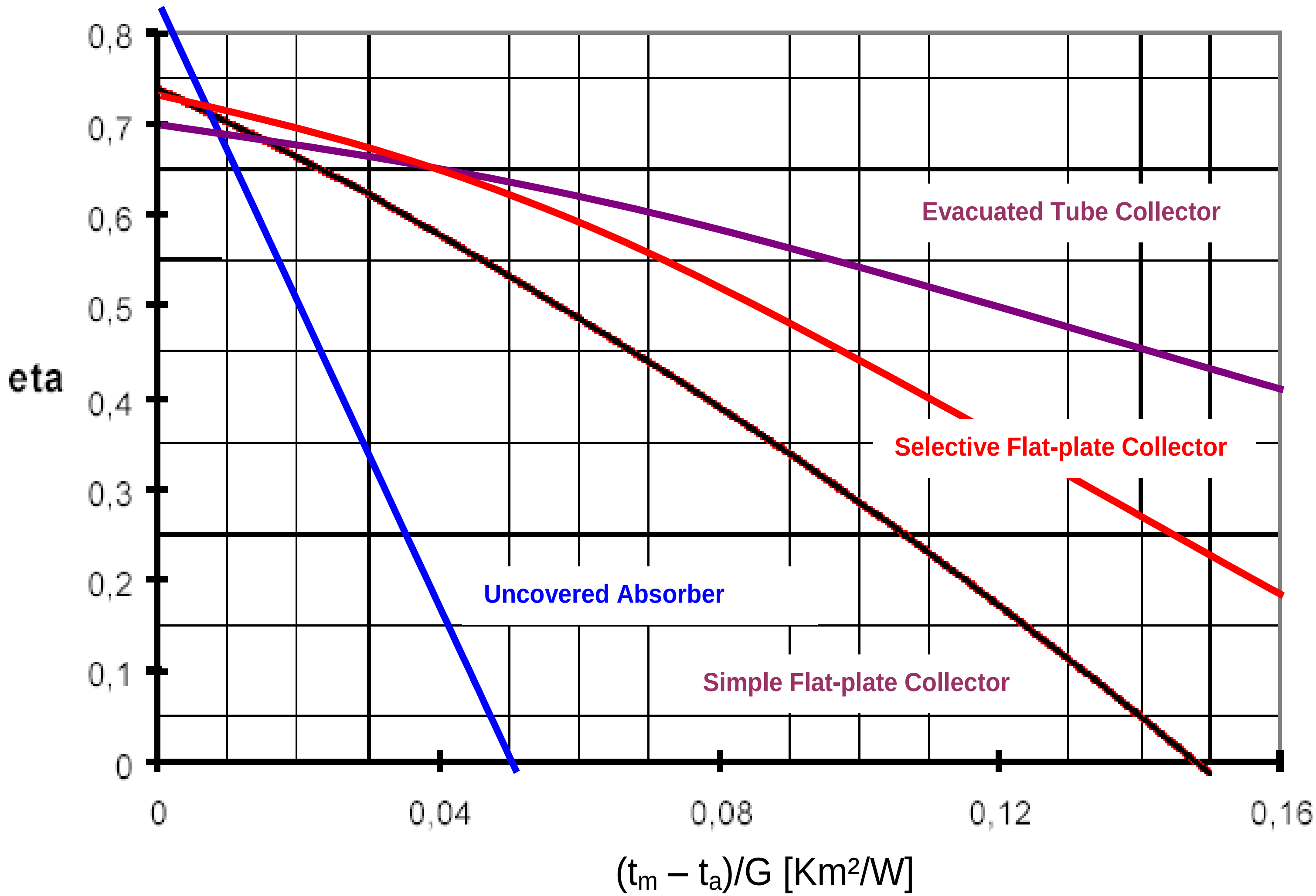
$$\eta = \frac{useful\ energy}{solar\ energy}$$

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

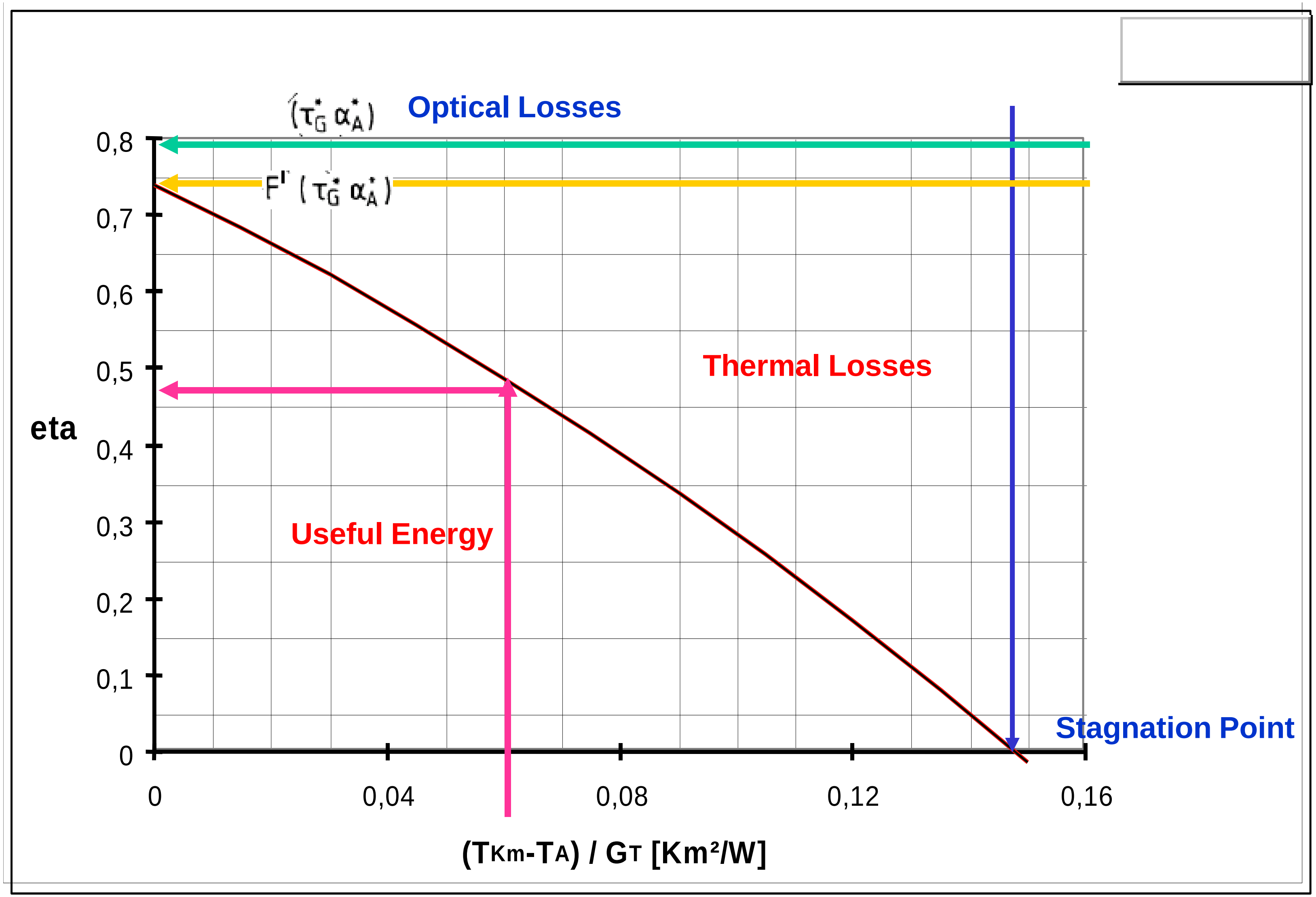
Collector Efficiency

η_0	maximum efficiency (= efficiency at $t_m = t_a$)	
a_1	linear heat loss coefficient	$\frac{W}{m^2 \cdot K}$
	s. T-Sol Collector data	
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
G	incident radiant energy (global radiation)	$\frac{W}{m^2}$

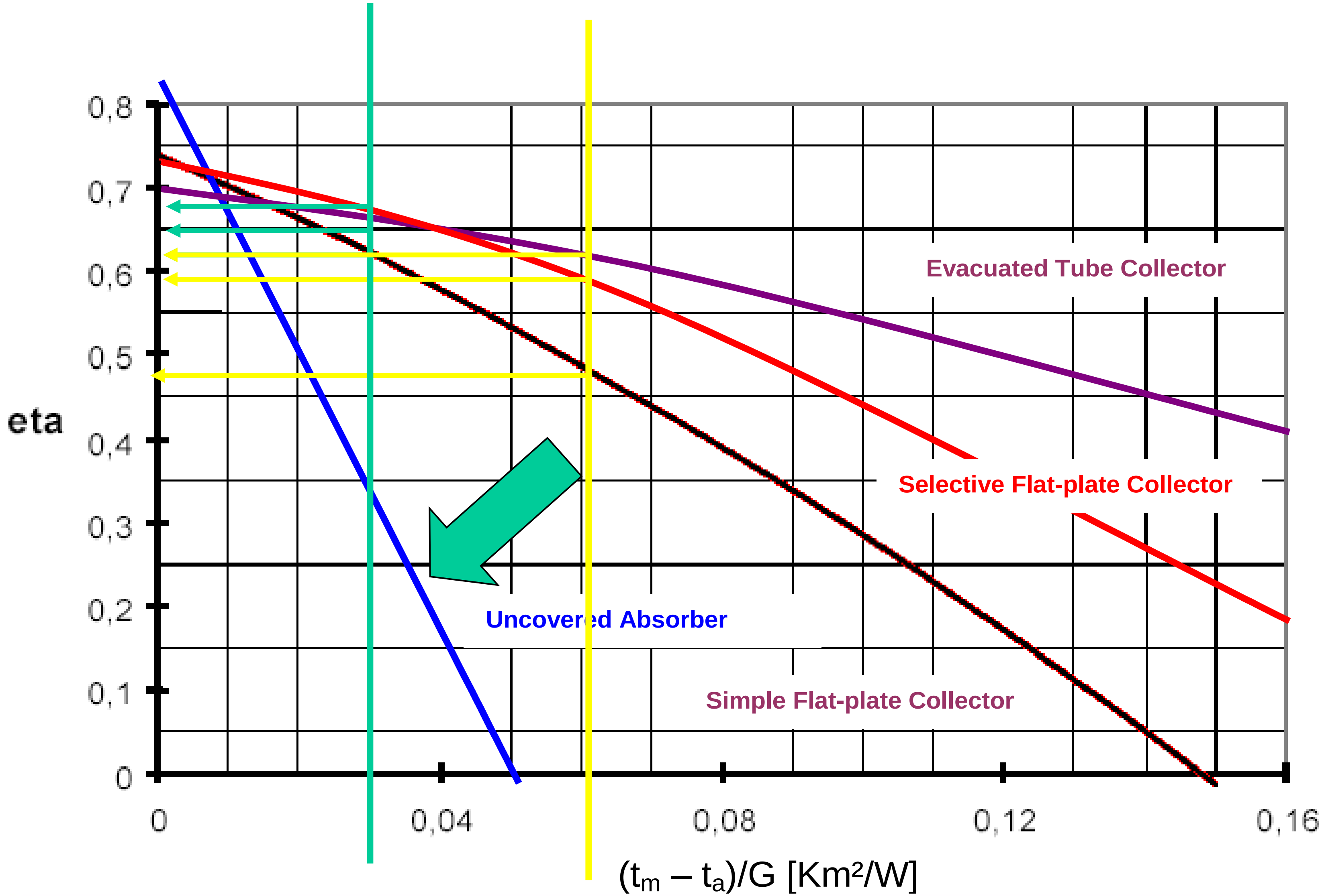
Efficiency curves for different flat-plate and evacuated tube collectors



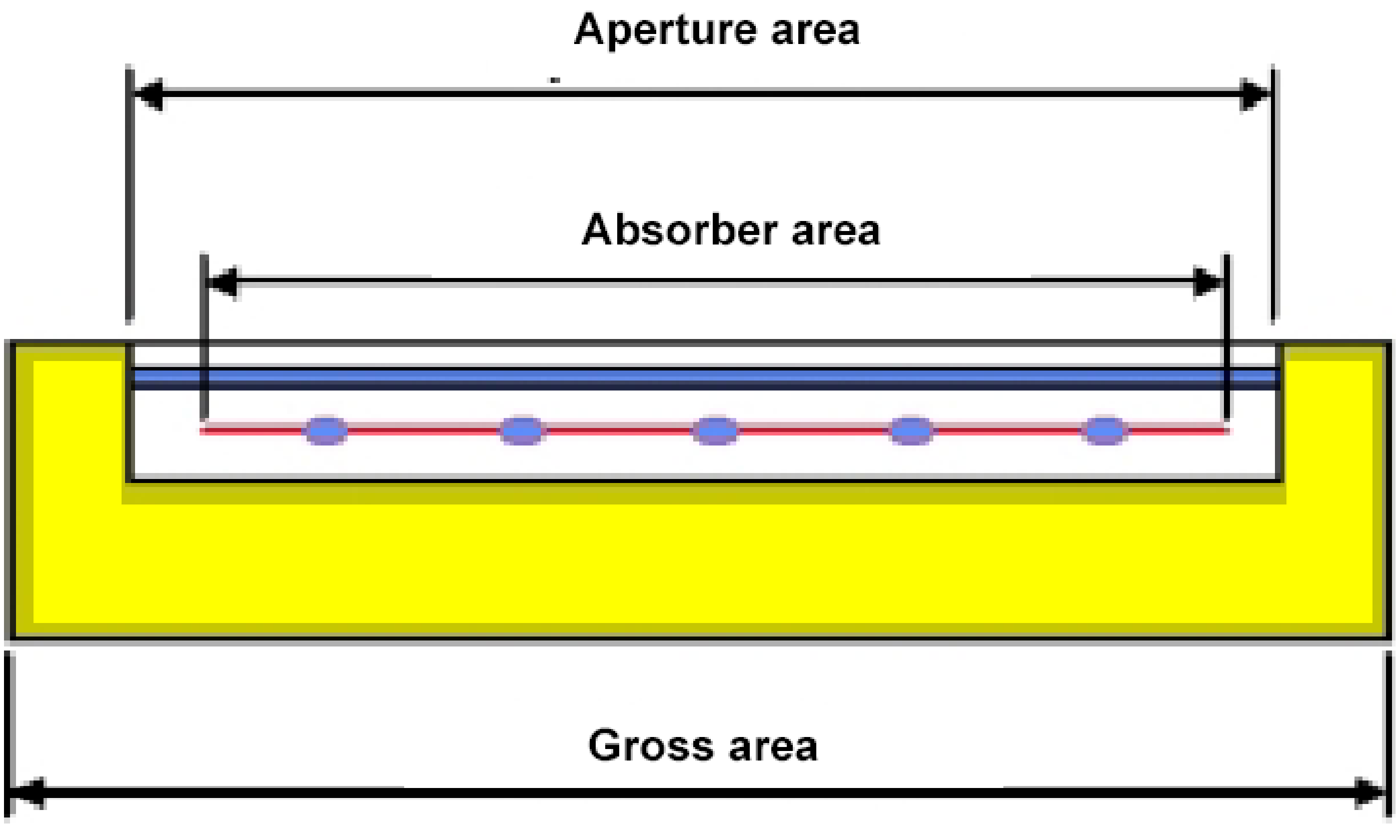
Collector efficiency curve



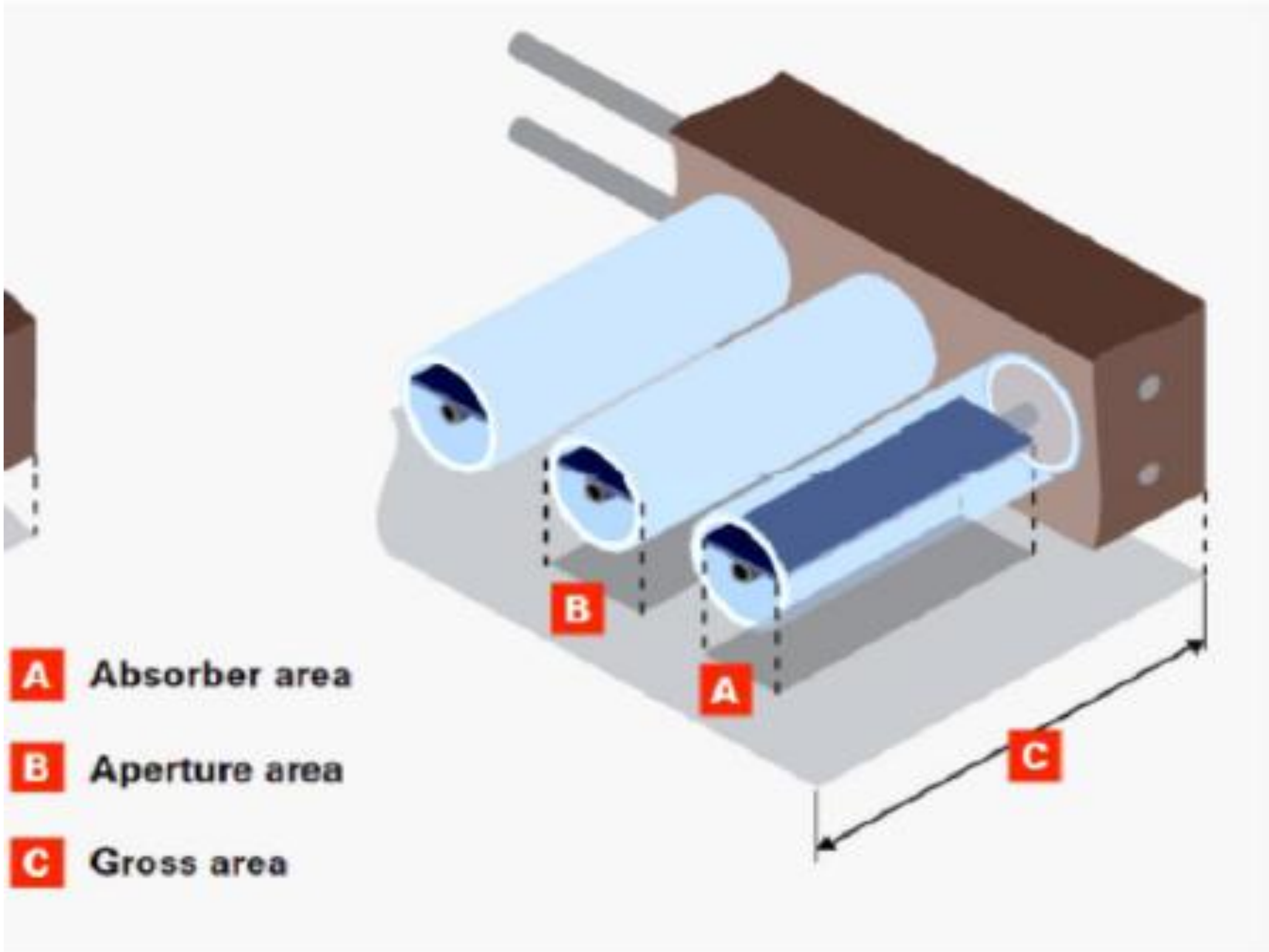
Efficiency of different collector types (calc)



Area Definitions



Area Definitions



Thank you for your attention