Components of active thermal solar systems

>> Types of collectors

Active thermal solar systems are systems in which the entered solar radiation is converted using technical equipment (collector) for heating purposes and delivered to a consumer (hot water storage tank, space heating, swimming pool). The central part of a thermal solar system is the collector. The four typically collector constructions are:

- Plastic absorber
- Flat plate collector
- Evacuated collector
- Air collectors

Plastic absorber for heating of a swimming pool

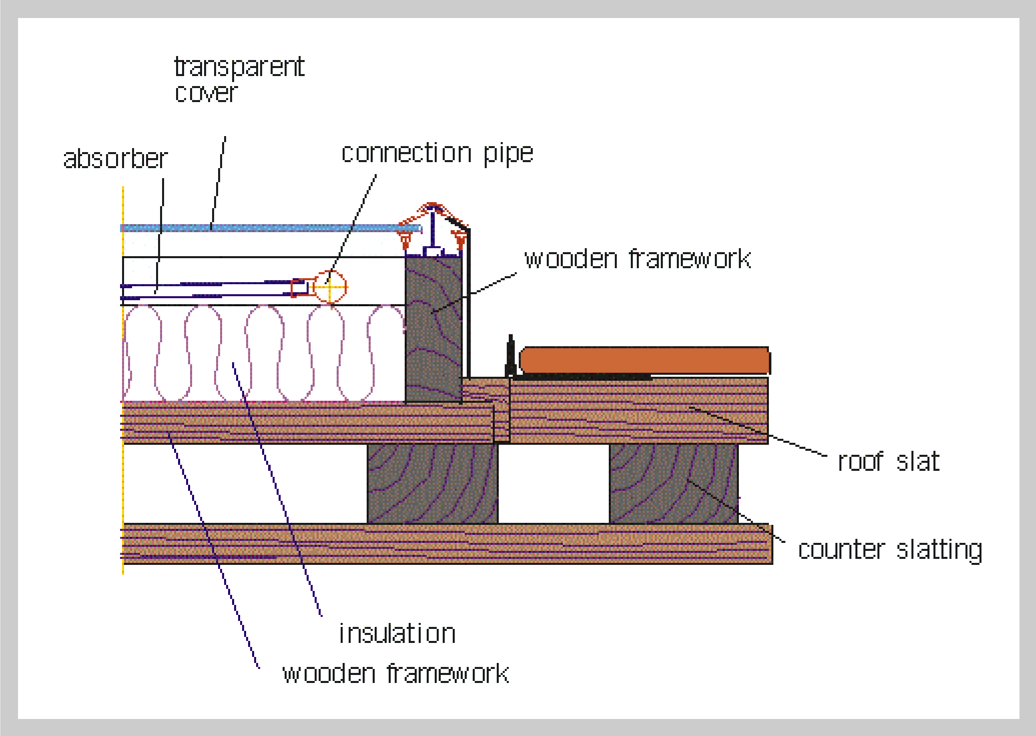
Due to their limited pressure and temperature durability, plastic absorbers are mainly used for the heating pool water. In this case, the desired temperature level is only a few degrees higher than the ambient temperature. Thus, simple plastic absorbers can usually be mounted uncovered on a flat roof or on a lawn. Since they are made entirely of plastic, they have the advantage of a single-circuit operation. The chlorinated pool water is directly pumped through the absorbers by a circulation pump and no heat exchanger is needed.

Figure 4: Plastic absorber for swimming pool heating

Flat plate collectors

The flat plate collector consists essentially of the collector box, the absorber, the heat insulation and the transparent cover.

Figure 5: Basic layout of a flat collector (assembly in roof)

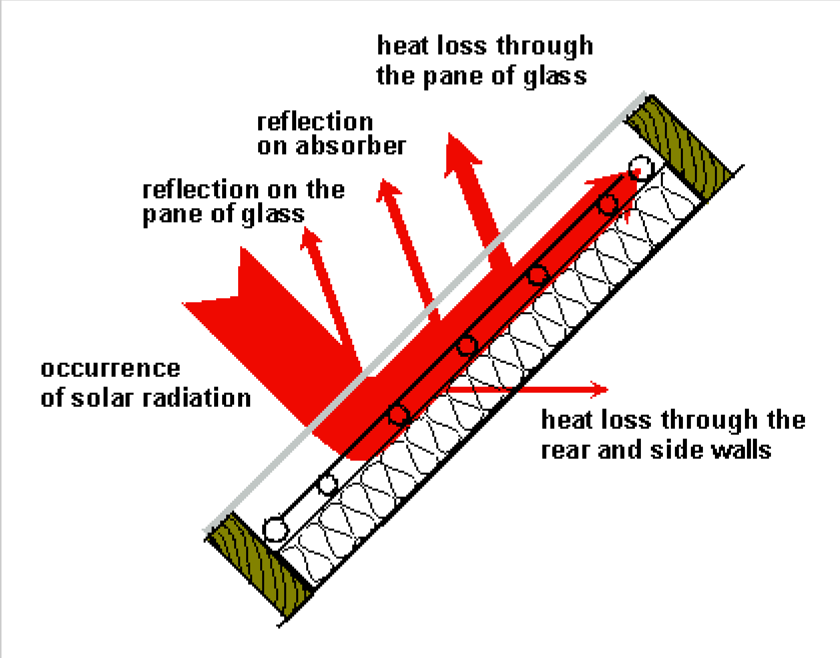


In the first instance, solar radiation hits the transparent cover of the collector. Due to reflections both on the surface and at the interface (transmission) of the cover, some of the radiation is lost for further utilisation in the collector. Depending on the type of covering, the solar radiation which strikes the absorber is almost entirely converted to heat. The coating should have a high absorptance and the lowest possible emittance. The absorption capability is characterised by the absorption coefficient * and it is mainly determined by the black colour of the absorber. The absorption coefficient for a solar coating with a solar varnish as well as for good selective covering is between 0,94 and 0,97. The emission coefficient lies between 0,86 and 0,88 for coatings with solar varnish; for selective covering it is only 0,05 to 0,20.

The covering can be applied either by spraying (in the case of a coating with a solar varnish), by galvanic means or by means of an adhesive film (in the case of selective covering). Good selective coatings are offered since 1996 where the special physical process of sputtering has been used. Compared to galvanic methods, this technique results in a much more ecologically benign covering which also requires less energy.

Heat losses are also caused as a result of convection in the collector and occur at the back side of the absorber.

Figure 6: Losses of a flat plate collector



Evacuated collectors

For technical reasons, most of the evacuated collectors are constructed in the form of tube collectors. A thin absorber strip with selective coating is closed inside an heat-resistant glass tube of great light transmitting capacity. As a result of evacuation the collector has very little convection- and heat losses.

Figure 7: Vacuum-tube collector

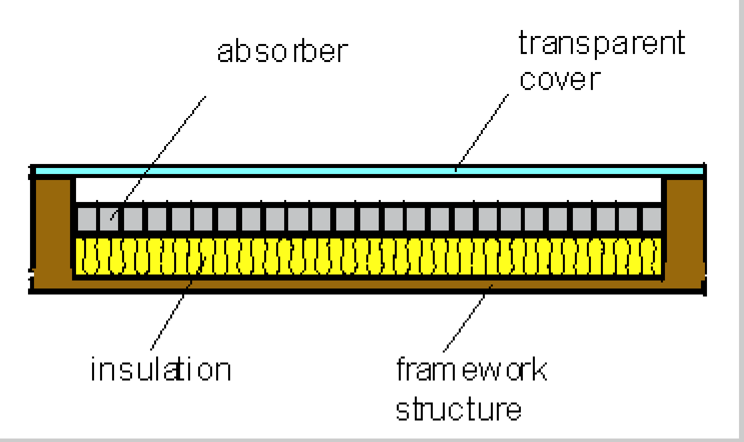
Evacuated tube collectors obtain higher yearly solar yields per square unit in domestic hot water systems than flat plate collectors. However, as a result of their higher price, market penetration is still low. In Austria, the share of the market is about 1%.

Since the excess yield from vacuum tube collectors increases quite considerably, particularly in the high collector temperature range, they are ideally suited for the production of process heat.

Air collectors

The basic layout of air collectors is the same as for flat plate collectors. They comprise the collector box, the transparent cover, an absorber and thermal insulation on the back side. When it comes to the selection of materials the same basic rules are to be observed with regard to the components and weather-resistance as for a flat plate collector. Concerning the air collectors there are basically three construction types: collectors with a downstream, upstream or wetted absorber. Wherever higher air temperatures have to be reached, constructions with back-wetted absorbers would be advantageous since the heated air is not directly in contact with the cold upper cover.

Figure 8: Principal layout of a solar air collector with a back-wetted absorber



Applications for collectors

"Contrary to the promises made by the manufacturers, there is not a best collector but rather one or several suitable products for each application" /7/. A Selection of the suitable collector for the respective application is shown in figure 9.

Figure 9: Applications for collectors

Collector construction	Valuation
A: plastic absorber for pool heating	++ very qualified
B: flat plate collector (non selective covered)	+ qualified
C: flat plate collector (selective covered)	- not qualified
D: evacuated - tube collector	
E: air collector	

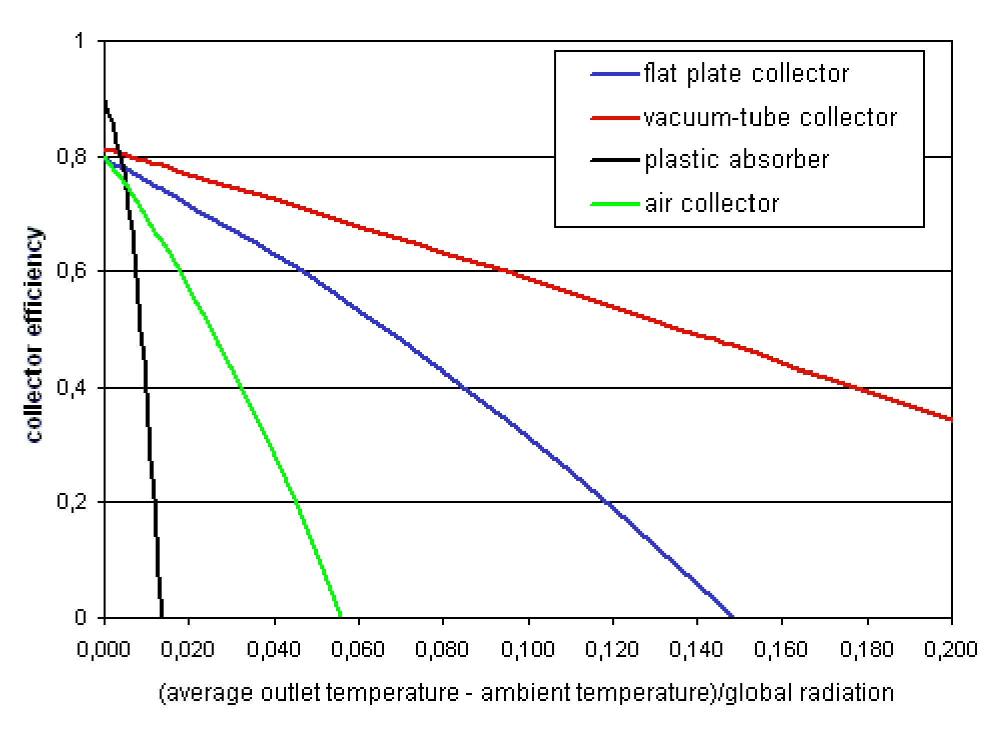
Application	A	B	C	D	E:
Pool heating for open-air swimming pool	++	+	+	-	-
Domestic hot water for single family houses	-	++	++	+	-
Domestic hot water for multiple family houses	-	++	++	-	-
Domestic hot water and space heating	-	+	++	++	+
Space heating	-	+	++	++	++

Commercial application for preheating up to 50ºC					
(hotels, campsites, indoor pools)	-	++	++	-	-
Commercial application for temperatures up to 80ºC (laundries, car wash)	-	+	++	++	-
Commercial application for process heating up to 150ºC	-	-	-	++	-

Characteristic values of flat plate collectors

The collector efficiency curve is an important physical property of a solar collector. The efficiency of a collector is defined as the ratio of the energy amount transferred from the collector to the heat transfer medium to the incident radiant energy on the collector. Especially for temperatures (heat transfer fluid) higher than 40ºC, high efficiency values are desirable for flat plate and evacuated - tube collectors. The efficiency depends on the quality of the absorber surface, the geometry of the absorber, the heat conductivity of the absorber material, the transparency of the cover and the heat losses of the collector through infrared radiation, conduction, and convection. A quantitative comparison indicates that the efficiency is particularly dominated by the radiation losses. The efficiency for a certain collector is not a fixed value, but rather it is dependent on the application, e.g. temperature levels, wind speed, etc.

Figure 10: Collector efficiency curves for various types of collectors



Conversion factor [eta]0

The conversion factor [eta]0 is defined as the maximum efficiency of a collector under the precondition that the average temperature of the heat transfer medium in the absorber equals the ambient temperature.

Heat loss coefficient k

The heat loss coefficient is the average heat loss of a collector per m² effective collector area divided by the temperature difference between the absorber and the ambient temperature.

The k-value of the collector is described by the two values k1 in accordance with the share dependent on the temperature and k2, the share that is not dependent on the temperature. The conversion factor [eta]0 of a collector should, therefore, be as high as possible and the k-value as low as possible. The collector parameters are ascertained using a standardised testing procedure conducted by an authorised test institute.