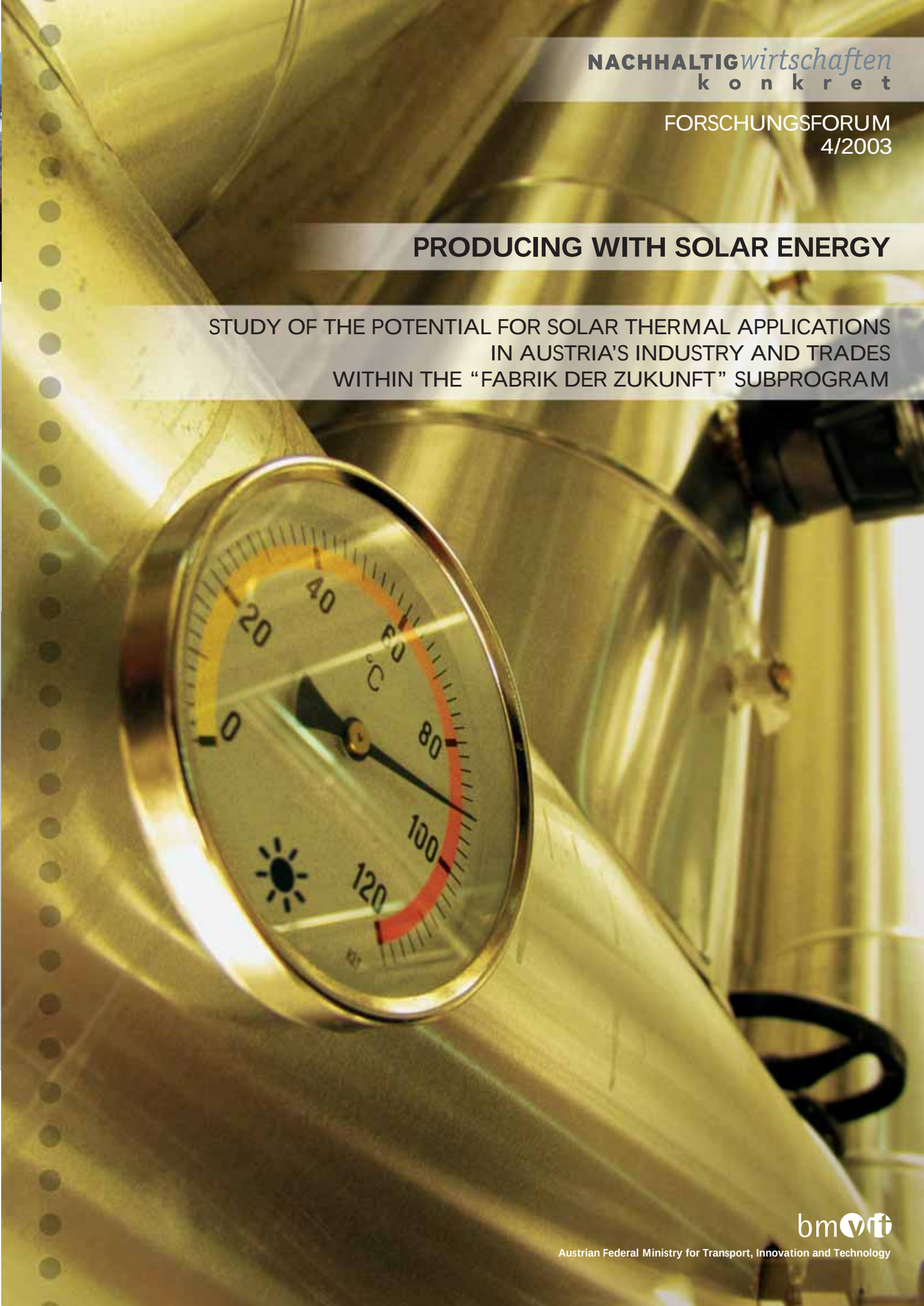

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4/2003

PRODUCING WITH SOLAR ENERGY

STUDY OF THE POTENTIAL FOR SOLAR THERMAL APPLICATIONS IN AUSTRIA'S INDUSTRY AND TRADES WITHIN THE "FABRIK DER ZUKUNFT" SUBPROGRAM

bmvit
Austrian Federal Ministry for Transport, Innovation and Technology

THE USE OF SOLAR THERMAL ENERGY IN THE INDUSTRIAL SECTOR: RESEARCH AND PRACTICAL EXAMPLES

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In addition to the improvement of energy efficiency the use of renewable sources of energy constitutes an important strategy towards a ***sustainable economy***. One such future-oriented technology consists in the thermal use of solar energy, which, so far, has – almost exclusively - been applied for hot water supply and space heating in single- and multi-family homes.

However, a large share of the overall energy demand is attributable to the industries and trades, too; in the EU the proportion amounts to some 30%, and in Austria the industry also has the greatest share in the overall energy demand (269 PJ). As a considerable portion (30%) of the energy used in the industrial sector is low temperature heat, the use of solar thermal energy for process heat and space heating should be feasible. However, this field of application has not yet been opened up, nor has it been investigated systematically, so far.

The "Arbeitsgemeinschaft Erneuerbare Energie" (Working Group Renewable Energy), in cooperation with Joanneum Research (Institut für nachhaltige Techniken und Systeme) conducted a new study within the "Fabrik der Zukunft" subprogram. This study aimed to identify the potential for the use of solar energy in the industrial sector and to gather relevant information and findings and to present these as a basis for decision making in enterprises. The study identified manufacturing processes and industrial sectors for which the use of thermal solar energy is a technically and economically feasible option. This approach is to further the development towards a sustainable economy.

The study focused on the following **key tasks**:

- Documenting examples of the successful use of solar thermal installations in the industry and trades
- Systems analyses for the integration of solar heat in production processes
- Working out system concepts for solar space heating in machine shops
- Identifying the potential for solar heat supply in production processes and for space heating in machine shops
- Case studies that encourage the realization of demonstration plants

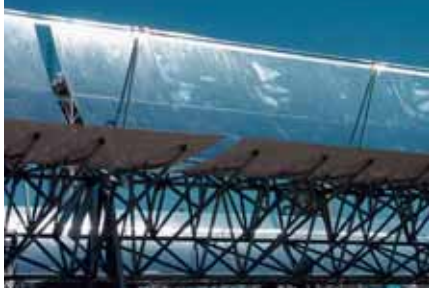
The method used in the study consisted in first establishing and documenting the energy demand in the low temperature range for Austria's industry and trades. Relying on these findings the study ascertained to what extent and under what conditions heat in the low temperature range can be supplied by means of solar installations.

Austrian and international publications were used to identify industrial sectors with a high energy demand in the low temperature range and to document existing installations in this country and abroad. The analysis of a questionnaire survey among Austrian enterprises confirmed the results of the first phase of the study. On account of the lively interest in the enterprises it was possible to realize six case studies, which demonstrated the potential for solar process heat generation using concrete examples. The results of the case studies were to provide enterprises that consider investing in a thermal solar installation with a basis for decision-making. One new installation ("SunWash" in Köflach, Austria) was realized on the basis of a case study and has been in operation since October 2002.

*In 1999, the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) launched the research and technology program **"Nachhaltig Wirtschaften"**, which aimed to effectively stimulate a restructuring process towards sustainability. Various research and development projects as well as demonstration and diffusion measures, which give new impetus to innovation in Austria's economy have since been supported within the scope of a number of subprograms.*
*The **"Fabrik der Zukunft"** subprogram aims to encourage trend-setting pilot projects in the field of sustainable technology development. Examples include innovative manufacturing processes and future-oriented product development and enterprises. Innovative development should focus primarily on the fields "technologies and innovation in production processes", "use of renewable raw materials", and "products and services".*

THERMAL SOLAR APPLICATIONS IN THE INDUSTRIES AND TRADES

Industrial Sectors and Production Processes – Potentials – System Concepts



© Eurotrough – Plataforma Solar de Almeria, Parabolic Trough Collector

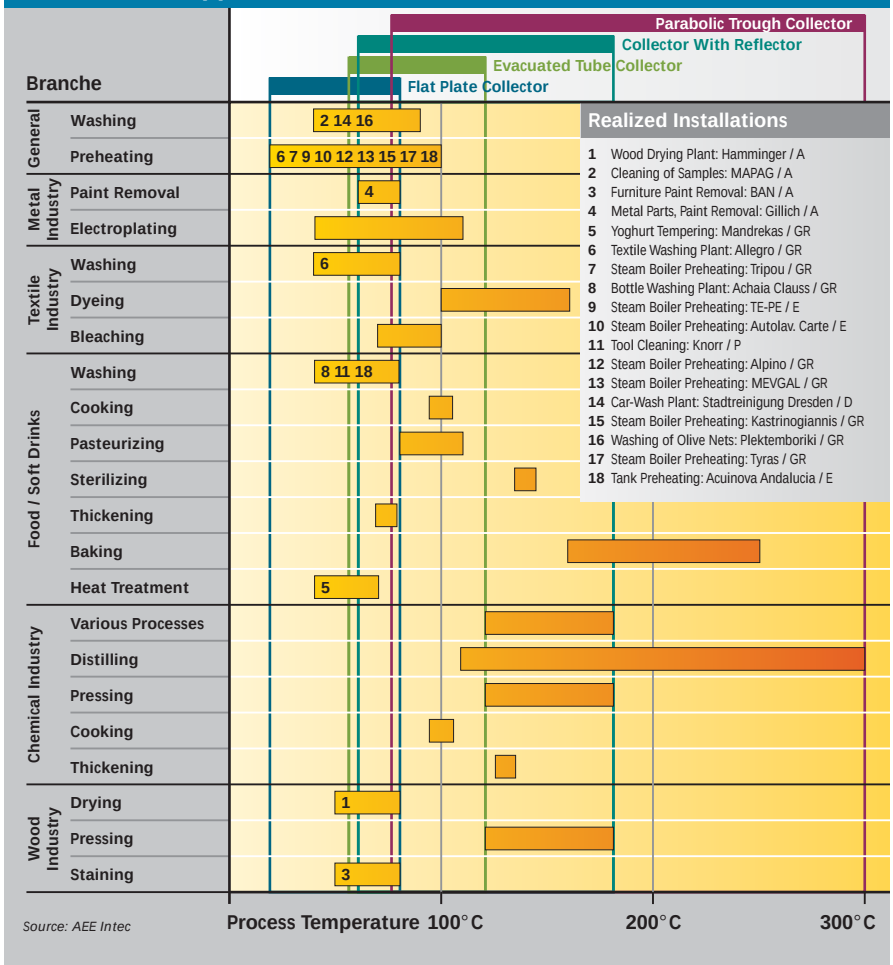
■ One important objective of the study consisted in identifying ***production processes and industrial sectors*** that are suitable for thermal solar energy applications. An essential parameter for the use of solar technologies in the industrial sector refers to the temperature range of the processes involved. Solar installations currently available on the market are able to supply energy in the low temperature range; flat-plate collectors, which can operate in a range up to 100° C are most common at present. Solar technology can, however, also be used in a temperature range of up to 250° C. These applications require collector types such as evacuated tube collectors, collectors with reflector, and parabolic trough collectors (the latter still need further development).

A great part of the industry's energy demand comes from low temperature processes, i.e. in the 20° C to 250° C range. In order to be able to assess the potential for the use of solar heat in the industry and trades it is, therefore, important to establish the energy demand for space heating and for process heat in this temperature range.

Investigations have shown that the food and soft drink industries, the textile, chemical, and wood processing industries, in particular, use low temperature processes, which could rely on solar systems for energy supply. Industries that require process heat in the high temperature range above 300° C were not included in the study.

The figure below shows the most important applications for solar process heat including temperature ranges and suitable collector types. The figure also indicates the existing installations documented in the study.

Process Heat Applications (Suitable Thermal Solar Collectors and Realized Installations)



Source: AEE Intec

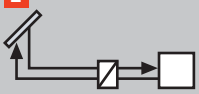
The examples use solar installations primarily to preheat boiler feed water. Other frequently used applications include washing processes and drying of various materials such as wood or foodstuffs. The process temperature involved in these applications ranges from 25° C to max. 80° C; flat-plate collectors are commonly used in these installations as they demonstrate good efficiency ratings in the temperature range up to 80° C. There is only limited experience for processes in the higher temperature range (up to 250° C); in this field there is need for further research to develop suitable concepts for the integration of solar technologies and the use of different collector types.

In 1997, the end-use energy demand for process heat, space heating, and cooling in the industrial sectors investigated in the study (food, textile, and chemical industries) amounted to 28,5 PJ/yr, which corresponds to 11.0% of the overall end-use energy need of the Austrian industry. While the other sectors have less potential for solar process heat, they show a substantial energy demand for space heating and cooling, which amounts to some 14 PJ/yr.

In ***assessing the potential*** for solar applications researchers departed from realistic assumptions, which also included measures aiming at improved energy efficiency and higher solar fractions. **The potential for solar thermal energy for industrial processes up to 100° C would require a total collector area of 2.5 million square meters.** For applications involving higher temperatures up to 200° C the requisite collector area would be as much as 4.2 million square meters.

Comparison of System Concepts

Source: AEE Intec

System	Solar Fraction	Storage Tank	Type of Process	Process Heat Demand	Heat Transfer Medium	Collector Type
1  Direct heat transfer	Low	No	Continuous	Always much higher than solar gain	Air Water, Process Medium Steam	Air Collector Depending on Process temperature Parabolic Trough Collector
2  Indirect heat transfer	Low	No	Continuous	Always much higher than solar gain	Primary: water or water/glycol or heat transfer oil Secondary: air, water, steam, process medium	Depending on process temperature
3  Direct heat transfer with storage	High	Yes	Batch-wise, continuous	Usually equal to or higher than solar gain	Primary: water or water/glycol or heat transfer oil Secondary: air, water, steam, process medium	Depending on process temperature

SYSTEM CONCEPTS FOR THE INTEGRATION OF THERMAL SOLAR INSTALLATIONS

Before planning a solar installation for the supply of process heat it is necessary to analyze the currently used method of heat generation of an enterprise. Planners should work out a comprehensive concept that also highlights possible improvements in energy efficiency. Sizing of the solar installation can then be adapted to the improved energy situation in the enterprise. As a rule, industrial production is not possible without the support of a conventional heating system. A thermal solar system can considerably reduce the primary energy demand of a process, but complete coverage by means of a solar system will be possible only in rare cases.

Several ***different approaches*** can be used for the integration of a thermal solar installation into a conventional heating system. Important aspects in this context refer to how the solar system is integrated into the existing heating system, to the method of heat transfer to the process, and to sizing of the solar installation. Air, water or steam can be used as heat transfer medium in industrial processes.

Basically, we can differentiate between open and closed systems. While in open systems all of the process water is heated and subsequently leaves the plant as wastewater, it is recovered in closed systems. Solar heat may be used at different points of the system (hot water system, preheating of cold water supply or process medium return).

Concerning the type of heat exchange we differentiate between systems with or without storage tank. In the simplest system **1** the process medium flows directly through the collector where it is heated; this method can be used only with non-corrosive media and when there is no danger of freezing.

The dual circuit system **2** uses a solar circuit with a water/glycol mixture, which transfers heat to the process circuit via heat exchanger. The advantage of this system is that it can be also operated in freezing conditions and with corrosive media or other media than water in the secondary circuit.

The technically most intricate system relies on indirect heat exchange and uses a storage tank **3**. The benefit of this concept lies in the fact that heat can be stored and is available in periods of low insolation. This system is suitable for discontinuous processes as heat storage provides for additional energy gains. This also increases the fraction of solar energy supply, but, on the other hand, also causes higher investment costs.

Another aspect in planning a solar system refers to sizing. If a solar installation contributes only a small fraction of the required overall energy demand, all solar gains should be used for the process. This concept should be used for continuous processes and if the current heat demand exceeds the gains from solar energy. A system with a high fraction of solar energy is the best choice for discontinuous processes as this approach permits to use solar gains generated during down times of the plant as well.

In any case, the decision for one of the various system concepts has to be based on a calculation of economy. This analysis should also be the basis for choosing the method of heat transfer unless technical reasons forbid the selection of one of the system concepts.

CASE STUDIES

Case Studies
in Austrian Enterprises

■ Six Austrian enterprises were included in case studies, which aimed to investigate the possibility of using solar energy to supply heat for production processes and to prepare suitable system concepts. By varying collector field sizes and storage tank capacities in their calculations, researchers identified the most economical solution for each application. The results from the case studies were submitted to the companies and are to be used as a basis for the decision-making process in enterprises.

An important task in the case studies consisted in establishing the heat demand profile for each process, i.e. the distribution of the overall energy demand along a day, week, month, and year, respectively. In most cases it was necessary to calculate the current heat demand because the companies only had data referring to the annual energy consumption. All basic data were entered in a simulation program developed for the sizing of solar thermal installations (T*Sol 4.0), and different solutions with varying collector sizes, storage capacity, and system concepts were analyzed.

Comparison of the variants and recommendations concerning a certain system were based on an economy calculation, which, in most cases, departed from achievable costs for heating. Another method consisted in comparing possible payback periods. In addition, researchers investigated options of heat recovery and improvement of energy efficiency in order to achieve an overall reduction of the energy consumption in the enterprise. All calculations assumed a service life of 20 years for the system, operating costs were set at 1% of investment costs, and a 30% subsidy for the investment granted by Kommunalkredit AG was taken into account for calculations.

The table below shows the results of four (out of a total of six) ***case studies***:

The case studies document possible technical applications for solar thermal systems in the industrial sector and demonstrate that integrated concepts can yield economically feasible solutions. If a concept for the integration of a solar thermal system also includes measures for the improvement of energy efficiency, the achievable heating costs are comparable to those associated with conventional fossil fuels.

® Sonnenkraft Vertriebs GmbH, Evacuated Tube Collector

Source: AEE Intec

Results Of The Case Studies

	1 Körner KvK	2 SunWash	3 S&W	4 Beerenfrost
Energy Demand	48,000 kWh/yr	52,500 kWh/yr	93,350 kWh/yr	32,900 kWh/yr
Solar Energy	31,240 kWh/yr	13,350 kWh/yr	23,870 kWh/yr	29,100 kWh/yr
Solar Share	45 %	26 %	23 %	85,6 %
Saving Energy Source	8,550 m^3/yr Natural Gas	1,600 l/yr Light domestic fuel oil	2,390 l/yr Light domestic fuel oil	4,850 l/yr Light domestic fuel oil
CO_2 Saving	17,090 kg/yr	4,540 kg/yr	6,350 kg/yr	13,800 kg/yr
Collector Area	60 m^2	30 m^2	40 m^2	100 m^2
Storage Capacity	10 m^3	1 m^3	7 m^3	2x 9 m^3 1x 2 m^3
Heat Price	0.038 €/kWh	0.039 €/kWh	0.042 €/kWh	0.042 €/kWh

1 Körner KvK – Wies Eibiswald

Production of epoxy resin composite boards / curing process at 35° C

The energy demand of this plant can be reduced from currently 110,000 kWh/yr to 48,000 kWh/yr by modifying the manufacturing process (which would require only minimal financial investment). This possible reduction has already been considered for calculations. Installing the recommended solar system would afford an additional saving of primary energy of 31,240 kWh/yr. The comprehensive solution thus reduces the primary energy demand by 72%.

2 SunWash – Köflach

Car washing plant / hot washing at 60° C

(For further information see page 6)

3 S&W Umwelttechnik – Klagenfurt

Production of concrete slabs / concrete mixing at 20° C

This company will need a new hot water boiler as the existing hot water system permits constant quality in production only during a part of the workday. A combination using a new storage tank and a solar thermal system would reduce fuel oil consumption and ensure improved product quality all day long.

4 Beerenfrost – Lieboch

Plastic crate washing plant / hot water at 40° C

In this case, a solar thermal system could cover the hot water demand for the washing process in summer and part of the space heating load in the cold season. A buffer storage tank, a boiler for space heating, and a floor heating system have already been installed in this company, so the only investment necessary here would be the installation of a collector field.

SUCCESSFUL IMPLEMENTATION OF THE "SUNWASH" PLANT IN KÖFLACH

Departing from the case study, "SunWash" company in Köflach, Austria installed a solar system with a collector area of 40 m^2 to support the hot water supply for a carwash plant.

The analysis performed for the case study was based on consumption data, specifications, and plans of the plant. The newly built plant consists of 5 washing bays and a control room and is situated close to a shopping center. The washing cycle with detergent requires hot water at a temperature of 60° C; the subsequent rinsing cycle uses cold water. In order to avoid drying spots on the cars, the cold rinsing water is softened by means of reverse osmosis. A floor heating in the bays prevents icing of the floor in winter.

The original plan was to cover the energy demand for hot water and floor heating by means of an oil-fired boiler. In the course of the study, however, researchers also discussed coupling the plant to the local biomass district heating system as well as the installation of a solar system. The biomass district heating facility also serves the space heating system of the neighboring shopping center.

Finally, researchers compared two variants of a central solar hot water system with different fractions of solar derived energy supply concerning technical data, yields, investment costs, energy saved, and payback periods. From an economic point of view there was the advantage that this was a completely new installation and, therefore, overall costs and payback time would be only marginally higher through the addition of a solar system.

In the end, the study authors succeeded in convincing the operators to realize the proposal and to install a system using heat from the local biomass district heating system in combination with a solar system instead of the originally planned oil-fired boiler. This solution enables the enterprise to cover the heat demand of the carwash plant by means of completely CO_2-neutral methods, i.e. without the use of fossil fuels. This project, which has already been implemented, demonstrates that the use of solar systems for the generation of process heat is feasible even from the perspective of hard economic facts. On account of the successful implementation the operator is currently planning to set up two new plants in Gratkorn near Graz this year.

® AEE Intec / Carcleaningfacility „SunWash"

FIGURES / DATA / FACTS

PROJECT SPONSORS

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Thomas Müller, AEE INTEC, Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Institut für nachhaltige Technologien, Gleisdorf 2003, in cooperation with JOINTS (Joanneum Research, Institut für nachhaltige Techniken und Systeme, Prof. Hans Schnitzer)
Commissioned by the bmvit within the "Fabrik der Zukunft" subprogram

INFORMATION PUBLICATIONS

The final report on the above-mentioned study has been published in issue 1/2004 of the bmvit series "Berichte aus Energie- und Umweltforschung" ("Reports on Energy and Environment Research") and is available from:
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