Chapter 1

Introduction

1.1 Background of Research

The tendency of increasing consumer demand with time and the need to meet load demand continuously caused electricity demand analyses are important to be done as a basis to maintain optimal performance of a power system. A demand analysis can be in the form of characteristics analysis, load forecasting, and etcetera. Basically, each form of the analysis provides different output information regarding situation of demand. For analysis of characteristics, it is done to identify relationship between observed electricity consumption and related driver variables under a certain condition. How far considered variables influence demand, and which one dominantly affect the demand are kinds of information that possibly resulted from the analysis. Knowing the information may facilitate electric utilities to serve consumer demands in power systems more effective by means of continuity of supply, high quality, and economic. Effective operation of power systems gives benefits not only to utilities, but also to electric consumers.

In general, one of the essential tasks to carry out demand analysis is identifying of appropriate variables in the composed model. As a tool analysis, variables which involved in the model that can explain situation of demand maybe unique in one place [1] and area. The situation causes a proper identification concerning driver variables is required to determine necessary drivers when construct a demand model. For example, meteorological parameters, they probably differ in magnitude, timing, and type of parameter in one place associated with demand. Involving of appropriate variables in a model may lead to the effectiveness of model. Besides, as only important data are considered, it may also reduce computational burden when estimation of the model parameters. From this viewpoint, suitable demand model should be developed based on the environment where the demand
case is located (place based) [1,2]. In this framework, all kinds of driver variables in terms of general and unique (local) variables which influence / have link to demand can be highly considered in the models. However, the availability and accessibility of variables data are other important aspects since some of them maybe not open for public or not available at certain place.

To present a demand analysis, a method or approach is normally used. Regression analysis [1-8], principal component analysis (PCA) [9], index [10], curve fitting technique [11], and methods under computational intelligence (such as artificial neural network (ANN) [12-14], fuzzy logic [15]) are some kinds of methods that have been used successfully. However, each method has its own concept and system in its application to solve a problem. Therefore, applied approach is commonly based on the purposes of study to achieve good results.

For regression analysis, application of this approach to analyze electricity consumption at certain place can be found in [1-8] as stated before. Reference [1] investigated influence of economic variables to the annual electricity demand in Northern Cyprus. Reference [2] developed model for residential electricity consumption for Bangkok Metropolis (RECB) using regression analysis, to analyze effect of climatic and economic factors on demand, and to forecast the demand. Reference [3] developed a model for all sectors using a stepwise procedure to forecast daily electricity demand in Spanish. Reference [4] developed regression equations to analyze residential electricity demand in Hong Kong by using climatic and economic variables. Reference [5] developed two statistical models, namely daily and monthly models to forecast electricity demand up to 12 months ahead (mid-term demand) in Greece. Reference [6] investigated economic and demographic variables to develop a long-term electricity demand forecasting model in Italy. Reference [7] used regression analysis to examine relationship between electricity consumption in Jordan and climate/non-climate factors. Meanwhile in Ref. [8], the authors studied effects of economic and demographic factors for electricity load forecasting in New Zealand.

As electricity demand consumption may differ to time [2,4] and place in general, this research attempts to find electricity demand characteristics for Japan context by developing demand models specifically for seasonal level. The analyzed demands are two major
demand areas in Japan which consume relatively high electric energy namely residential and commercial. These areas are mainly correlated by meteorological parameters and existing holidays, use typical normalized hourly data. Regression-based seasonal models are developed to reveal more detail the characteristics of demands. Another models namely half-year models are also constructed for characteristics investigation. Besides, a demand comparison between areas is carried out by introducing testing models in the analysis to check logically whether studied demand areas is different related to implemented variables. The proposed demand models are validated by many standard statistical tests. Several options when constructing models are also calculated and assessed to get the better results. As an effort to find Japanese electricity consumption characteristics, the overall results confirmed that more specific demands characteristics can be revealed through the proposed models which validated well for both residential and commercial areas. Likewise in demand comparison, clearer characteristics comparison can be achieved.

The application of regression analysis in the context of this research is quite effective. Beside obtained regression coefficient and statistics provide information about direct relationship between demands and implemented variables, the models are not difficult to construct as well. There are potential benefits can be obtained from results of this research. It is expected that proposed models are useful in quantifying influence of variables or contribution on demand for certain period or area. Besides, as a part to maintain operation of power systems, it is helpful in drawing seasonal strategies to meet existing demands continually in certain periods, and also in understanding situation of demand more detail.

1.2 Research Objectives

This thesis presents an electricity demand characteristics analysis for Japanese demand areas. Regression-based seasonal models are proposed to reveal in detail characteristics of the demand for more specific periods. The developed models (summer, autumn, winter, and spring models) are based on the season periods in Japan. Another model that is half-year demand models is also composed to investigate demand characteristics under specific condition of temperature and humidity as mainly load drivers. The observed demands are residential and commercial areas in one specific city in Japan. A comparison characteristics
analysis between areas for seasonal level is also performed to investigate how far the same variables influence differently electricity demand areas. Applying statistical tests shows composed demand models are validated well. The proposed models reveal more specific information which can facilitate developing characteristics analysis for observed demand areas.

1.3 Scope of Research
An electricity demand model is commonly developed based on the place to capture important variables which influence an electricity demand. Therefore, demand model is unique which probably different at each place. The proposed seasonal demand models are developed to analyze more detail electricity consumption characteristics in one specific city in Japan by using meteorological parameters as primary variables. Regression-based demand models are using to reveal characteristics of the observed demands i.e. residential and commercial areas under certain time period. In this framework, selecting proper variables especially for meteorological parameters in each model and area which is based on the season periods in Japan is an important part when constructing the models. As relationships between observed demand and temperature are non-linear, heating and cooling degree days (HDD and CDD) variables are implemented in the models [3,5,10]. Each composed model is validated by many statistical tests. To determine better models, some options for models are assessed by using standard tests i.e. Akaike Information Criterion and Schwarz Criterion [3,5]. The adjusted coefficient of determination ($R^2$) values of models is also assessed. Beside seasonal models, another demand models that is half-year models which is different in time length are also developed. By these models, specific characteristics of related demand under two different conditions of temperature and humidity can be explored. Two demand period separation categories are calculated and assessed. Next, characteristics comparison analysis especially between residential and commercial areas is carried out. The analysis procedure includes composing (initial) models, creating testing models, determining models for comparison analysis, and selecting best model. The comparison analysis is specifically done in the seasonal level.
1.4 Structure of Thesis

The structure of this thesis is organized into five chapters as follows:

Chapter 1 is introduction of the thesis which consists of research background, research objectives, scope of research, and structure of the thesis.

Chapter 2 presents analysis of typical electricity demand characteristics of residential areas in Japan using regression-based models. This chapter reports the seasonal variation of characteristics in three demand places for residential area.

Chapter 3, in this chapter, electricity demands characteristics investigation based on regression models for Japanese commercial area is presented. Two period levels of seasonal demand models are developed to reveal more characteristics for the studied area.

Chapter 4 presents comparison of electricity demand characteristics between areas i.e. residential and commercial areas. This chapter shows the difference effects of meteorological variables on the observed demands specifically.

Chapter 5 concludes by summarising the main results of the research in each part. Recommendations for future research are also outlined.
Chapter 1. Introduction

References


