Data-Driven Demand-Response Modeling for Electricity Consumption in Sri Lanka

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K. A. D. Deshani
Faculty of Science
University of Colombo
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Abstract

Due to inaccurate demand forecasts in Sri Lanka, especially during the peak times, the authorities use high cost electricity generation options needlessly. This causes a considerable economic loss, which can be avoided with accurate forecasts. To address this national issue, this research developed a short term load forecasting system with high accuracies and named it as "***Two Level Neuro-Functional Load Forecaster***". Thus, this method could facilitate the decision making process of the Ceylon Electricity Board when scheduling and managing available electricity generation options for the next day. Accuracy levels were high, even with scares data. This method is generalized and can be customized to suit other applicable contexts.

The hourly electricity demand from 2008 – 2012 was considered for this research. Through a comprehensive cluster analysis process, similar day types were identified as clusters, where the results obtained were used in making the forecast more accurate as well as to make the training processes more efficient. Literature revealed that temperature is highly correlated with electricity demand and it was decided to incorporate temperature to the models to capture weather sensitive load. To address the scarcity of the hourly temperature data, a novel methodology named as "***MinMax Cos-LEA estimation***" was implemented to estimate hourly temperature readings using daily maximum and minimum temperatures. This method outperformed the existing methods in the literature for the Sri Lankan context which is a significant contribution of this research. This method was further improved with the inclusion of the influential variable rainfall, and was named as "***RATE***" (Rainfall Adjusted Temperature Estimation). No published work was found incorporating influential factors, when estimating hourly temperatures. A general methodology named as "***MinMax Curve Estimation***" has also been presented to customize and used in other similar applications.

The final load predictive model, ***Two Level Neuro-Functional Load Forecaster,*** is a novel hybrid model, combining functional principal component regression approach with a neural network approach using data at daily and hourly levels. This model is capable of accommodating more recent data, with a moving window, bringing a dynamism to the model. The novelty of the model is due to its unique combination of a statistical and a neural network approach and its dynamism. When forecasting electricity demand of the next day, temperature values required were forecasted using a neural network

The implemented model was tested for demand data in 2012, where average Mean Absolute Error for the entire year was 3.324%. The peak time had been accurately forecasted, which is very crucial in scheduling high cost generation options which are very costly. The obtained accuracy of this hybrid method can be argued to be high, with the limited data, when compared to other related forecasting models. A user friendly computer system was developed incorporating four forecasting approaches, that generating the demand plots and their respective accuracy levels.