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Identifying Drivers of Residential Energy Consumption by Explainable Energy Demand Forecasting

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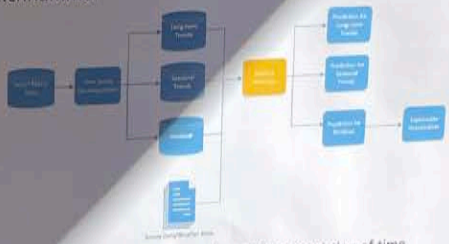
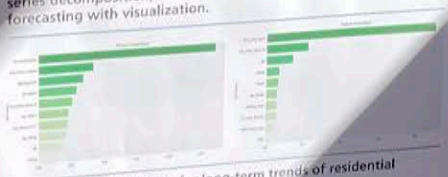
Reducing primary and final energy demand is crucial for substantially decreasing Greenhouse Gas (GHG) emissions and reaching global and European climate targets. To understand what drives energy consumption behaviour is crucial for decision-makers to design policies in an effective manner. Most current studies focus on smart meter data and sensor data. These data should be complemented by contextual, sociological and behavioural data (acquired for example through surveys), which allow to study more precise user profiles. Integrating user profiles may reveal more valuable information, at the same time too much redundant information may also harm the prediction accuracy. How to select the crucial drivers is still understudied, but has direct impacts on the performance of the prediction.

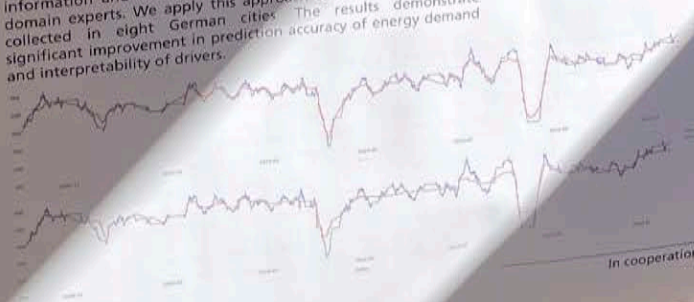
This paper presents an explainable three-step forecasting method, which identifies long-term as well as seasonal trends and the most important drivers of household energy demand. In the first step, times series analysis (Bayesian Structural Time Series - BSTS) is applied to decompose energy demands into long-term, seasonal and residual components. In the second step, features are selected through a hybrid machine-learning approach (combining Extreme Gradient Boosting - XGBoost and Random Forest - RF), which reveals the key drivers of energy consumption. Finally, the energy consumption for each household is predicted with a deep-learning algorithm (Long Short Term Memory - LSTM). Furthermore, drivers of household energy demand – covering energy usage, building information and user profiles – are extracted and validated by domain experts. We apply this approach to a real-world dataset collected in eight German cities. The results demonstrate significant improvement in prediction accuracy of energy demand and interpretability of drivers.



Explainable three-step forecasting method, consisting of time series decomposition, feature selection, energy demand forecasting with visualization.



Top 10 important drivers for long-term trends of residential energy demand.
(a) XGBoost (b) RF



Hourly forecasting results for long-term trends of residential energy demand.

(a) XGBoost

(b) RF

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