Possible Title: Load prediction of partially observed (digitalized) systems using Machine Learning

Thesis description

Swedish authorities in order to prevent climate change and environmental pollution have set as national goals to achieve 100% power produced by renewable energy resources by 2040 and 0% CO2 emissions by 2045 in the Swedish power system value chain. To this end, several technologies are deployed. Renewable energy resources, storage systems, smart monitoring, big-data handling, artificial intelligence and internet of things (IoT) are some important enabling technologies aiming to optimize and secure the performance of energy systems by balancing demand and supply. Optimal and secure performance of the electricity grid entails extended measuring infrastructure (high level of observability) for real-time measurements. To this end, advanced metering infrastructure like smart meters are used for energy systems digital observation regarding power production, load demand and in general, system estimation. Despite the recent vast deployment of smart meters (SMs), the monitoring of energy system is still underdetermine. In addition, privacy issues and possible metering or communication problems causing missing and/or delayed data create partially unobserved and/or fully unobserved parts of the energy system that in turn contribute to real-time measurements scarcity. This lack of knowledge in real-time behaviours about power production from renewable energy resources, storage capacity and load demand inhibits effective monitoring and management of energy systems. One approach for solving this problem is to widely install SMs, which is cost prohibitive while privacy technical issues are still real barriers. Alternatively, data-driven real-time estimation based on machine learning for inferring systems' behaviours is a feasible alternative solution for electric utilities and companies active in the smart solutions software applications.

This thesis aims to apply machine learning for load demand classification and estimation with limited available time-series data. In particular, clustering and classification methods are going to be developed by using time-series data from fully digitalized systems. Then, regression models are going to be developed to predict energy demand by using monthly billing data from un-observed or partially observed systems. The expected results contribute to improved energy systems observability and operations such as, demand response incentives, peak shaving and ancillary services, energy management optimization for efficient deployment and coordination of energy resources as well as electricity grid security to balance supply and demand segments.

The thesis project is supported by DAMI4.0 research center at Karlstad University via AI-4ENERGY project in terms of data sharing, co-participation in working groups and advisory issues. The project's workflow is preliminary described as follows. At first, load classification, segmentation and prediction by using real measured time-series data is conducted. Then, Machine learning models will be trained to cluster and classify consumption patterns, to identify multi-time-scale consumption components and then to predict consumption load profiles in cases of partially observed or fully unobserved customers with limited and/or missing data by using their monthly billing data.

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