Enhancing Grid Resilience Entangled with Federated Learning for Secure Data Aggregation in Smart Grids

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***Abstract*— Accurate load forecasting is crucial for the optimized operation and planning of smart power grids. However, the increasing penetration of renewable energy sources and the emergence of flexible loads like electric vehicles create significant uncertainties and complexities in load patterns. Traditional centralized forecasting models struggle with data privacy concerns, communication overheads, and lack of model adaptiveness. This paper proposes a privacy-preserving federated learning-based framework for short-term load forecasting in smart grids. Local machine learning models are trained on distributed private datasets across different stations of the grid and only the model parameters are communicated to a central server to create an aggregated global model for load forecasting, without exchanging any raw private data. The proposed approach harnesses edge resources efficiently through decentralized on-device training while providing enhanced accuracy and personalization over centralized models. Several experiments conducted on electricity consumption data validate the effectiveness of proposed approach in handling complex spatio-temporal load changes and generating station-specific adaptive forecasts. By adopting a decentralized approach, proposed methodology seeks to enhance grid resilience by preserving data privacy, mitigating security risks, and optimizing the efficiency of smart microgrid operations. The proposed solution can enable optimized capacity planning and retail pricing for sustainable grids of the future.**

***Keyword*—A Smart Grids, Grid Resilience, Federating Learning**

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