Comparative Analysis of Electrical Consumption

Sven Hominal & Quentin Poindextre

Design Project - SS 2024-2025, SSIE, DISAL-SP201, Project Summary
EPFL, Lausanne, Switzerland

Professor : Alcherio Martinoli, Assistants : Nicolaj Schmid & Emmanuel Droz
External Supervisors from SIE SA : Mathieu Veriter & Kevin Gallego

The project was carried out under the co-supervision of DISAL and SIE SA. It aimed at establishing relevant indicators and methods to analyze the electricity load curves of private individuals and professionals. A web-based application was developed to help users better understand their electricity consumption through meaningful indicators and metrics. The objective is to characterize the consumption patterns, to detect anomalies and highlight potential energy savings.

The web app follows a top-down approach, from the simplest to the most elaborated indicator. It's developed in Python using the library *streamlit*. The tool allows the user to upload their quarter-hourly consumption data, as a *.XLSX* file, and visualize electricity use at multiple temporal scales, such as yearly, seasonal, weekly, and daily levels, as shown on Figure 1.

We implemented a set of indicators to describe electricity consumption patterns. These include temporal analyses at different scales, energy cost estimation, base and mean load power, as well as behavioral ratios such as weekday-weekend and day-night consumption.
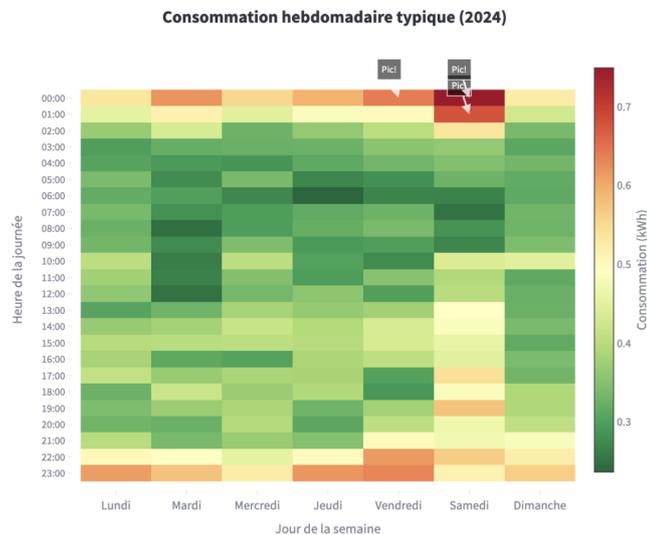

Fig. 1: Weekly heatmap through the year for pattern recognition

Additional contextual information can be collected through user input forms, allowing for more personalized analyses, such as electricity consumption per square meter and per capita. Particular emphasis was placed on the clarity of the visualizations and the simplicity of the interface, ensuring that non-technical users can easily interpret the results and identify inefficient consumption behaviors.

To get into more details, we used an unsupervised machine learning method for private users. A clustering framework based on principal component analysis and K-Means was developed using a large dataset provided by SIE SA. This approach allows users to be compared with households exhibiting similar consumption behaviors. The main features retained after a PCA analysis are Standard deviation of consumption, Base load, Mean Consumption in Winter, Mean Consumption in Summer, Ratio Weekday-Weekend, Ratio Day-Night, Average morning ramp-up slope (6-9am) and Evening load drop (6-10pm). Our results show that clustering significantly enhances the interpretability of residential electricity profiles, as shown on Figure 2.
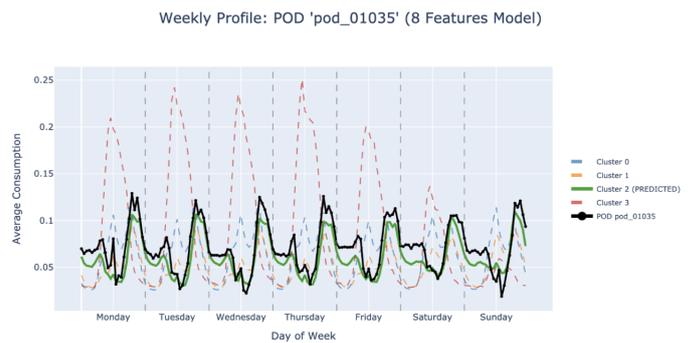

Fig. 2: Weekly profile prediction through custom K-means

We emphasized the distinction between human-oriented interpretation and machine-based representation of the problem. For human users, a set of indicators and functions was selected to be visually intuitive, easy to understand, and capable of conveying meaningful insights. In contrast, the features used in the K-Means clustering correspond to higher-level abstractions derived from the underlying consumption curves.

Although these features effectively summarize complex temporal behaviors, their interpretation can be challenging for non-expert users, as they do not directly correspond to intuitive physical quantities. Instead, they capture latent structures embedded within the data, serving as compact yet abstract descriptors of electricity consumption dynamics. A **demo video** of the web application is available and the first deploy.

The tool bridges the gap between complex machine vision and intuitive human understanding, empowering non-technical users to optimize behavior. Future improvements include integrating real-time climate data, integrating solar and battery energy system diagnostic, prediction and optimization, storing form data to enable supervised learning, and expanding the dataset beyond the Lausanne region.