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An adaptive non-imaging optical method to optimize secondary optics of concentrating solar power collectors

Guangdong Zhu
National Renewable Energy Laboratory, USA

Concentrating solar power (CSP) technology is a vivid application of non-imaging optics in real life. It utilizes large aperture tracking mirrors to concentrate sun lights a small-aperture receiver at the focal point, which carries a type of heat transfer fluid (HTF). The HTF will be heated to a high temperature (400 – 560^{0}C, limited by the material chemical properties) and produces electricity through a thermodynamic cycle. CSP has a growing impact on the global energy market. The current global installed capability has reached about 6 Gigawatts-electricity. From an optical point of view, CSP collector designs have a strict requirement on the optical precision of components: overall optical error needs to stay below 3~4 mrad. Otherwise the performance may drop substantially. For CSP collectcors requiring a secondary stage of reflectors to improve the performance, such as linear Fresnel collectors, the secondary optics design is particularly critical. Optimization of secondary optics is an extremely challenging task because there is no established theory to ensure superior performance of derived secondary reflectors. In this talk, a newly developed innovative method is presented to optimize the secondary-reflector profile of a generic linear Fresnel configuration. The method correctly and accurately captures impacts of both geometric and optical aspects of a linear Fresnel collector to secondary-reflector design. This adaptive approach does not assume a secondary profile of any particular form, but rather starts at a single edge point and adaptively constructs the next surface point to maximize the reflected power to be reflected to receiver(s). As a test case, the new method is applied to an industrial linear Fresnel configuration and the results show that the derived optimal secondary optics is able to redirect more than 90% of the power to the receiver. A comparison of the new method with past approaches is also conducted. The new adapative method can be naturally extended to other types of solar collectors as well and it will be a valuable tool for solar-collector designs with a secondary reflector.

Guangdong.Zhu@nrel.gov