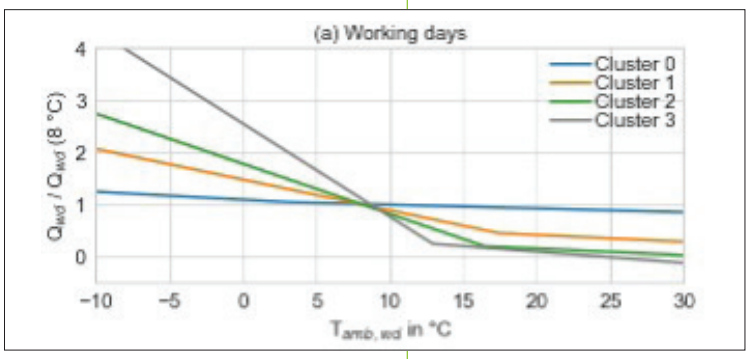
How Load Profile and Roof Area Limit Solar Fractions of SHIP Plants

Solar heat for industrial processes (SHIP) is a pivotal technology to decarbonize the industrial heat demand worldwide. And participants in SHC Task 64 on Solar Process Heat are working on the system level to identify, verify, and promote the role of solar heating plants in combination with other heat supply technologies.

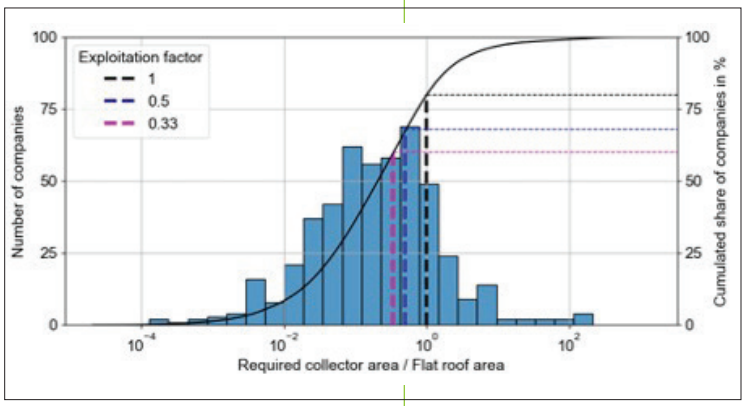
One area SHC Task 64 experts are focusing on is the heat load, and they have produced reference heat load profiles for industrial applications with different shares of space heating demand have been developed (SHC Solar Update, December 2020). Figure 1 shows these load profiles as a function of the ambient temperature: Cluster 0 represents classical industries such as chemicals, food, etc., in which the heat load is constant throughout the year. In contrast, Cluster 3 represents industries whose load profiles are strongly correlated with the ambient temperature as space heating of halls plays a significant role, which is typical for the manufacturing industries, for example.



▲ Figure 1. Reference load profiles showing the ambient temperature dependency.

In a recent study, Felix Pag, head of SHC Task 64 Subtask A on Integrated Energy Systems, analyzes the influence of the heat load profiles over a year on the possible solar fractions in Northern Europe. In this study, a collector field is pre-designed according to the summer heat demand following the methodology of the VDI guideline 3988 for 489 industrial companies whose load profiles were available. The resulting collector area is compared to the available roof area, which is analyzed from OpenStreetMap data.

The results show that the majority of companies have enough roof area available to cover their summer heat demand with solar collectors. Assuming a realistic utilization of the roof area (exploitation factor 0.33, meaning the roof area is three times bigger than the collector area), only 40 % of the companies do not have sufficient roof area, as shown in Figure 2.



▲ Figure 2. The absolute number of companies and cumulated share of companies as a function of the relation of the required collector area and the flat roof area (area availability factor) in logarithmic scale. The exploitation factor represents the relation of the collector area to the roof area.

But the load profile often limits the potential solar fractions even more. Figure 3(a) shows the potential solar fractions of every company, neglecting the collector area's potential limitation by the roof size. Obviously, companies from Cluster 0 with a constant heat load profile over the year have a high summer heat load compared to winter load and consequently can achieve high solar fractions of up to more than 40%. On the other hand, the more space heating is included in the heat load, the more the solar fraction is reduced. So, companies from Cluster 2 rarely achieve more than 10%. Figure 3(b) shows the potential solar fractions of the roof area availability considering an exploitation factor of 0.33. The solar fractions of the companies with limited roof area compared to the potential collector area are significantly reduced (right of the dashed line), partly from more than 40% to below 5%.

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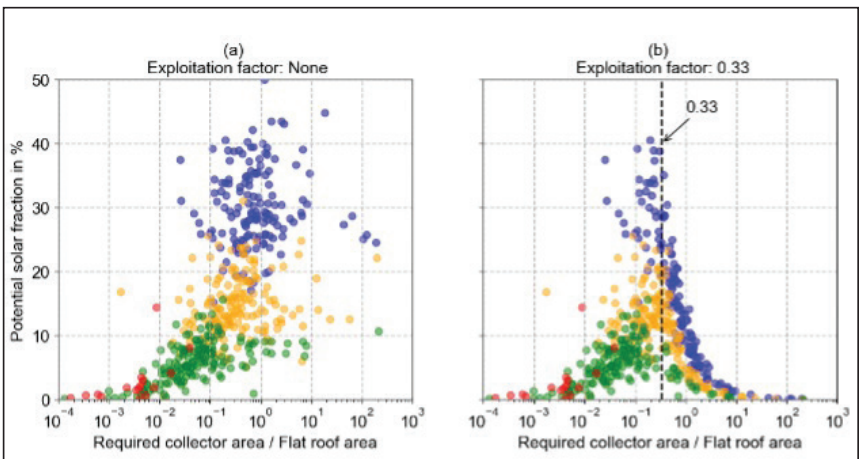
The results of this study imply two main consequences for the design of future solar process heat systems:

1. If the heat load profile is seasonal, the solar collector area should be oversized compared to the VDI 3988 to reach higher solar fractions.

2. Solar solutions must focus on combining with other technologies, such as heat pumps, and highlighting synergies.

Both these consequences are part of the upcoming work in Task 64 Subtask A. And the results will be shared with the public on the SHC website.

This article was contributed by Felix Pag of the University of Kassel, Institute of Thermal Engineering, and leader of Task 64: Solar Process Heat, Subtask A: Integrated Energy Systems. For more information on this work and other Task news, visit the SHC Task 64 webpage, https://task64.iea-shc.org/.



▲ **Figure 3. The potential solar fraction is shown as a function of the relation of the required collector area and the flat roof area (area availability factor). In (a), the collector area is as large as needed according to the VDI 3988 and is not limited to the roof area. In (b), only one-third of the total roof area is utilized as collector area at a maximum representing a realistic exploitation factor of 0.33. The dashed line shows the insufficient threshold above which the roof area is insufficient.**