# DNI Prediction Using Deep Learning for Optimization of Concentrated Solar Power (CSP) Plants

Kashif Liaqat

Energy Systems Lab, Department of Mechanical Engineering, Rice University, Houston, TX, 77030
Kl112@rice.edu

Keeping the net-zero by 2050 target in view, the energy sector is transitioning towards sustainable methods of power generation such as renewables. The recent trends show that the interest in solar energy is increasing faster than the previously predicted rate of growth. The recent event of Russian invasion in Ukraine has catalyzed the energy transition. Solar energy is the most abundant resource among renewables, and it can be converted into electricity using Photovoltaic (PV) and Concentrated Solar Power (CSP) technologies. CSP has gained interest in recent years since it can be linked with thermal storage to cover resource uncertainty and to supply power when we do not have energy from the sun. This also makes CSP dispatchable, and hence it can provide better flexibility to grids for handling fluctuations and peak hours. Furthermore, CSP power plants are more similar to conventional fossil power plants than they are to PV. The main disadvantage of CSP is the levelized cost of electricity, since it can be more expensive compared to PV technology. Currently, research and development are focused on further reducing the cost of CSP so it can compete with PV economically as well.

In CSP, mirrors are used to focus the solar irradiance on a receiver containing the heat transfer fluid. The heated fluid then powers a Rankine cycle consisting of a steam turbine to generate power. Commercial-scale CSP power plants have more than 10,000 mirrors and large-scale turbo machinery. The plant requires frequent mirror washing and preventive maintenance, due to which some power production time is lost as the plant is not operational. This raises the question of when to schedule mirror washing and maintenance activities so that minimum power is lost and, as a result, the cost is reduced. This work presents a solution to the scheduling problem by predicting the direct normal irradiance using deep learning. A deep neural network-based model has been developed to predict the direct normal irradiance (DNI) using the dataset obtained from the National Renewable Energy Laboratory (NREL). The model is capable of predicting DNI with a mean absolute error of 11.76 (W/m$^2$) and 14.7 (W/m$^2$) for training and testing, respectively. The total percentage change in predicted vs. actual values is found to be 1.18%. The predicted DNI will help us identify the periods when the entire plant or the solar field alone is not operational. The maintenance and mirror washing (solar field) activities will be scheduled during these periods. This will significantly reduce the power generation loss due to maintenance activities and will result in a lower cost. Finally, an extension of this work would be to develop a case study of a commercial-scale power plant using the strategy we propose.