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Influence of hot water consumption patterns on the viability of low-temperature solar thermal systems in the food industry

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ABSTRACT

The thermal demand in agri-food industries is characterised by its considerable variability, hindering the implementation of Solar Water Heating Systems (SWHS). The main objective of the study is to provide an overview of how consumption patterns influence the profitability and energy savings of SWHS in the sector, while also identifying additional key variables that affect their viability. For this purpose, approximately 1,300,000 cases have been examined, considering a wide range of consumption patterns, economic variables, and locations. Demand seasonality, weekly frequency and energy prices exhibit the greatest impact on the feasibility of SWHS. Uniformity of daily demand, location and investment cost are also determinants. Thus, single-day-per-week consumption patterns make SWHS unviable in most scenarios. However, with only three non-consecutive days, feasibility increases significantly, achieving paybacks of less than 5 years and energy savings of over 40 % when conditions are highly favorable. In strongly seasonal industries, the viability of SWHS is seriously compromised. The payback in patterns with a peak consumption in the early morning can double the value with uniform one (e.g., from 4 to 8 years in the most favorable scenarios at a price of 0.1 €/kWh). The results tables reflecting payback and energy savings in thousands of different scenarios represent a valuable tool for decision-making in industries. By looking for the scenario with the most similar characteristics, it is possible to estimate the profitability and savings of the SWHS in a given industry, as well as the possible variations when changing the assumed variables.

1. Introduction

This comprehensive study evaluates the feasibility of Solar Water Heating Systems (SWHS) in the food industry. The main objective of the study is to provide an overview of how consumption patterns influence the profitability and energy savings of SWHS in the sector, while also identifying additional key variables that affect their viability.

The use of SWHS for water heating has experienced a significant growth, with installed capacity worldwide having doubled in the last decade [1]. Among the most common collectors, there is a notable increase in the adoption of Evacuated Tube Collectors (ETC) compared to Flat Plate Collectors (FPC), owing to advantages such as superior performance, especially in cold climates. The performance of an ETC system is 41 % better than that of an FPC system, and the yearly useful energy gain of ETC is 30 % higher than that of FPC in cold climates [2]. In 2021, a considerable portion of the new installed capacity globally was attributed to ETC systems, primarily due to their prevalence in leading countries such as China and India [1]. It is expected that ongoing advancements, including the use of reflectors, nanofluids, and phase change materials [3], will continue to drive their widespread adoption in the coming years.

The industrial sector is increasingly recognizing the value of solar energy since it can cut energy charges while simultaneously promoting energy security and environmental sustainability [4]. This growing interest is reflected in the scientific community, with several review

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