SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Technology Position Paper

Solar Heat Integrations in Industrial Processes

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Contents

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This position paper explains the relevance, potential, and the present status of the development and market of Solar Heat for Industrial Processes (SHIP), leading to actions needed to further and best exploit. It addresses policy and decisionmakers as well as influencers and aims to present high-level information as a basis for uptake and further development of SHIP.

1 Introduction and Relevance

Solar Heat for Industrial Processes (SHIP) is at the early stages of development but is considered to have enormous potential for solar thermal applications. The industrial sector accounts for approximately 30% of the total energy consumption in OECD countries. And, the major share of the energy needed in this sector is used for heating and cooling buildings and production processes at temperatures from ambient up to approximately 350°C. This is a temperature range that can be addressed with solar thermal technologies.

The first applications were experimental and relatively small scale. In recent years, significantly larger solar thermal fields are being installed, with a total of 635 operating solar thermal systems for process heat reported worldwide.

2 Current Status

2.1 Existing SHIP plants worldwide

Currently, 635 operating solar thermal systems for process heat are reported in operation worldwide. The total gross area of the 301 documented systems which are larger than 50 m^2 is 905,000 m^2gross and the thermal capacity is 441 MWth.

2017 was a record year for SHIP systems, with at least 110 large systems adding up to 192,580 m^2 put into operation[1]. The SHIP database, has been developed by AEE INTEC and PSE within the IEA SHC Task 49/SolarPACES Annex IV, detailing the technical and economic key parameters of the realized plants.

With the development of the SHIP database, an important milestone was reached towards promoting SHIP plants. The listed plants and key data available prove the reliability of this technology and act as a frontrunner for other companies to follow.

Most of the reported plants in the SHIP database use flat plate collectors, followed by evacuated tube and parabolic troughs. With regard to the share of collector technologies, about 88% of the systems use non-concentrating collectors and 12% concentrating collectors, of which 79% are parabolic trough collectors. The industry sectors with the highest number of realized SHIP plants are the food and beverage industry and textile and pharmaceutical manufacturers. [2]

[1] https://www.solarthermalworld.org/content/solar-industrial-heat-market-2017-survey
[2] http://ship-plants.info/

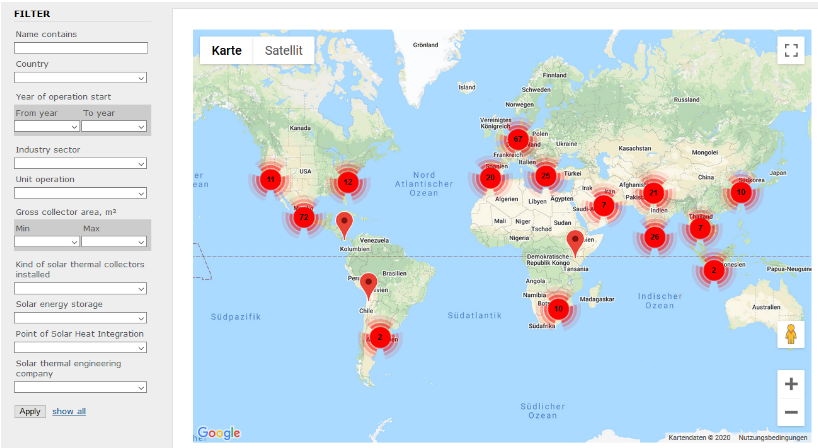

Figure 1. Map of solar thermal plants for industrial processes listed in the SHIP database developed within IEA SHC Task 49. Source: http://ship-plants.info/

2.2 Process heat collector development

Collectors used as process heat collectors are well developed and cover a wide range of possible temperatures. A report on the State-of-the-Art can be found on the SHC Task 49 website, http://task49.iea-shc.org/.

New collector developments focus on *medium temperature collectors*. This trend is very important to cover the temperature requirements in industry. New collector developments were presented within SHC Task 49 by various suppliers and research institutions aiming to lower costs and lighten construction to enable installations on industry halls, which have a lower bearing capacity. Their continued development and appropriate system solutions will be essential for future research projects.

Stagnation measures are well documented and solutions regarding stagnation are known. However, the international usage of these measures needs a wider distribution of knowledge. A comprehensive report on overheating prevention and stagnation handling is now available on the SHC Task 49 website.

Regarding test procedures, recommendations for high-concentration systems were an important development within this project as earlier test procedures were based on procedures not explicitly developed for concentrating systems.

In summary, important steps on the development of components and systems have been taken and documentation to help facilitate the integration and application of solar thermal process heat plants are now available to foster and enhance the roll-out.

3 Potential

Based on studies conducted within SHC Task 49, some general conclusions can be made on the tremendous potential of Solar Process Heat – total global process heat demand was about 85 EJ in 2014. Based on the evaluation within the review on potential studies, about 4% or 3.4 EJ global technical potential for solar process heat should be a conservative estimate. To very roughly calculate the order of magnitude of this, one could assume a mean useful annual solar irradiance (not specifying if global or beam) of 1,200 kWh/(m²a) and an annual solar thermal system efficiency of

40%. This would result in a solar collector area of close to 1,900 million m².

Concluding, it can be said that there is great potential for this market and technological developments, also by considering that, in 2014 industry consumed 32% of the worldwide energy demand. Process heat accounts for 74% of the industrial energy demand, and half of it is low to medium-high temperature (150-400°C), as can be seen in Figure 2.

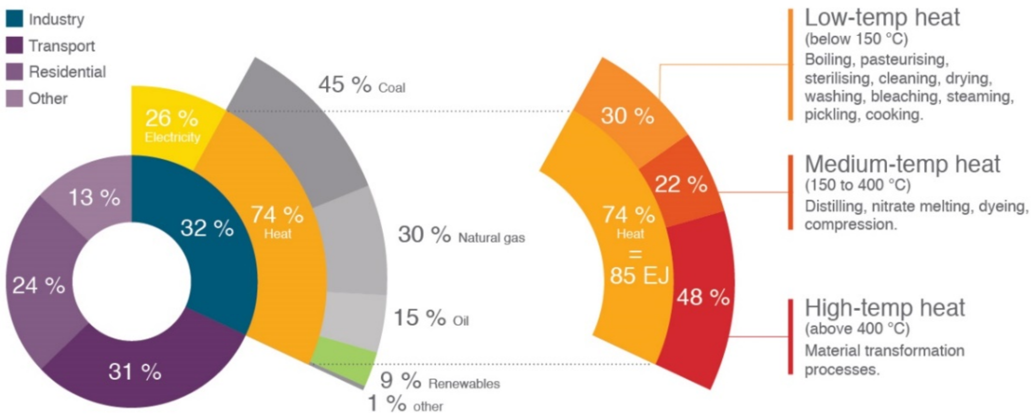

Figure 2. Total final energy consumption, 2014: 360 EJ. Source: Solar Payback https://www.solar-payback.com/markets/

In several specific industry sectors, such as food and beverages, machinery, textiles, pulp and paper, there is a high demand for heat at low and medium temperatures, as shown in Figure 3. Tapping into this potential can provide a significant solar contribution to industrial energy requirements.

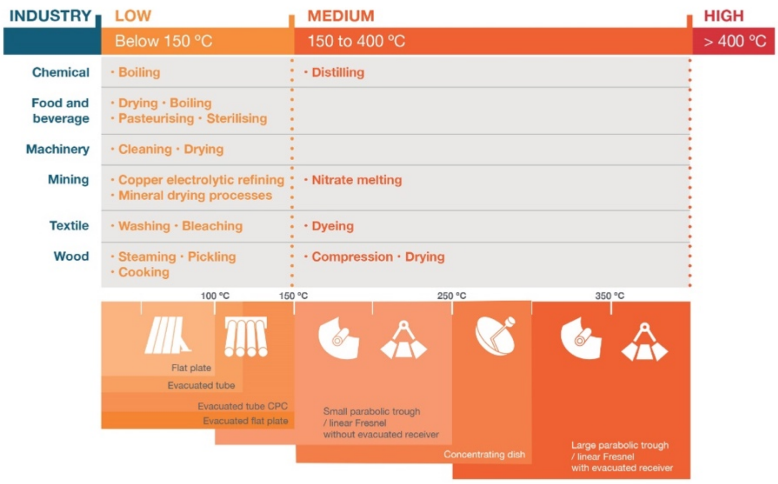

Figure: 3. Industrial sectors and production processes most suitable for each solar thermal collector type. Source: Solar Payback https://www.solar-payback.com/markets/

4 Actions Needed

Hybrid solutions for the thermal supply of industrial companies: In the future, the industrial energy supply will be based on hybrid solutions and closely linked to regional structures (city, neighboring companies, etc.). Hybrid solutions for the complete thermal supply of industry with renewable energies need an innovative and coordinated interaction of solar process heat, heat pumps, biomass, and biogas as well as district heat. At this point research demand for tailor-made system solutions for industry sectors and locations is necessary

Thermal collector and storage development: To reach higher solar ratios in large-scale industrial projects, also new storage technologies will continue to be an important research topic to realize large scale storage capacities on an economically feasible scale. New collector developments will further focus on the medium temperature level, with a focus on little collector weight, simple installation procedures, and economic realization potential.

Emerging process technologies: Research concerning the integration of solar thermal energy in industrial process will focus on new process technologies. On the one hand, it will focus on new technologies that provide the usage of low temperature heat (e.g., thermal driven separation technologies - membrane distillation), and on the other hand, a more integrated research approach connecting collectors and process technologies will be decisive.

Cost reduction combined with tailor-made funding and financing schemes: Finally, economic barriers will be further in the center of attention as there are still many projects not realized because of economic reasons. Cost reduction and promising financing mechanisms are indispensable to enable further market penetration.

Challenge	Action needed
Space **availability for large scale systems (plant size, solar ratio, etc.)** Availability of suitable heat storages at **acceptable costs**	Increase support for further heat **collector development** Increase support for the development of **innovative storage technologies for industrial requirements**
Lack of experience with storage handling and integration	**Support storage integration** and **long-term evaluation** to gain experience in storage handling
Challenging integration (comprehensive process modification necessary, integrated process technologies not designed for solar process heat)	**Emerging process technologies** to increase the potential of SHIP **Combination** of collector and process in one unit **Hybrid solutions** for the thermal supply of industrial companies
Low **awareness** & little **visibility** High upfront **investment costs and low energy prices** (unattractive investment) Long **payback periods**	**Reduction of energy price form SHIP** in combination with other renewable heating technologies Tailor-made **funding and financing schemes**