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LSTM-SEF: Enhancing Prediction Intervals in Renewable Energy Forecasting

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Over time, a larger percentage of the electricity generated has been from renewable energy sources namely solar and wind. Nevertheless, the electrical output from these two renewable resources significantly differs depending on various aspects among them weather conditions. For this reason, it is impractical to forecast the quantity of electricity that can be produced in the short run as it might affect network management/stability. This would require some means of measuring uncertainties to estimate potential energy production variations which could also lead to different decisions on system operations for energy management or grid reliability. Therefore, methods are needed for producing indicators that quantify this uncertainty by giving a range of deviations from expected generation thus aiding decision-making regarding both systems' operation and its sustainability over time. The paper introduces LSTM-SEF technique meant for predicting uncertainties associated with power generation based on renewable sources. To address uncertainty in forecasting renewable energy generation, we suggest LSTM-SEF which combines the recently proposed Shifting Error Function (SEF) approach together with Long Short-Term Memory (LSTM) neural networks for developing forecasting intervals. From such predictions, one can learn how much electricity will be generated but only within a given probability level, e.g. 95% – one may also check where actual production may fall through these predictions by considering the given confidence interval(s). Our study assesses how well LSTM-SEF performs using wide-ranging information gathered from the ENTSO-E Transparency Platform spanning between January 1st, 2019 and August 9th, 2024 focusing on Greek hourly solar-wind power production outputs. Measures used in appraising performance include Prediction Interval Coverage Probability (PICP) and Mean Prediction Interval Width (MPIW). This research makes a significant contribution into literature concerned with machine learning in terms of quantifying uncertainty with applications in managing energy systems more specifically. Regarding decision makers in the sector of clean power generation industry, LSTM-SEF method offers an invaluable instrument for making informed strategies related to grid management and energy trade.

Keywords: LSTM neural networks; Prediction intervals; Uncertainty quantification;
Renewable energy forecasting; Time series analysis; Energy systems