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A Comparative Study of the Techno-Economic Performance of the Linear Fresnel Reflector Using Direct and Indirect Steam Generation: A Case Study under High Direct Normal Irradiance

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Abstract : Researchers, power companies, and state politicians have given concentrated solar power (CSP) much attention due to its capacity to generate large amounts of electricity whereas overcoming the intermittent nature of solar resources. The Linear Fresnel Reflector (LFR) is a well-known CSP technology type for being inexpensive, having a low land use factor, and suffering from low optical efficiency. The LFR was considered a cost-effective alternative option to the Parabolic Trough Collector (PTC) because of its simplistic design, and this often outweighs its lower efficiency. The LFR has been found to be a promising option for directly producing steam to a thermal cycle in order to generate low-cost electricity, but also it has been shown to be promising for indirect steam generation. The purpose of this important analysis is to compare the annual performance of the Direct Steam Generation (DSG) and Indirect Steam Generation (ISG) of LFR power plants using molten salt and other different Heat Transfer Fluids (HTF) to investigate their technical and economic effects. A 50 MWe solar-only system is examined as a case study for both steam production methods in extreme weather conditions. In addition, a parametric analysis is carried out to determine the optimal solar field size that provides the lowest Levelized Cost of Electricity (LCOE) while achieving the highest technical performance. As a result of optimizing the optimum solar field size, the solar multiple (SM) is found to be between 1.2 – 1.5 in order to achieve as low as 9 Cent/KWh for the direct steam generation of the linear Fresnel reflector. In addition, the power plant is capable of producing around 141 GWh annually and up to 36% of the capacity factor, whereas the ISG produces less energy at a higher cost. The optimization results show that the DSG's performance overcomes the ISG in producing around 3% more annual energy, 2% lower LCOE, and 28% less capital cost.

Keywords : concentrated solar power, levelized cost of electricity, linear Fresnel reflectors, steam generation
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