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Forecasting electricity consumption in Pakistan: the way forward

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HIGHLIGHTS

- We forecast total and component wise electricity consumption for Pakistan.
- Electricity shortfall in Pakistan will increase in future if same situation exists.
- Various options exist to cope with the electricity crisis in the country.
- Holt-winter model gives best forecasts for electricity consumption in the country.

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ABSTRACT

Growing shortfall of electricity in Pakistan affects almost all sectors of its economy. For proper policy formulation, it is imperative to have reliable forecasts of electricity consumption. This paper applies Holt-Winter and Autoregressive Integrated Moving Average (ARIMA) models on time series secondary data from 1980 to 2011 to forecast total and component wise electricity consumption in Pakistan. Results reveal that Holt-Winter is the appropriate model for forecasting electricity consumption in Pakistan. It also suggests that electricity consumption would continue to increase throughout the projected period and widen the consumption-production gap in case of failure to respond the issue appropriately. It further reveals that demand would be highest in the household sector as compared to all other sectors and the increase in the energy generation would be less than the increase in total electricity consumption throughout the projected period. The study discuss various options to reduce the demand-supply gap and provide reliable electricity to different sectors of the economy.

1. Introduction

Energy is an important ingredient for the economic growth and development of any country. Electricity being a highly versatile form of energy, fuels the performance of almost every sector of an economy. The miserable failure of Pakistan's energy policy over the last few decades has left the country with acute electricity crisis and causing its economic underperformance. Like Spain (Carcedo and Otero, 2005), New Zealand (Mohamed and Bodger, 2005) and other advanced countries (Larson and Bromley, 1990), Pakistan's electricity demand is partly driven by factors such as the burgeoning population, extended set of economic activities, the price of electricity, the movement of people to cities and weather. However, issues which are specific to Pakistan and turn its electricity shortfall into a crisis are theft, misuse and overuse of electricity at household and industrial sectors, unjustifiably huge line losses, low institutional capacity, corruption, mismanagement and political controversies over mega power projects (Government of Pakistan, 2013).

Among the influencing factors of escalated electricity demand, population growth deserves specific mention. The population of Pakistan was 79.98 million in the year 1980 increasing to 176.17 million in the year 2011 (SESRIC, 2014). On the other hand, the energy consumption in the year 1980 was 24759.68 thousand metric tons of oil equivalent while its production in the same period was 20922.38 thousand metric tons of oil equivalent. The increasing gap persists till 2011 where the total energy consumption was 84844.56 thousand metric tons of oil equivalent and total production was only 65066.58 thousand metric tons of oil equivalent (SESRIC, 2014).

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Furthermore, the number of domestic consumers is expected to grow from 17152209 in 2010 to 20908447 in 2020 (National Transmission and Dispatch Company, 2008). The electricity shortfall in the year 2008 was 3338 MW and will reach 13651 MW in the year 2020 (Private Power and Infrastructure Board, 2008). Besides, the activity net of the economy has been extending overtime as the past trend shows an increase Pakistan's Gross Domestic Product (at 2005 constant prices) from the US$ 34399.85 million in the year 1998 to the US$ 143102.00 million in the year 2011 (SESRIC, 2014). All these statistics suggest that the gap between demand and supply is widening and require more attention.

The policymakers should have sufficient information about the future electricity consumption in order to take adopt appropriate measures to bridge this gap. In Pakistan various studies have been conducted focusing on sectorial level demand of electricity (Iqbal et al., 2013; Nasir et al., 2008), sources of electricity (HAWA, 2014) and its residential consumption (Alter and Syed, 2011; Malik, 2012). However, literally no one has forecasted component wise electricity consumption and identified an appropriate model for the country's electricity consumption forecasting. The present scenario necessitates carrying out research over the issue of electricity forecasting, and this piece of work will bridge this gap. Therefore, the objective of this paper is to forecast total and component wise electricity consumption in Pakistan. The findings will have useful policy implications for sectorial planning and management of electricity demand in the country.

2. Methodological choices for forecasting electricity consumption

Literature on forecasting models is full of controversies as determining the future is complex and tied with infinite possibilities. In economic analysis, forecasting is made to predict future based on past observations (Brockwell and Davis, 2006; Granger and Newbold, 2014; Makridakis et al., 2008). Although there are arguments in against and in favor of using forecasts for policy analysis (Sims, 1986; Zaman, 2012), many researchers support it arguing that forecasting provides guidelines for policymakers to take steps for the future based on past experiences. Although it is impossible to predict a future scenario exactly as it would be, but too many things run smooth over time. Therefore, researchers always strive to tackle this issue with minimum possible errors.

For forecasting a time series variables both single and multi-equation techniques are available (Hamilton, 1994; Kuo et al., 2001; Park et al., 1991; Pesaran and Pesaran, 2010; Pindyck and Rubinfeld, 1998). Regression analysis adjusts one or more inputs to forecast a variable (Haida and Muto, 1994; Levis and Papageorgiou, 2005; Papalexopoulos and Hesterberg, 1990). The exponential function method projects a variable by fitting exponential curve rather a straight line. However, to entertain different growth rates, Power Function is used for projections. The moving average method forecasts based on the average of past observations by assigning the same weights. While the Exponential smoothing method assigns different weights to each observation in projecting a time series variable (Wei, 1994; Winters, 1960).

Autoregressive Integrated Moving Average (ARIMA) model projects a time series univariate variable based on three parameters i.e. order of the moving average, order of differencing and order of autoregressive scheme (Kavasseri and Seetharaman, 2009; Williams and Hoel, 2003; Zhou et al., 2006). The Holt-Winter forecasting model not only entertains the exponentially smoothed component but also the trend component while projecting a time series variable.

Researchers used different methodologies to forecast electricity consumption. Saab et al. (2001) estimated Lebanon's one-period ahead monthly electricity consumption during 1990–1999 different models and they proposed that the AR(1) high pass filter model is best for forecasting energy data.

Kermanshah and Iwamiya (2002) applied back propagation network and Jordan recurrent network to forecast long-term electricity energy consumption in Japan. Al-Saba and El-Amin (1999) projected Saudi Arabia's peak load from the year 1997 to 2006 by applying artificial neural network (ANN) and Box–Jenkins methods and compared the results of these two techniques. The neural network has the feature to process many things simultaneously while ANN is the one of its type. Hamzacebi (2007) applied the ANN model to project electricity consumption in Turkey. He found that electricity consumption would increase for industrial, residential, agriculture and transportation would increase in the 2020. The industrial sector would have the highest increase (49.9%) as compared to other sectors. Erkan (n.d) used cointegration analysis, ARIMA models for the forecasting turkey electricity demand. He also compared the results with official projections.

Pai (2006) forecasted local electricity loads in Taiwan and proposed a Hybrid Ellipsoidal Fuzzy System for Time series forecasting (HEFST) as suitable and good alternative method for forecasting local electricity loads. For forecasting electricity consumption, Azadeh et al. (2007) proposed ANN method based on supervised Multi-Layer Perception (MLP) while Lepojević and Anđelković-Pešić (2011) proposed the Holt-Winters model and seasonal regression models.

For efficient allocation of resources, it is important to have reliable projections. Brandt and Bessler (1983) pointed out that forecasting methods yields good information for policymaking and health of good decisions depend on good forecasts (Diebold and Lopez, 1996). As the situation is more serious in Pakistan, where electricity shortage hits almost all the sectors, an inappropriate policy response may cause a further slowdown of the economic growth. The present study advances in literature as it applies Holt-Winter and ARIMA forecasting models for forecasting electricity consumption in Pakistan up to 2020, followed by identification of an appropriate model to forecast electricity consumption in the country. The study also elaborates some policy options to tackle the growing electricity shortfall in Pakistan.

3. Methods

The ARIMA and Holt Winter forecasting models are widely used in literature (Cholette, 1982; Ediger and Akar, 2007; Kumar and Jain, 2010; Makridakis et al., 2008; Mohammadi and Su, 2010; Roberts, 1982; Shouluan et al., 2003) and are appropriate methods for long-term projections utilizing time series data. Therefore, those two methods have been applied and compared their results in this study. The appropriate forecasting model out of these two has also been identified.

The Holt-Winter forecasting model had been successful for forecasting electricity consumption. Taylor (2003) used this model to forecast electricity demand and concluded that the Holt-winter outperform as compared to well-fitted ARIMA models. Taylor (2008) forecasted the electricity demand for UK and concluded that the Holt winter gave the best forecasting results.

The other methods like moving average and exponential smoothing methods are not included in the analysis, because of their limited application for long-term forecasts. Furthermore, the other methods rely on too many assumptions for their validity. However, the ARIMA Model is associated with few flexible assumptions (Ho and Xie, 1998; Ho et al., 2002). These models translate the pattern of past data into the future absorbing the effect of various influencing factors. In fact, the ARIMA and Holt-Winter models are already used in the other countries of the