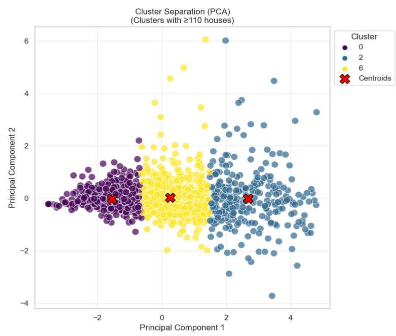
HSLU Hochschule Luzern

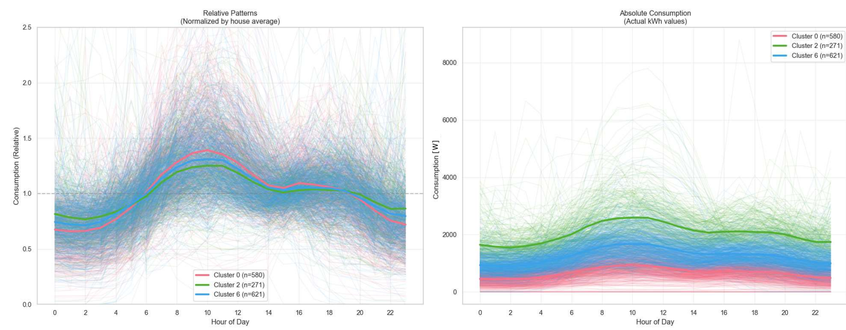
Technik & Architektur
Master of Science in Business Engineering

Master Thesis

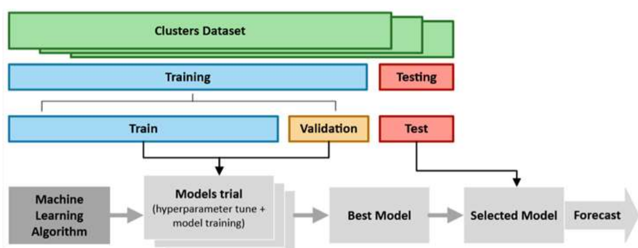
Energy analysis and prediction in buildings



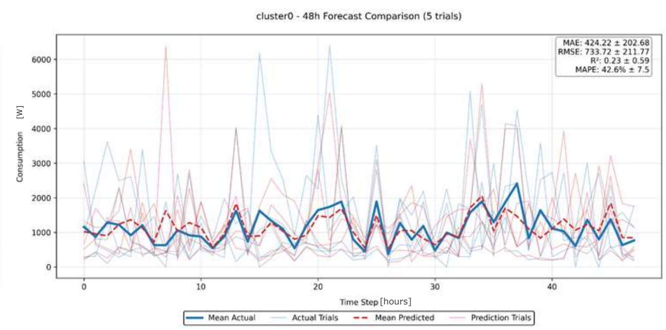
Cluster visualization (PCA) 2D



Absolute and relative average consumption per cluster over a day



The use of data splitting in model training



Forecast output of next 48 hours

Problem statement

Switzerland's energy transition, driven by decentralisation, decarbonisation and digitalisation, is transforming the electricity grid. As decentralised generation and electrification (e.g. electric vehicles and heat pumps) increase, achieving a real-time balance between supply and demand is becoming more challenging.

Accurate short-term load forecasting at the household level is essential for grid stability and supports operations such as load balancing, congestion management, economic dispatch and flexibility integration.

Current models often compromise on accuracy, interpretability and computational efficiency. This study addresses these issues by suggesting a hybrid forecasting approach that combines the XGBoost algorithm with clustering techniques. This approach enhances the accuracy and scalability of predictions regarding household electricity demand. The goal is to support a more resilient, flexible, and cost-effective smart grid.

Solution proposal

This study addresses these challenges by proposing a Machine learning forecasting approach combining the XGBoost algorithm with clustering techniques to identify distinct consumption profiles and improve forecasting accuracy. The proposed approach is expected to facilitate the delivery of accurate, interpretable, and scalable forecasts.

Results

The proposed forecasting framework, which combines XGBoost with clustering techniques, demonstrated strong performance in predicting residential electricity consumption.

Forecast accuracy varied across clusters, being higher where sample sizes were larger and consumption patterns were more stable. Seasonal trends had a significant influence on performance, with forecasts proving more reliable in summer than in winter, likely due to reduced volatility in household behaviour.

These results emphasise the importance of tailoring models to specific consumption profiles and incorporating seasonal features to improve predictive accuracy. This approach shows good promise for scalable, interpretable and data-driven energy management in a variety of residential settings.

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