NREL Highlights RESEARCH & DEVELOPMENT

NREL Develops New Optical Evaluation Approach for Parabolic Trough Collectors

New analytical method makes it possible to carry out fast evaluation of trough collectors for design purposes.

Parabolic trough collectors are one of the main concentrating solar power (CSP) technologies used in commercial utility-scale power generation plants. A key parameter for trough performance evaluation is the collector optical efficiency, which is the ratio of the absorbed solar power by the receiver to that intercepted by the collector aperture. This has a direct influence on annual electricity generation, annual plant revenue, and, eventually, the levelized cost of energy (LCOE). The factors determining a trough collector's optical performance include the sun shape, various system optical/geometrical errors, and physical properties of system components. Optical performance is often evaluated using either a simple but low-accuracy analytical probability-approximation method, or an accurate but potentially time-consuming ray-tracing technique.

The National Renewable Energy Laboratory (NREL) has developed a new, fast, and accurate analytical method for the optical evaluation of parabolic trough collectors: First-principle OPTical Intercept Calculation (FirstOPTIC). FirstOPTIC employs first-principle optical treatment of collector optical error sources and derives analytical mathematical formulae to calculate the intercept factor of a trough collector and the optical efficiency when combined with optical material properties. The analytical nature of the method makes it suitable for fast and accurate evaluation of large sets of collector design options, while the first-principle treatment of optical error sources inherent in this method yields high accuracy. In the future, FirstOPTIC may be naturally extended to other types of CSP technologies such as linear Fresnel collectors and central receiver towers.

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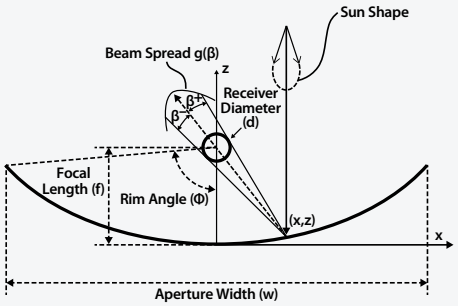
Reference: Zhu, G.; Lewandowski, A. (2012). "A New Optical Evaluation Approach for Parabolic Trough Collectors: First-Principle OPTical Intercept Calculation." *J. Sol. Energy Eng.* 134, 041005.



Simplified representation of a parabolic trough collector. Note that the receiver size and the sun shape are exaggerated for demonstration purposes. Illustration by Guangdong Zhu, NREL

Key Research Results

Achievement

NREL researchers developed FirstOPTIC, a fast and accurate tool to evaluate the optical performance of parabolic trough collectors.

Key Result

The analytical nature of FirstOPTIC makes it suitable for fast and accurate evaluation of large sets of collector design options, while the first-principle treatment of optical error yields high accuracy.

Potential Impact

In the future, FirstOPTIC will be enhanced to take into account three-dimensional effects for trough collectors at nonzero incidence angles and is planned to be further extended to linear Fresnel collectors and central receiver towers.

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