Cyprus University of Technology

FACULTY OF GEOTECHNICAL SCIENCES AND ENVIRONMENTAL MANAGEMENT

Master's Thesis

AN OVERVIEW OF CONCENTRATED SOLAR POWER TECHNOLOGIES AND ITS FUTURE PROSPECTS

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*"What a source of power! I'd put my money on the sun and solar energy. I hope we don't have to wait until oil and coal run out before we tackle that."*_Thomas Edison, 1847-1931

ABSTRACT

As reported by the International Energy Agency's (IEA) World Energy Outlook 2016, the energy demand worldwide is set to grow by one-third to 2040. CO2 emissions are set to increase in this period as well. Therefore, there is an urgent need to reduce the dependence on conventional energy sources which are expendable and accompanied by a high carbon emission as result of their utilization. Consequently, the use of renewable energy technologies to generate clean energy and to sustain fossil fuel reserves has to become a priority on a worldwide level.

Solar energy is one of the most promising renewable sources of energy. To utilize its vast potential it is necessary to use an appropriate technology that would capture, store and dispatch this valuable resource. The two major categories of solar technologies are Concentrated Solar Power (CSP) and Photovoltaics (PV).

In contrast to PV, CSP has the ability to deal with the intermittent and sometimes unreliable nature of solar input by incorporating low cost thermal storage or through hybridization with other plants such as natural gas or coal. The added benefit of increased capacity and dispatchability derived from thermal storage or hybridization enables a greater penetration of CSP in the grid. Furthermore, CSP technology is more adapted for large-scale generation because it uses the same power block (steam turbines) as the existing conventional fuels plants. Additionally, CSP can be a competitive source of power during peak and intermediate load by 2020 and for base load power by 2020 – 2030 according to the CSP technology roadmap by IEA.

To achieve the utilization of solar energy, CSP concentrates, using different configuration of mirrors and receivers the solar energy into a focal point or line. The concentrated solar radiation will heat up an HTF either oil or molten salt which through a heat exchanger will interact with the power block feeding it the necessary energy for it to operate properly i.e. produce steam that will drive the turbines and create electricity.

There are currently four existing CSP technologies, the parabolic trough (PT), solar tower concept (ST), Fresnel reflectors (FR) and solar dish (SD). The most mature technology is PT and is responsible for 90% of CSP's current capacity although the solar tower concept despite its demonstrational level is expected to surpass PT technology in the future since it can

achieve higher operating temperatures and therefore greater efficiency. FR and SD concepts are less mature concepts.

Current costs associated with CSP especially investment and financing costs (84% of the installation costs of CSP of which 1/3 is attributed to the solar field) result in the technology having the highest LCOE amongst other renewables (PV, wind, hydro, biomass, geothermal). Therefore, current implementation of CSP needs financial incentives such as tax exemption or reductions, long term loans, low interest rates etc. for the technology to remain competitive with other renewables.

Finally, along with financial incentives cost reduction efforts and performance improvements are necessary for the technology to be deployed at a greater scale. Higher performance and lower cost can be realized through technical advances in the components and systems, advanced thermal storage, economies of scale in the plant size and industrial learning in component production. In the years to come all of the above improvements along with policy incentives will reduce capital costs and LCOE by 30-50% by 2020. These efforts will increase capacity of CSP and its presence in the global energy generation mix.

Keywords: Renewable Energy, Concentrated Solar Power, Parabolic Trough, Solar Tower, Fresnel Reflector, Solar Dish