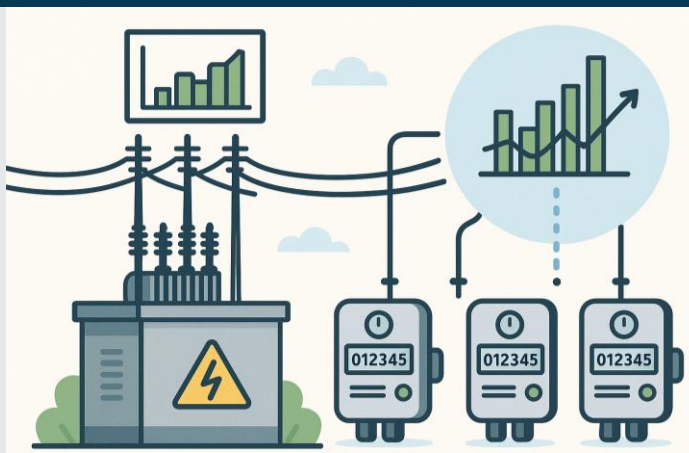
SUCCESS CASE 25.2025

Feeder Load Estimation

LOW-VOLTAGE SECONDARY SUBSTATIONS



THE CHALLENGE

CEZ Distribuce (CEZd) operates an extensive low-voltage distribution network with a high number of individual feeders in the Czech Republic. Instrumenting each of these feeders with measurement devices would require a significant financial investment, with estimated costs reaching approximately 60 million EUR. Such an approach is not only cost-prohibitive but also logistically complex, given the geographical spread and infrastructure constraints. As **energy management and grid optimisation become increasingly data-driven**, the need for accurate and granular load visibility grows. However, achieving this level of insight through conventional hardware-based solutions is not sustainable at scale. Therefore, CEZd needed an alternative, an **intelligent, scalable method to estimate feeder-level loads without relying on widespread physical metering**.

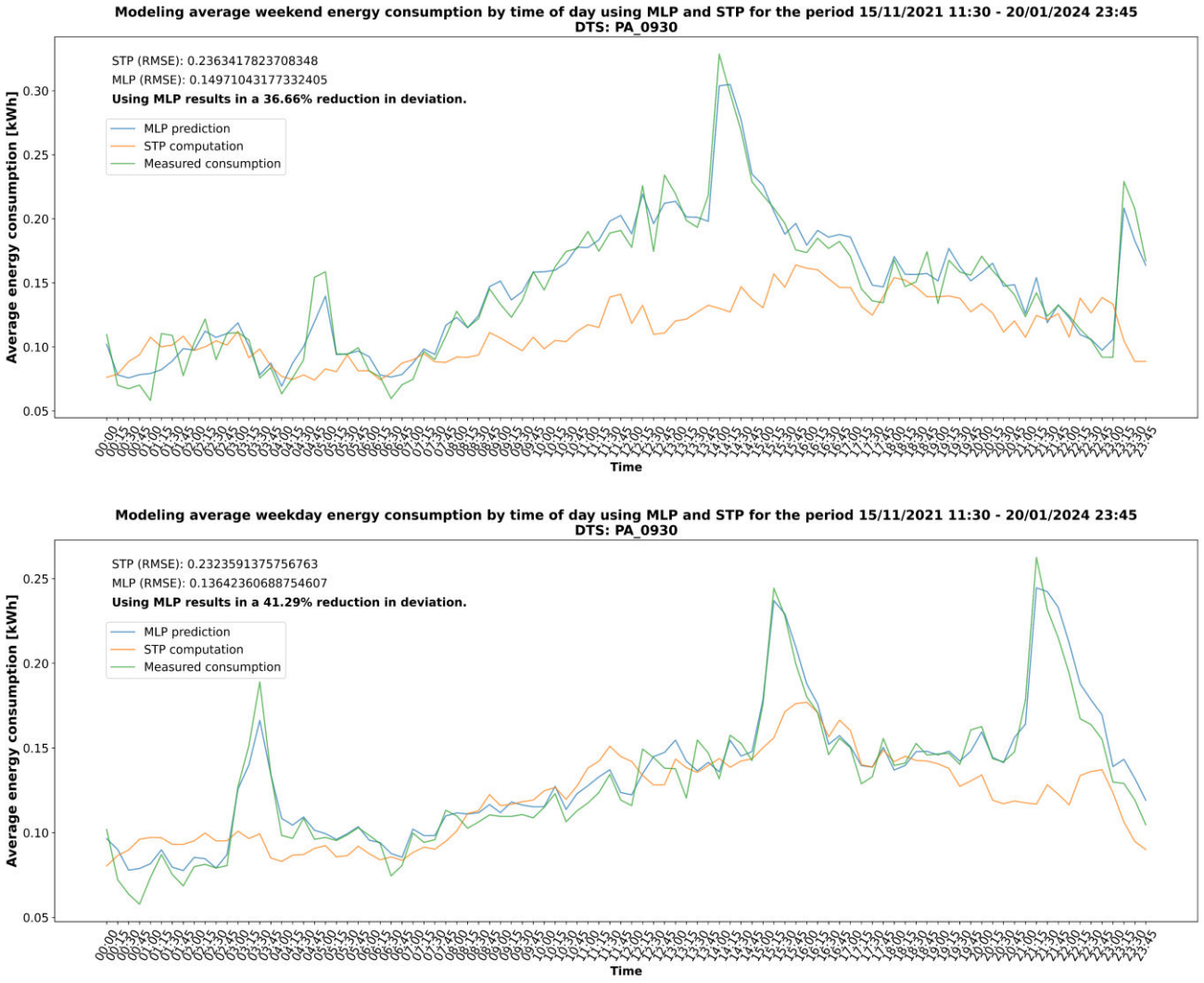
THE SOLUTION

To address this challenge, CEZd initiated a project leveraging artificial intelligence (AI) to redistribute transformer-level load data across individual feeders using machine learning (ML) techniques. Specifically, a **Multi-Layer Perceptron (MLP)** model was developed and deployed to estimate feeder loads based on available aggregated data from secondary substations and characteristics and measured consumption from points of delivery. This AI-driven approach eliminates the need for extensive hardware deployment by inferring localised consumption patterns through existing measurements and historical data. The project demonstrated not only the technical feasibility of the model but also its operational relevance, paving the way for **data-driven network management** across the company's infrastructure.

MAIN ACHIEVEMENTS

The project delivered a significant increase in the accuracy of load estimation compared to the

previously used Standardised Load Profile (STP) method. The use of STP remains crucial for load flow analysis, as smart metering has only recently been introduced in the Czech Republic. However, the AI model predicts energy consumption for customers without Automated Meter Management (AMM) measurements more accurately than the conventional STP-based estimation. This improved individual consumption prediction directly contributes to a more precise understanding of load distribution at the feeder level. The AI model substantially reduced the deviation between estimated and actual values, supporting better planning, enhancing grid stability, and opening new possibilities for predictive maintenance and demand forecasting. Most importantly, **the solution enables CEZd to bypass a massive capital expenditure**, demonstrating how advanced analytics can drive smarter and leaner grid operations.



Comparison of average energy consumption modelling by time of day on weekends (top) and workdays (bottom) using MLP and STP methods. The MLP model demonstrates significantly improved accuracy, achieving a 36.66% lower root mean square error (RMSE) than STP on weekends and a 41.29% lower RMSE on weekdays.

KEY SUCCESS FACTORS

The success of the project was underpinned by several critical enablers. First and foremost, the **availability and quality of historical data** played a crucial role in training and validating the machine learning models. A **robust ML infrastructure** allowed for efficient development, testing, and iteration of predictive models. Equally vital was the **strong collaboration between the data science team and operational experts**, from business stakeholders who provided strategic alignment to field technicians who contributed essential domain knowledge. As part of the validation process, **field workers** were also instrumental in temporarily installing measurement hardware at selected feeders to provide real-world data for comparing estimated values with actual load measurements. This hands-on support ensured the model's accuracy and relevance in operational conditions. This interdisciplinary approach ensured that the solution was not only technically sound but also aligned with real-world operational needs.

WAY FORWARD

Following the success of the project, CEZd is now focusing on **scaling the solution across its entire distribution network**. Efforts are also underway to further automate the solution. This initiative represents a major step towards a more intelligent and efficient energy distribution system, mainly at the low-voltage level, leveraging data science to deliver high-impact results without incurring prohibitive infrastructure costs.