Master's Thesis Project Plan

Electricity Consumption Forecasting Using High-Resolution Customer Data and External Data Sources

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1 Introduction

Bakgrund och syfte med studien. Varför är detta ett viktigt ämne att studera, vilken kunbskapslucka försöker du täppa igen (från tidigare forskning alltså)?

In recent years, the electricity market has been affected by large variations in price and periodically very high electricity prices. This has increased the need for customers to understand and influence their electricity consumption and future electricity costs. To address this need, Umeå Energi has worked on developing and improving their interfaces for customers, for example by developing an application for private customers. Customers wish to, before the invoice arrives, receive an estimation of the electricity cost. A first step towards a cost forecast is forecasting the electricity consumption. Currently, Umeå Energi has developed a linear regression model to forecast the consumption for the current month. The model is based on historical consumption and temperature, aggregated by month. For certain customer groups, Umeå Energi has access to high definition measurement data where electricity consumption is registered on a 15-minute level, which creates opportunities for more advanced modeling. There may also be other factors, apart from historical consumption, that affect the electricity consumption, for example weather data, calendar information (holidays etc.), and energy prices.

The goal with this Master's thesis is to develop and evaluate forecasting models that show the predicted energy consumption for the current month. The forecast will be updated continuously during the month, and as actual observed values of electricity consumption become available, these values will

be used to improve the forecast. Explainable AI will be used to evaluate the contributions of different variables to the forecast.

2 Problem Formulation

This project aims solve the problem of accurately predicting customers' electricity consumption based on consumption data and external data sources. The forecasts will have a monthly scope. Several research questions are posed:

- What type of forecasting model gives the best results for predicting electricity usage of the current month?
- Which external sources of data contribute to the accuracy of the forecast, and which sources provide little to no improvement?
- How can the accuracy of the forecasts be validated over time after the models are implemented in production?

3 Method

To answer the research questions, the following main steps will be performed:

- **Literature study**: Review existing work in the field of electricity consumption forecasting, in order to gain valuable theoretical background and insights on suitable statistical/ML models.
- **Data gathering**: Assemble 15-minute level electricity consumption data, as well as relevant external data sources (such as weather data, calendar data, and electricity prices).
- **Development and evaluation of models**: Implement and evaluate several different statistical and ML (possibly DL) forecasting models.
- **Evaluation of data sources**: Analyze and evaluate how different combinations of the data sources contribute to the accuracy of the forecasts. The goal is to identify data sources that add significant value, and sources that are not able to motivate the increased complexity.
- **Continuous forecast updates**: Develop a method for improving the forecasts during the current month by continuously replacing predicted values with actual observations.

- **Integration perspectives**: Develop a prototype that demonstrates how the forecasting models can be integrated into Umeå Energi's existing environments (Microsoft SQL Server). The prototype includes reading of input data from database tables, execution of forecasting models in Python, and storing of results.
- **Quality assurance**: Develop a suggestion on how to continuously follow up the accuracy of the models after implementing them in production.

3.1 Evaluation Methods

Evaluation will mainly be performed on the data sources' contributions and the different models' performance. As a baseline comparison, an existing linear regression electricity consumption model (based on historical monthly consumption and temperature data) will be utilized. The different statistical/ML/DL models will also be evaluated and compared against each other. For the data sources, different combinations will be investigated, and their contribution to the forecast accuracy will be evaluated both individually and in the different combinations. Results will be evaluated for statistical significance.

4 Literature

- An overview of many studies in the field: [1].
- Forecasting cooling energy using ANN: [2].

5 Implementation

The implementation of the project consists of models for predicting electricity consumption, as well as integration of resulting model predictions in the existing database. The models will predict based on electricity consumption data from Umeå Energi's database, idk. Part of the implementation is also to use Explainable AI (XAI) methods to evaluate the contributions of each variable to the prediction.

6 Work Structure and Time Plan

The work structure of the project will follow agile principles, in order to allow flexibility and adjustments of plans as the project develops.

7 Risk Analysis

- Risk 1:

8 Supervision

8.1 UmU Supervision

Table 1: Contact information for internal supervisor.

Name	Esteban Guerrero Rosero
Email	esteban.guerrero@umu.se

8.2 External Supervision

I will be spending most of my time at the Umeå Energi office, so arranging supervision with my external supervisor will be easy. If needed, I am also able to get help from other team members at Umeå Energi.

Table 2: Contact information for external supervisor.

Name	Elin Eriksson
Email	elin.eriksson@umeaenergi.se

References

[1] Mat Daut, M.A., Hassan, M.Y., Abdullah, H., Rahman, H.A., Abdullah, M.P., Hussin, F.: Building electrical energy consumption forecasting analysis using conventional and artificial intelligence methods: A review. Renewable and Sustainable Energy Reviews **70** (April 2017) 1108–1118

[2] Deb, C., Eang, L.S., Yang, J., Santamouris, M.: Forecasting diurnal cooling energy load for institutional buildings using Artificial Neural Networks. Energy and Buildings **121** (June 2016) 284–297