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Comparative study of two configurations of solar tower power for electricity generation in Algeria

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Abstract

The aim of this paper is to provide a comparative energetic and economic assessment of two solar tower power configurations; the molten salt (MS) and the direct steam generation (DSG) technologies in order to study the appropriate configuration for Algerian climate conditions. For this, Tamanrasset has been chosen as representative site to simulate the proposed solar tower power plant configurations. The first section of this paper analyses the conversion of the solar energy into electric energy. The NREL's SAM software (Solar Advisor Model) is used to evaluate the energetic performances of the two plant configurations in the proposed site and also to study their economic feasibility in the second section.

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Keywords: Solar energy, solar tower, DSG, multen salt, techno-economic, SAM, Algeria.

1. Introduction

The solar tower power system is one of the four concentrating solar tower power technologies for electricity and heat production, together with dish Stirling, parabolic trough and Fresnel collector technologies.

In the case of solar tower power, a thousand of two axis tracking mirrors are used to reflect the solar radiation onto a receiver located on top of a tall tower. The enormous amount of concentrated energy is used for heating a heat transfer fluid up to temperatures of 500-1000 °C. The steam generated is then fed through a turbine generator to generate electricity.

This article presents a preliminary attempt towards the conditions and configurations making the solar tower power as a technical feasible and economic viable technology for electricity production under Algerian climate condition notably in Sahara area. In this study, two configurations have been considered; the molten salt and the direct steam generation. One site has been chosen to simulate the proposed solar

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tower power plant configurations. An output of 30 MW has been taken as reference case. The NREL's SAM software (Solar Advisor Model) is used to evaluate the energetic performances two plant configurations in the proposed site and also to study their economic feasibility.

2. Solar tower power technology description

A. Basic concept

Solar power tower is characterized by the centrally located large tower. This kind of CSTP technologies uses a thousand of two axis tracking mirrors called heliostats to reflect the solar radiation onto a receiver located on top of a tall tower, where the solar energy is absorbed by a heat transfer fluid (molten salt, water, liquid sodium or air) which is heated up to temperatures of 500-1000 °C, then used to generate steam to power a conventional turbine which converts the thermal energy into electricity as shown in figure1. A power tower system is composed of five essential components: heliostats, receiver, heat transport and exchange, storage and controls [1].

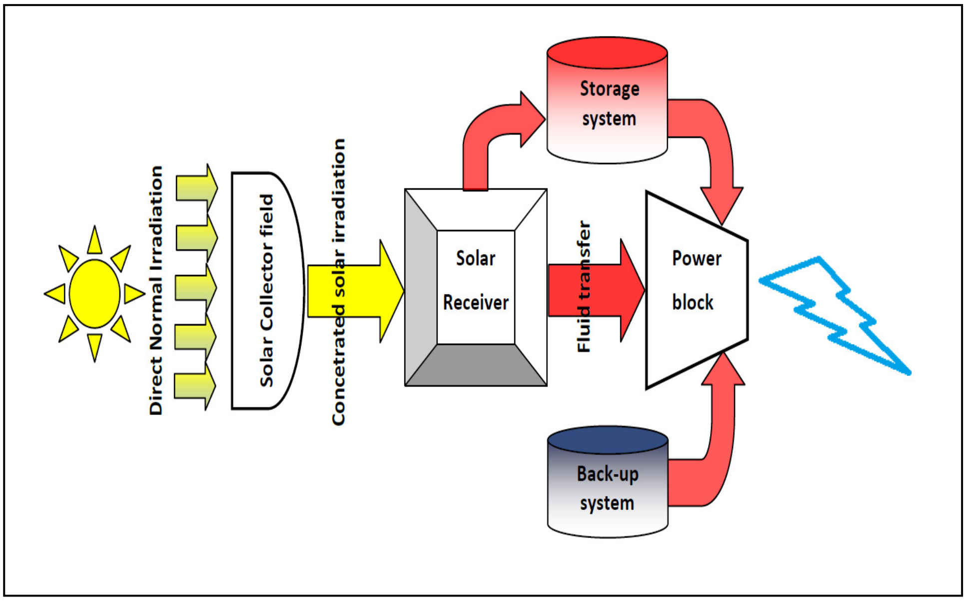

Fig.1, Flow diagram for a typical power tower plant

The heliostats design must ensure that radiation is delivered to the receiver at the desired flux density at minimum cost. Receivers are made of ceramics or the metals stable at high temperature. A variety of receiver shapes has been considered, including cavity receivers and cylindrical receivers [2].The average of solar flux impinging on the receiver is between 200 and 1000 kW/m^2 which facilitate the high working fluid temperature [3], without significant thermal losses and yields very high concentration ratio (300-1500 suns). Thank to these high operation temperatures, it is easy to integrate hybrid operation in these power plants, as well as thermal storage, at a lower cost.