Potential of Solar Process Heat In Switzerland

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Abstract

The potential study showed that 9% of the final energy consumption in Switzerland by the industry could be tapped with solar thermal systems. In order to check whether the theoretical potential corresponds to reality, a survey was conducted throughout Switzerland in the four industries best suited to solar process heat: food, chemicals/pharmaceuticals, paper and textiles. The participating companies provided information on their energy consumption, the proportion of process heat in certain temperature ranges and load profile among other things. Based on the enquiries three companies were selected for a more detailed feasibility study and a rough concept planning of a solar process heat plant. Finally, a freely available tool, 'Solind', was developed that can be used by industry, planners, energy consultants and other interested parties without prior knowledge about solar process heat systems to make decisions about the possibility of the integration of solar thermal into the existing process. The tool can be used to evaluate if solar process heat is applicable for a specific company, calculate the solar gain and give a rough cost estimation.

Keywords: solar process heat, potential study, techno-economical estimation tool

1. Introduction

Although solar process heat has great potential to be a renewable heat source for industry, the big breakthrough for this technology is still missing. There are several hurdles to overcome before it can establish itself as a competitive technology in this field. One of these hurdles is its technical complexity, which requires a lot of experience from planners and installers. Then there is a lack of suitable business models and, in some cases, subsidies. Finally, the industrial sector is largely unaware of the great solar potential and many possibilities of solar thermal energy as a renewable, CO_2-neutral heat source. In order to promote the use of solar process heat, it is therefore necessary, on the one hand, to develop financing models and simplifications through standardized systems. On the other hand, to draw the attention of industry and energy consultants to its real potential. For this purpose, a potential study on solar process heat and an industry survey in Switzerland were carried out. The aim was to promote the technology and to compare the theoretically usable potential with the real potential resulting from technical boundary conditions such as process load profile, temperature level, available roof area (for a solar collector field) and heat energy supply system integration possibilities. The study should also convince politicians in Switzerland that solar thermal should be supported not only for standard domestic applications, but also for other applications such as process heat. In this contribution, we present the results and conclusions from our investigations.

2. Potential Study

The study focused exclusively on the heat demand at (related to process heat) low temperature levels (<130°C) of the different industrial branches and individual processes and is described in detail in [1]. In this temperature range, energy can be provided with well-known, inexpensive and reliable solar thermal collectors that have been known for decades in the residential sector. According to the Swiss Overall Energy Statistics GEST, in 2016 the Swiss industry consumed 156 PJ and thus accounted for 18 % of the total final primary energy consumption in Switzerland. Of this industry's share, the provision of heat alone requires more than half, namely 59%. Fossils fuels provided 40% part of the industry energy consumption while renewable energy accounted for only 8 % [2]. The main energy consuming application in the industry is process heating and

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account about 63 PJ or about 40 % of the energy demand of Swiss industry [3].
The food, textile, paper and chemical/pharmaceutical sectors are interesting for the implementation of solar thermal systems, as they have high thermal energy consumption for process heat generation and predominantly low operating temperatures [4]. Together, these four industrial sectors have a heat demand of around 33 PJ, which corresponds to 21 % of the energy consumption of Swiss industry in 2016. From this demand, the share of heat at low temperature (<130 °C) is valued at 14.6 PJ. This represents the theoretical maximum potential that can be tapped by conventional solar thermal systems in these four industrial sectors. This value represents 9 % of the final energy consumption of Swiss industry and 1.7 % of total energy consumption in Switzerland in 2016.
In a next step, a Swiss-wide survey was conducted in the four identified industrial sectors of the potential study. Based on the enquiries three companies were selected for a more detailed feasibility study. Based on the results and the experienced gained in the project a fast feasibility tool was developed, which is able to do a quick suitability check and a rough energetically and economical estimation of a solar process heat plant for the interested company.

3. Results

3.1 Survey

In the survey, companies of the forenamed sectors were contacted to find out about the actual potential for solar process heat and the boundary conditions. Furthermore, we took the opportunity to inform them about solar process heat application. Out of 483 contacted industrial companies throughout Switzerland 54 participated in the survey – that is a share of 11 %. Broken down by the industry sector, 33 participants from the food sector, three from the paper sector and nine each from the textile and chemicals/pharmaceuticals sectors took part in the study. The response rate in German-speaking Switzerland was 25 % (41 out of 179), which is a typical response rate for a voluntary survey and signals interest in this technology in German-speaking Switzerland. The reason why the response rate for the French and Italian-speaking part was <10 % needs yet to be identified. The participating companies from these sectors provided information on the energy sources used, the energy consumption, the proportion of process heat in certain temperature ranges and time profiles, the payback period for heat generators, etc. For example, one of the most important criteria for integrating solar thermal systems into a production process is the required temperature of the process heat. The companies were asked to assign the thermal energy consumption to the temperature ranges 30-60 °C, 60-100 °C, 100-130 °C and >130 °C as a percentage. Except of the participants from the paper industry sector, the evaluation of the survey showed the same tendencies in the low temperature range below 100 °C as described in the potential analysis. Figure 1 shows the percentage energy consumption of the survey participants broken down by temperature level and industrial sector.

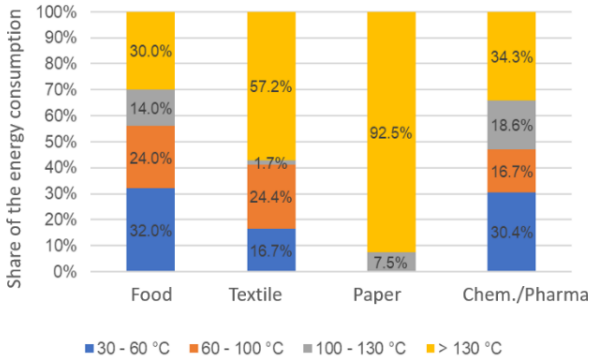

Figure 1 Distribution of energy consumption by temperature in the different industrial sector

On the basis of the information obtained from the survey, we were able to establish that 70 % of the participating companies are actually suitable for the use of solar process heat. The remaining 30 % either had no roof area available, no processes with the corresponding temperature range or it would not be technically possible by other reasons. The results also indicated that about one third of the participating companies had already thought of solar process heat for their heat generation but did not pursue and implement it mostly because of financial reasons.

3.2 Feasibility study

For the feasibility studies three companies were selected, which reveal great potential and showed a strong interest in solar process heat. In the first step, a more detailed analysis was carried out for the three participants and a first /rough concept was developed. This included site visits, inspection of the available space for solar thermal energy system installations, discussions with production employees (responsible persons for energy supply systems), identification of integration points for solar thermal energy in processes and an energy flow analysis. For these companies a rough planning for a solar collector field and system integration was performed. Furthermore, tenders from various system and collector providers were collected to obtain cost estimations for the best practice systems. Rough planning for a solar collector field and integration was carried out for these companies. Depending on the available roof area at the site of the investigated companies(between 1'000 m^2 and 200 m^2) the levelized heating costs were between 7 Eurocent/kWh and 14 Eurocent/kWh.

3.3 Solind tool

Based on the results of the questionnaires and investigations, a freely available tool was developed to assist the evaluation the versatility of solar thermal in industry. 'Solind' can be used by industry, planners, energy consultants and other interested parties without prior knowledge about solar process heat systems. In a first step basic questions are asked (e.g. heat demand <130°C, available roof space) in order to quickly determine whether solar process heat makes sense for a company at all. If this is the case, more detailed questions concerning the energy consumption and process demand are asked and based on the provided information the tool quickly gives an overview about the possible solar yields and a rough energy cost (EURO/kWh) estimation, as shown in Figure 2.

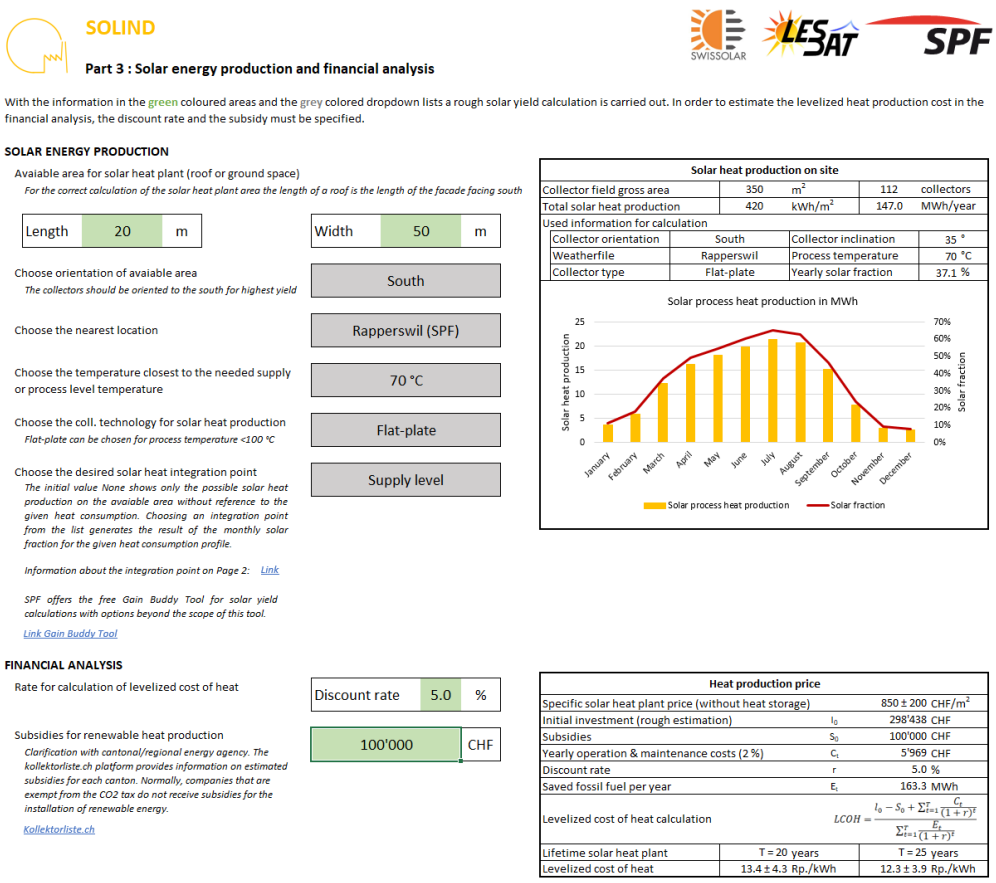

Figure 2 Extract out of the Solind tool. The right side graphs result from the information given on the left side and previous fields in the tool

The estimated heat yield is based on the Gainbuddy tool which was developed by the SPF Institute, which is a gross heat yield calculator for a solar field of given available area and temperature. The row spacing between the collectors was estimated at 3 m to 5.5 m with an elevation of 35° depending on the chosen collector type to minimize the row shading and to use the available area as well as possible. For this purpose, calculations of a field on $1m^2$ at different locations in Switzerland, solar field orientations and outlet temperatures were performed, which in the Solind tool are up-scaled without taking row shading into account. All this information is provided in the background of the tool and can be extended. In the current version of the tool it can be only choosen between flat plate and vacuum tubes collectors. It is important to stress that the Solind tool has the only goal to give initial estimates, thus the achieved accuracy is sufficient. The same applies to the estimation of costs, where the aim is to give the interested party a feeling for the magnitude of such an investment. The calculation of the levelized cost of heat LCOH is based on the calculation of Task 49. In addition, all important key data is compiled in a document to serve as a start of the detailed planning phase of such a system.

4. Summary

The aim of our project was to demonstrate that there is a real potential in Switzerland for solar process heat in industry that could help to cover 9 % of the final energy consumption by the industry. Based on the results of the questionnaires and investigations, a freely available tool was developed to assist the evaluation the versatility of solar thermal in industry. 'Solind' can be used by industry, planners, energy consultants and other interested parties without prior knowledge about solar process heat systems. The method developed in the project and the relevant know-how are passed on to plant planners and plant constructors. In this way, it should be possible to increase the share of solar (thermal) energy for the provision of process heat in suitable industries in Switzerland.

5. Reference

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