English Summary

As society moves towards increasing electrification in areas such as transportation, the future peak electricity demand may very well exceed the capacity of the electricity grid. Consumption flexibility is expected to play an important role in peak shawing and smart meters can help analyze demand. Electricity smart meters are capable of recording consumption at very high frequency, down to the minute. These recordings allow for unprecedented consumption insights and identification of consumption patterns and flexibility. This thesis investigates the ability of electricity smart-meter consumption data to be used for consumption clustering to identify consumer types and enable diverse tariff structures and thus incentivize flexible consumption patterns.

Through a systematic literature review the state of the art in smart meter consumption clustering is outlined and evaluated, the systematics of the review ensure reproducibility of the results. The review identifies that simple methods such as K-Means and Hierarchical clustering are prevailing; though more advanced methods are applied but their complexity and lack of improved cluster structures render them as unpopular choices. The review recognizes that smart-meter consumption data collected for billing purposes are applicable for clustering, but that the clusters are ambiguous, and their long-term stability is questionable.

The lessons from the review are applied to a Danish electricity consumption dataset containing readings from more than 32,000 smart meters. The results obtained from the Danish data are comparable to international studies of electricity smart-meter consumption data. Furthermore, the analysis of the data introduces autocorrelation features to successfully improve the clustering potential of K-Means to include temporal dependencies. The clusters produced are still ambiguous but clustering is finer grained and within-cluster variance is reduced. It is investigated if the results from the review and the electricity data are readily applicable for clustering of smart-meter district heating consumption data. The methods used for electricity data are successfully applied to cluster consumption for district heating heat exchange stations, without change in methodology. The results are similar to those of electricity consumption clustering with equivalent conclusions regarding clustering of consumption data with temporal components.

This thesis further investigates the time stability of the developed clusters by introduction of a novel methodology; Varatio able to evaluate if households are clustered together over time. Varatio applies variance ratios to compare clustering solutions. The analysis of cluster stability shows that the smart meter consumption clusters produced by K-Means are highly unstable, with stability of clusters being less than 20% of the meters.

The thesis concludes that smart-meter data can be applied to identify consumption clusters, but the current prevailing methodology produce academically viable clusters with limited practical applicability. There are structures in the data that the methodology currently applied are unable to manage e.g. reduce the within cluster variance to such a degree that the clusters are uniquely defined and identifiable. Further research into methods for time series clustering is needed to control the cluster variance and enable distinct consumption clusters.