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Optimization of a seasonal storage solar system using Genetic Algorithms

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Abstract

Seasonal storage solar systems are capable of storing thermal energy, from one season to another (typically a few months). In the present paper solar thermal energy generated during summer time, is stored for use in winter time (typically 120 days). The analyzed system consists of solar thermal collectors and a sensible heat storage device using water as storing media. The area of solar collector and the capacity of the storage tank are the basic sizing parameters, which have to meet the requirements of the load. The present case study considers the utilization of the seasonal storage solar system for heating greenhouses, with a 50 kW heating load. The whole system was modeled using a dynamic modeling tool and the sizing parameters were optimized through a Genetic Algorithm process. This optimization process was compared with other optimization methods by a pattern search, and the results showed the benefits of the Genetic Algorithm process.

Keywords: Solar energy; Thermal storage; Seasonal storage; Genetic Algorithms

1. Introduction

Solar seasonal storage systems are an interesting possibility to have solar thermal systems with very high solar fractions. These systems can have applications that go from the building sector to industrial and agricultural applications. In the framework of a project for heating greenhouses a study on using solar seasonal storage was produced having in mind to reach 100% solar fraction avoiding backup systems. The greenhouse facility was installed for production of endemic and autochthonous plants that are being used for reforest affected areas either by fires or by the construction of road infrastructures or energy infrastructures as for instance hydroelectric power plants. A dynamic model of the thermal behavior of the system was developed considering different load factors. The modeled system consists of a solar thermal array with a seasonal storage tank using water as the storage media and the main objective is to heat the greenhouse during winter season, about 120 days a year, with a constant rate of 50 kW. This load requires a big storage capacity as well as great solar collector areas. An alternative system was also studied, relying on a heat pump system for total or partial load.

The simulation results were optimized through Genetic Algorithms enabling to find the best combination between collector area and tank capacity, minimizing the overall costs of energy.

2. Dynamic modeling of the system

The solar seasonal storage system for heating the greenhouses is depicted in Fig. 1.

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