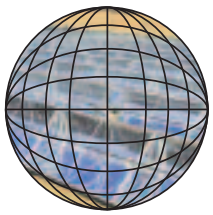


With industrial production accounting for 30% of all energy used in developed countries, and a large share of that going on heat for steam and manufacturing processes, Werner Weiss takes a timely look at the opportunities for using solar thermal heating in industrial applications.

At 30%, the industrial sector of OECD countries has the highest share of total energy use of any part of the economy, closely followed by transport. Yet because energy from fossil fuels has long been cheap and seemingly infinite, manufacturing companies have so far taken only modest steps towards replacing energy from fossil fuels with energy from renewable sources.

The use of solar energy in manufacturing and industrial processes, and to generate heat for production halls, has been limited to just a few applications. The vast majority of solar thermal collectors that have been installed world-wide, representing a total thermal capacity of around 105 GWth, are used almost exclusively for domestic hot water or for swimming pools and space heating in the residential and tourism sectors (Figure 1).[1]

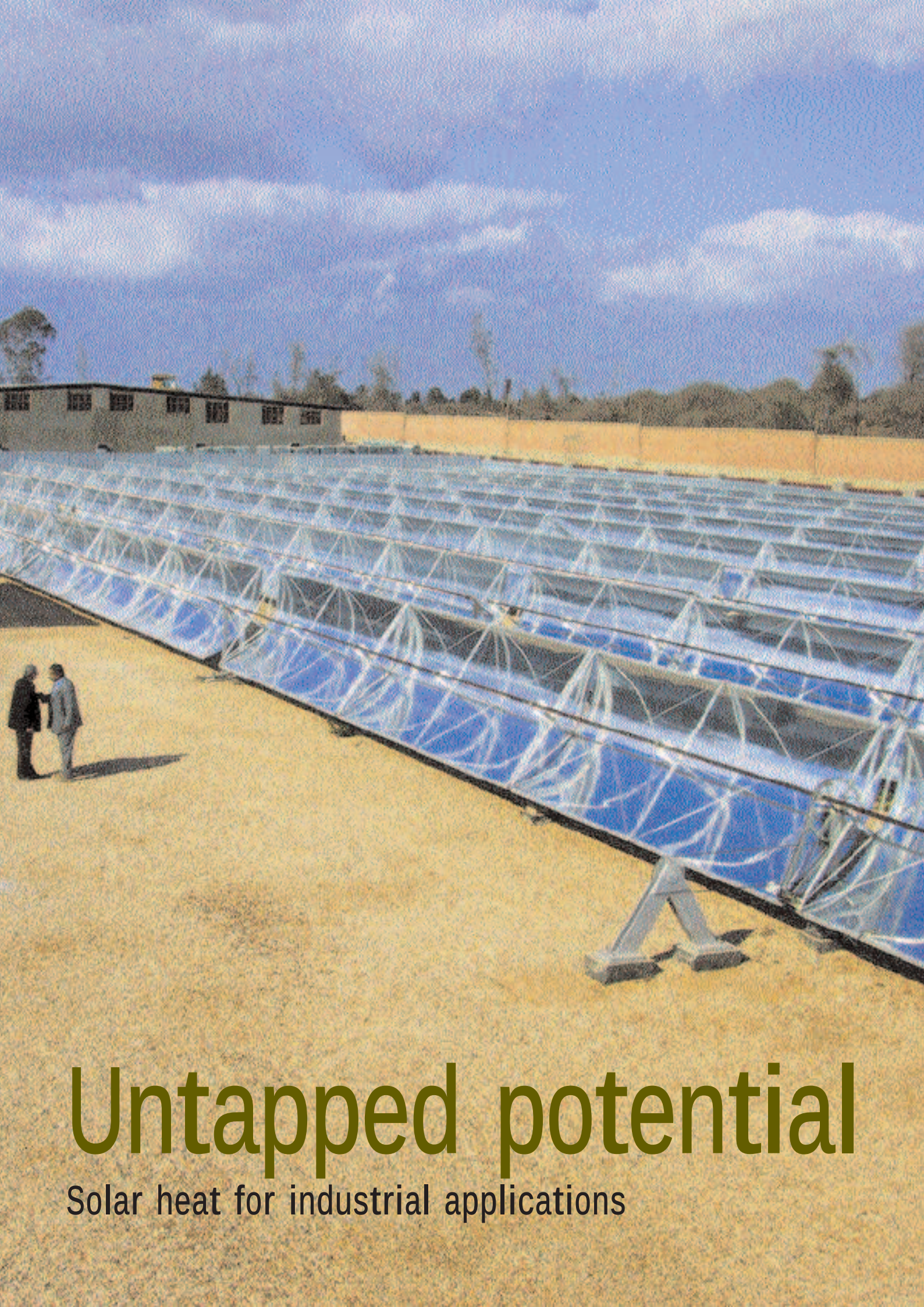
Therefore, one of the first steps for IEA Task 33/IV was to investigate the potential of solar process heat, to document existing plants and uses, and to analyse the experiences gained from these plants. Studies of the potential in three countries – Spain, Portugal and Austria – have shown that the need for low-temperature industrial heat, which could be supplied using solar heat, is around 26 PJ (technically achievable potential).[2] Even if only 5% of this potential were to be achieved in the coming years, equal to only 0.6 % of the low-temperature heat requirement of these three countries, this would require the installation of one million square metres of collectors with a capacity of 700 MWth.

INDUSTRIAL SECTORS INVOLVED AND EXISTING SOLAR PLANTS

Currently there are about 85 solar thermal plants for process heat reported worldwide, with a total installed capacity of about 27 MWth (38,500 m^2).

As Table 1 shows, the most significant potential for using

El NASR Pharmaceutical Chemicals, Egypt has an installed capacity of 1.33 MWth FICHTNER SOLAR GMBH



Untapped potential

Solar heat for industrial applications

solar heat plants is in the food and beverage industries, in the textile and chemical industries and for simple cleaning processes, such as car washes. This is due to the low temperatures required for the processes in these sectors, (usually 30°–90°C) allowing the use of flat-plate collectors, which are very efficient in this temperature range. Solar heat is used not only to provide process heat but also to heat production halls.

DEVELOPMENT OF MEDIUM-TEMPERATURE COLLECTORS

Table 1 also shows that, alongside the low temperature processes up to 80°C, there is significant potential for processes in the medium temperature range, up to around 250°C. To be able to provide heat for the whole medium-temperature range from 80°–250°C at a reasonable price, medium temperature collectors will need to be optimized and developed further. Therefore part of the work of Task 33/IV is to develop and test three categories of medium-temperature collectors.

IMPROVED FLAT-PLATE COLLECTORS

There are a number of different development possibilities for flat-plate collectors that would enable them to be used in applications between 80°–120°C. In the first instance it is essential for the thermal losses of the collectors to be reduced without losing too much optical efficiency. This can be achieved, for example, by using multiple-glazed flat-plate collectors with anti-reflective glass, or using a hermetically sealed flat-plate design where the collector is filled with a noble gas, or by the development of evacuated flat-plate collector designs.

Figure 2 shows the efficiency curves for single, double and triple-glazed collectors covered with newly developed anti-reflective glass.

CONCENTRATING FLAT-PLATE AND EVACUATED TUBE COLLECTORS

A further possibility for the development of medium temperature collectors is to reduce thermal losses in the collector by concentrating the solar rays and so reducing the required surface area. CPC collectors based on this principal are being developed in Portugal (AoSol and INETI) and Austria (Solarfocus). The concentration factor is around 2, and so no sun-tracking devices are needed. The diagram on the top-right of page 74 shows the construction of a collector made by Solarfocus, Austria, in which the absorber fins, which absorb on both surfaces, are mounted in reflector troughs perpendicular to the aperture opening.

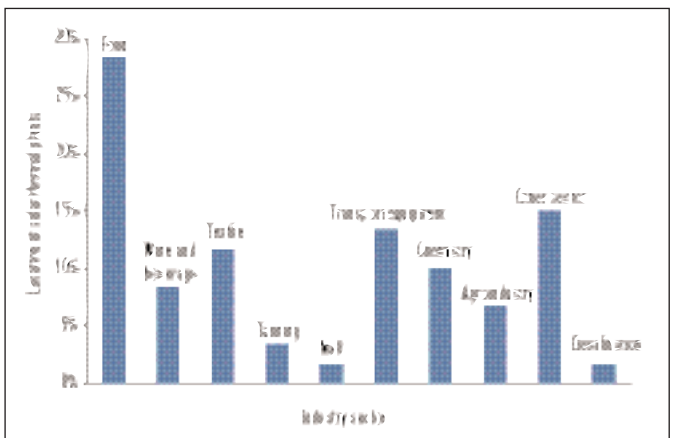


FIGURE 1. **Distribution of the documented solar thermal plants across different industrial sectors**

TABLE 1. Industrial sectors and processes with the greatest potential for solar thermal uses

Industrial sector	Process	Temperature level (°C)
Food and beverages	drying	30–90
	washing	40–80
	pasteurizing	80–10
	boiling	95–105
	sterilizing	140–150
	heat treatment	40–60
Textile industry	washing	40–80
	bleaching	60–100
	dyeing	100–160
Chemical industry	boiling	95–105
	distilling	110–300
	various chemical processes	120–180
All sectors	pre-heating of boiler feed water	30–100
	heating of production halls	30–80

SMALL PARABOLIC TROUGH COLLECTORS

For collector circuit temperatures of 150°–250°C in particular, it is interesting to consider more highly concentrating collectors. These, however, can no longer be mounted in a fixed position but require a one-axis tracking mechanism. At present, seven concentrating collectors are in development.

Further information on these developments can be found in the brochure 'Medium Temperature Collectors', available on the internet at www.iea-ship.org/3_1html.

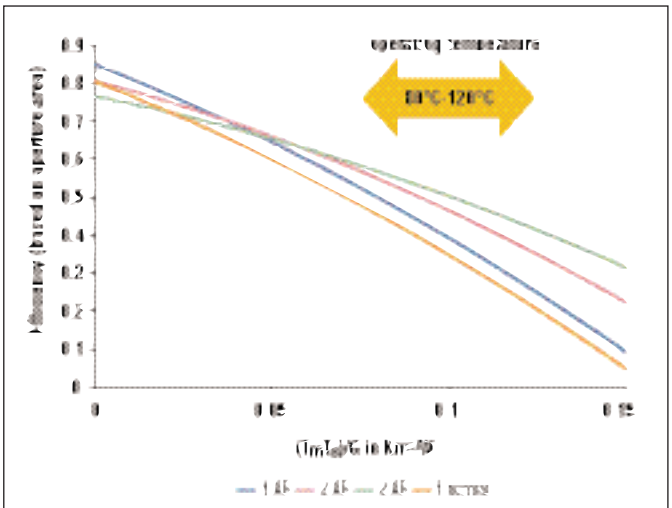


FIGURE 2. **Comparison of the efficiency curves for a standard flat-plate collector (normal solar glass) and the curves for single, double and triple- anti-reflective (AR) glazed collectors (G=800 W/m²). Source: M. Rommel, Fraunhofer ISE.**

ABOVE Testing of two PTC 1000 modular parabolic trough collectors at DLR in Germany. In these tests the collectors are installed on a tilted testing platform so that the effect of end-losses are eliminated ABOVE RIGHT Solar-heated production hall and office building DOMA

INTEGRATION OF SOLAR HEAT INTO INDUSTRIAL PROCESSES

The fact that solar plants used to produce process heat can easily achieve a capacity of several hundred kilowatts up to several megawatts represents a new challenge to system technology – in particular the standstill behaviour of the plant, since it is likely that the heat produced may not be used at weekends or during company holidays.

A further challenge is the integration of solar heat into the industrial process itself. When solar thermal energy is used, the temperature of the available heat and the variability of solar energy must be considered, as well as the heat profile required by the industrial process.

To rise to these challenges, the Task team developed more than 20 system concepts to suit the requirements of the different energy carriers (air, water-glycol, pressurized water or steam), the temperature levels and the process to be supplied with heat. These concepts are currently being trialled in demonstration plants.

PILOT AND DEMONSTRATION PLANTS

Three system concepts (generic systems) of the 23 that have been identified in the framework of Task 33/IV are described below. They show different characteristics in terms of collector types, heat carrier, temperature level and application.

Space heating of production halls

In contrast to other buildings such as offices and apartments, production halls are very tall, often 5–10 metres, and usually require a relatively low room temperature of 15°–18°C. The lower temperature requirements and simple systems that can be used for the heating of production halls together are ideal conditions for the use of solar thermal energy, and open up a

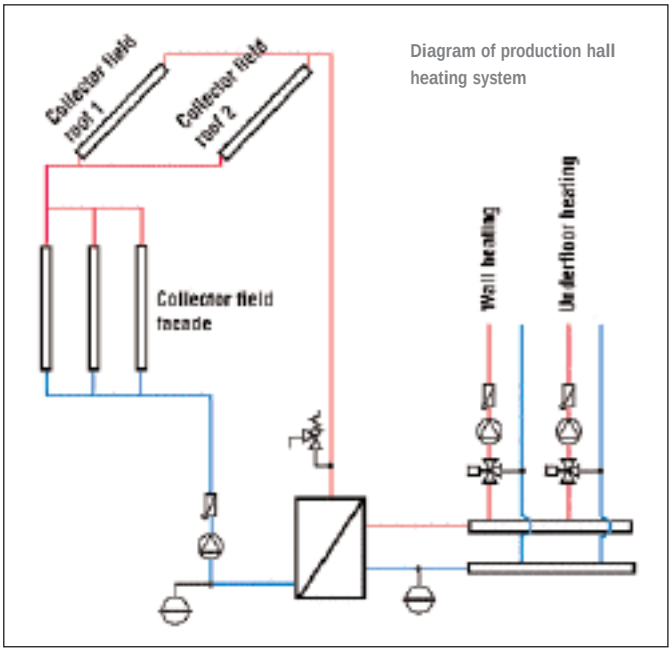


Diagram of production hall heating system

significant potential use in the industrial sector. In recent years many industrial spaces have been built, particularly in Austria, that are heated completely or partially using solar energy.

All of the documented spaces use underfloor heating systems to introduce heat to the space. These have the advantage of a low flow temperature and the additional advantage that the mass of the foundation can be used as a heat reservoir.

The solar collectors are often mounted on, or integrated into, the facade. In this arrangement the collectors fulfil multiple functions simultaneously, as a weatherproof facade, energy converter and as insulation (due to the rear insulation of the collector). Since the solar collectors are generally used for heating purposes, and since the hot water requirements of production halls are usually minimal, facade collectors are well oriented towards the winter sun.

The capacity installed in the halls built to date is between 60–150 kW_{th}. The percentage of each hall's total energy supplied by the solar installations lies between 20%–100%.

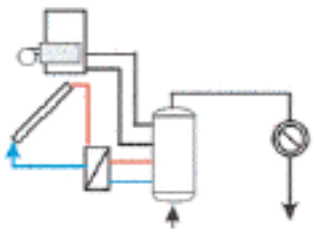
Washing processes

Cleaning processes are mainly applied in the food industry, the textile industry and in the transport sector. For cleaning purposes hot water is needed at a temperature of 40°–90°C. Because of the temperature range, flat-plate collectors are recommended for this application. The system design is quite similar to large-scale hot water systems for residential buildings, since they work in the same temperature range and the water is drained after usage. Concerning the hot water loop, it is an open system, with heat recovery usually not feasible.

Typical applications are washing processes in the food industry, such as feed water for bottle-washing machines, as well as washing processes in the textile industry and in the transport sector.

One of the first demonstration systems of Task 33/IV was realized in the transport sector.

Contank (Parking Service Castellbisbal S.A., Castellbisbal (Barcelona) Spain) is a company, which concentrates on the cleaning of containers used to transport liquid goods by rail.



Washing processes with open hot water loop – generic system concept

The major heat-consuming process in the company is washing, which uses heat in the form of hot water at 70°–80°C (approx. 46% of the total heat requirement) and steam (the remaining 54%). The company requires 70–80 m^3/day hot water. The conventional system for the preparation of hot water is a gas-fired steam boiler.

The solar thermal system at Contank consists of two solar fields with selective flat-plate collectors and a total peak heat capacity of 360 kWth (with a net absorber surface of 510 m^2) and a 40 m^3 unpressurized storage tank.

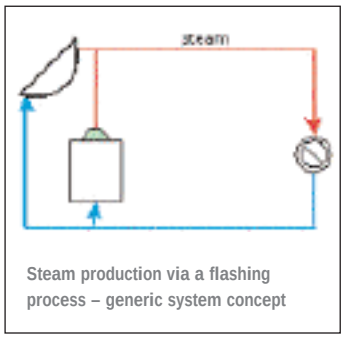
The yearly net heat production is 429 MWh (588 kWh/kWth) and solar energy makes up 21.55% of all energy used. If the gas price is assumed to be €25/MWh based on the calorific values, this results in an annual cost saving of €14,300. Taking into account maintenance costs, pay-back will be achieved in approximately 10 years.

ABOVE Parking service Castellbisbal SA, container washing, Barcelona, Spain. Installed capacity: 357 kWth AIGUASOL ENGINEERING

Even greater potential is anticipated in dairies. The capacities of solar thermal plants in this sector are in the order of 1–10 MW_{th}. This is indeed the case for one of several existing plants in Greece. The solar thermal plant at the Tyras dairy in Trikala has an installed capacity of 730 kW_{th} (1040 m^2). The average yearly production of the facility is 700 MWh meaning that solar heat makes up 7% of the total heat requirements. The total investment in the plant was €172,500, which is equivalent to €116 per kW_{th} of installed capacity. Thanks to grant funding, which covered 50% of the costs, the short amortization time required by the industrial sector was achieved.

Distilling and chemical processes

For industrial processes where temperatures between 120°–250°C are needed, concentrating solar collectors, such as parabolic trough collectors, must be used. The heat carrier in these systems is either pressurized hot water or steam.



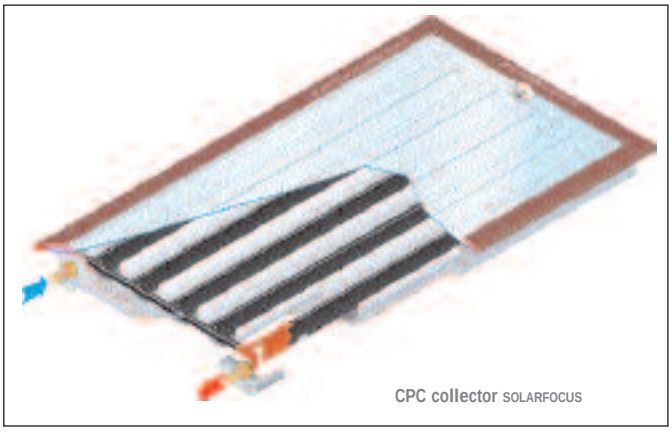
Steam production via a flashing process – generic system concept

The Egyptian New & Renewable Energy Authority (NREA) issued an international tender to build a 1.3 tonne/hour pilot solar steam plant using parabolic trough collectors at a site just outside Cairo. The project was financed by the African Development Bank.

The plant's 144 parabolic concentrators are arranged in four parallel loops providing a net reflective area of 1900 m^2. The steam is produced by the reduction of the water pressure in the collector loop, via a flashing valve and is delivered to an existing saturated steam network operating at 7.5 bar.

CONCLUSION

While the industrial use of solar thermal heat is effectively in its infancy, there is huge potential, particularly for low temperature needs. The technology is available, and by comparison to many of the renewable electricity systems, cheap and easy to install. Greater research in medium and high temperature ranges will increase the efficiency and range of industrial applications in which solar thermal energy can be used, leading to savings for business, and significant reductions in harmful emissions.



CPC collector SOLARFOCUS

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IEA TASK 33/IV

Task 33/IV is a collaborative project of the Solar Heating and Cooling Programme and SolarPACES initiative of the International Energy Agency (IEA) involving 16 institutes and 11 companies from eight countries. The aim of the project is to develop solar thermal plants for industrial process heat. To achieve this, studies of the potential are being carried out for the countries involved, medium-temperature collectors developed for the production of process heat up to a temperature of 250°C, and solutions sought to the problems of integrating the solar heat system into industrial processes. In addition, demonstration projects are being realised in cooperation with the solar industry. Knowledge is transferred to industry via an annual industry newsletter and by holding relevant conferences.