Abstract ID 547

COMPARATIVE ANALYSIS AND PERFORMANCE VALIDATION OF LOAD AND PHOTOVOLTAIC GENERATION FORECASTING USING REAL RESIDENTIAL DATA

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Keywords: Electric Vehicles, Energy Forecasting, Feature Engineering, Photovoltaic Generation, XGBoost

Summary: The integration of electric vehicles (EVs) and photovoltaic (PV) systems into residential settings presents both challenges and opportunities for energy management and transportation systems. Accurate forecasting of household energy consumption, PV generation, and EV power demand is crucial for optimizing energy usage, enhancing grid stability, and facilitating effective Vehicle-to-Everything (V2X) interactions. This paper presents a comparative analysis and performance validation of the forecasting module developed for the Portuguese demonstrator within the scope of the EV4EU project. The forecasting module predicts three key variables, electric vehicle (EV) power demand, PV power generation, and household energy consumption, over a 36-hour horizon with a 15-minute granularity. Leveraging real-world residential data from PV production and energy load, this study evaluates the module's accuracy and reliability by comparing forecasts against actual recorded data from residential houses. The forecasting framework is structured into five stages:

- Pre-processing: Initial data cleaning is performed to address missing values and negative values, ensuring data quality for subsequent analysis.
- Feature Engineering: New predictive features are generated based on temporal patterns, weather conditions, and historical consumption and generation trends to enhance model accuracy.
- Feature Selection: Key features influencing forecasts are identified using eXtreme Gradient Boosting (XGBoost) feature importance scores, optimizing the model's input variables.
- Forecast Method: XGBoost is employed for time-series forecasting, leveraging its capability to model complex, non-linear relationships and interactions among variables.
- Post-Processing: Forecast outputs are refined to meet practical constraints and improve applicability.

Performance evaluation is conducted using metrics such as Mean Absolute Error (MAE), Normalized Root Mean Square Error (NRMSE), and correlation coefficients. By identifying the strengths and limitations of the forecasting module, this research contributes valuable insights into the challenges of integrating distributed energy resources into modern transportation systems. The results highlight the potential for improved energy management (better scheduling and energy dispatch decisions in residential settings) and grid resilience through accurate forecasting. This work not only underscores the significance of real-time energy forecasting for residential applications but also provides a roadmap for future advancements in predictive analytics for sustainable energy systems.