

## Integrated MCRT–CFD Modeling and Neural-Network Estimation of Tracking Error for a Parabolic Trough Collector

**Belkacem Agagna \***

Physics Department, Higher Normal School, Laghouat, Algeria

**Ahmed Sayadi**

Physics Department, Higher Normal School, Laghouat, Algeria

**Abdelhamid Bouhelal**

Laboratory of Green and Mechanical Development, National Polytechnic School, B.P 182, El Harrach, Algiers, Algeria

### Abstract

We present an integrated workflow that couples a Monte-Carlo ray tracing (MCRT) optical model with a Computational Fluid Dynamics (CFD) thermal model to quantify the impact of tracking errors on a parabolic trough collector (PTC), and a lightweight neural network (NN) to estimate tracking error from synthetic flux/LCR maps. The testbed is the MicroSol-R pilot plant composed of three 12-m PTCs with model inputs and operating conditions drawn from the facility. The optical model produces Local Concentration Ratio (LCR) curves that degrade systematically with tracking error (0–20 mrad), and ray-path visuals that explain power spillover at 10 mrad. CFD predictions of HTF outlet temperature and thermal efficiency agree well with MicroSol-R measurements under the same conditions. Trained on MCRT-generated data, the NN reproduces measured tracking error with milliradian-level residuals and a slight underestimation bias. The combined approach provides a practical tool for diagnosing mis-tracking and quantifying associated thermal losses in PTCs.

### Keywords

Parabolic trough solar collector, Numerical study, Tracking error, Neural network, Performance analysis.