

Research Article

Techno-Economic Feasibility of Solar Water Heating Systems in the Winemaking Industry

José L. García ¹, Fátima Baptista ², Alicia Perdignes ¹, Juan Lizcano ¹,
and Fernando R. Mazarrón ¹

¹Departamento de Ingeniería Agroforestal, Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Madrid 28040, Spain

²MED–Mediterranean Institute for Agriculture, Environment and Development, CHANGE–Global Change and Sustainability Institute, Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, Universidade de Évora, Évora 7006-554, Portugal

Correspondence should be addressed to Fernando R. Mazarrón; f.ruiz@upm.es

Received 2 August 2023; Revised 11 December 2023; Accepted 6 January 2024; Published 30 January 2024

Academic Editor: Baojun Xu

Copyright © 2024 José L. García et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The present work analyzes the feasibility of using solar water heating systems (SWHS) to supply the hot water required in the winemaking industries. The hot water demand of the sector was characterized by selecting patterns that encompass the wide range of existing casuistry. After determining the production potential of the SWHS by using an experimental system, 22500 energy simulations were carried out, combining different locations, energy prices, and prices of the necessary investment. The results demonstrate that the seasonality and irregularity of a winery's demand pattern drastically condition the viability and profitability of SWHS. In wineries with high demand, which are relatively uniform throughout the year, the solar system with optimized design achieves energy consumption reductions between 32% (low radiation) and 52% (high radiation), with payback between 4.3 and 7.2 years. On the other hand, in wineries with highly seasonal consumption, SWHS are not profitable even in very favorable cases.

1. Introduction

The world wine industry generates billions of euros per year, thanks to the production of over 250 million Hl in recent years [1]. Within the European Union, wine stands as the foremost export product in the food and beverage sector, commanding a value exceeding 16 billion euros, nearly twice that of the second-ranking product on the list [2]. The economic importance of the sector, together with its high energy demand and the increase in energy prices, makes it necessary to improve the energy efficiency of wineries and to promote renewable energy sources.

Despite their significant global growth, solar water heating systems (SWHS) have seen limited implementation in wineries due to factors such as low energy prices and the irregularity of demand. However, the increase in energy bills over the last two years raises the need to analyze their

viability in the new energy context, taking into consideration the particularities of the hot water demand in the wineries.

1.1. Hot Water Consumption in the Winemaking Industry.

The use of water is necessary in practically all cleaning processes carried out in wineries. There are various cleaning methods, the most common being brushing, spraying, circulation, and CIP (cleaning-in-place). High-temperature water is mainly used in filter cleaning, bottling, barrel washing, and yeast rehydration.

Before bottling the wine, amicrobic filtration is carried out with membrane filters. The usual pore size of these membranes is $0.45\ \mu\text{m}$ to retain bacteria and $0.65\ \mu\text{m}$ to retain yeasts. According to Togores [3], the filter cartridges must be sterilized with water at 80°C before and after