FORECASTING ELECTRICITY CONSUMPTION USING AUTO-REGRESSIVE INTEGRATED MOVING AVERAGE

Kennet G. Cuarteros[1], Noel G. Cuarteros, Jr.[1]
[1]University of Science and Technology of Southern Philippines, Lapasan Highway, Cagayan de Oro City, Philippines
*For Correspondence; Tel. +639176774482, Email: kennet.cuarteros@ustp.edu.ph

ABSTRACT: *Electricity plays a vital role in this modern world. It is considered the backbone of an economy's prosperity and progress. The availability of a huge amount of energy has resulted in a shorter working day, higher agricultural and industrial production, and have better transportation facilities. Modern society is so much dependent upon the use of electrical energy that it has become part of our life. It forms a key part of human everyday life. As the economy grows, demand for energy increases. Cagayan de Oro City's growing population and developing technology have demanded increasing consumption of electrical energy to provide light, heat, and power for the countless machines that are essential to the life and work of the residents. Usage will continue to increase because of rising living standards but higher costs may act to reduce the rate of rising. With the premise, there is a need to predict the future electrical power consumption to help CEPALCO to be prepared and for them to provide sufficient electrical energy for Cagayan de Oro City. Statistical forecasting is a method that uses the past to predict the future by identifying trends and patterns within the data to develop a forecast. The study deals with the application of autoregressive integrated moving average (ARIMA) for electrical power consumption in Cagayan de Oro City. After obtaining the results of ARIMA, it shows that ARIMA accumulates less absolute percentage error. The reason why ARIMA performed well is that the nature or behavior of the data that have been gathered contains linear trends although the data are fluctuating still the behavior is increasing which implies that the data of the monthly electricity consumption are more likely linear. Hence, the more the behavior of the data becomes linear, the more ARIMA is effective in forecasting.*

Keywords: electricity consumption, forecasting, auto-regressive integrated moving average, mean absolute percentage error

1. INTRODUCTION

Energy is the basic necessity for the economic development of a country. The availability of a huge amount of energy has resulted in a shorter working day, higher agricultural and industrial production, and have better transportation facilities. Modern society is so much dependent upon the use of electrical energy that it has become part of our life. It forms a key part of human everyday life. As the economy grows, demand for energy increases.

Electricity is a typical form of energy and plays an essential role in modern life, bringing benefits and progress in various sectors, including transportation, manufacturing, mining, and communication sectors. Electricity is considered the backbone for an economy's prosperity and progress thus it plays a crucial role in socio-economic development [1]. The electricity consumption model reveals a significant trend due to socio-economic factors. The monthly behavior of our forecast values depicts that the electricity consumption is more for the summer season and this demand is expected to increase in the future. The forecast model and the forecast values reveal that electricity consumption is increasing over time.

The Cagayan Electric Power and Light Company, Inc. or CEPALCO is an investor-owned electricity distribution utility company serving Cagayan de Oro City (CDOC) and the other nearby municipalities in Misamis Oriental namely: Tagoloan, Villanueva, and Jasaan.

Cagayan de Oro City's growing population and developing technology have demanded increasing consumption of electrical energy to provide light, heat, and power for the countless machines that are essential to the life and work of the residents. Usage will continue to increase because of rising living standards but higher costs may act to reduce the rate of rising. With the premise, there is a need to predict the future electrical power consumption to help CEPALCO to be prepared and for them to provide sufficient electrical energy for Cagayan de Oro City.

Electricity is a known catalyst for economic growth and development. Cagayan de Oro is one of the developing cities in the country suffering from a high shortage of power supply due to some factors. Therefore the proper provision of adequate, affordable, accessible, and sustainable electricity supply is critical to development in Cagayan de Oro City. It is still grappling with problems of generating enough electricity to meet the demand of more than 100 MW.

Statistical forecasting is a method that uses the past to predict the future by identifying trends and patterns within the data to develop a forecast. The study deals with the application of autoregressive integrated moving average (ARIMA) for electrical power consumption in Cagayan de Oro City. The forecast of electrical power consumption 5 years from 2014 was shown in the study.

2. LITERATURE REVIEW

This section discussed the studies that have been carried out which have only one purpose, that is to forecast the electricity consumption.

2.1 Studies related to Electrical Energy Consumption

The study of [2] used Seasonal ARIMA to generate a five-year forecast of Davao del Sur Electric Cooperative. According to the results, there were two models used to forecast the electricity consumption, namely, ARIMA (0,1,1) x ARIMA $(0,0,2)_{12}$ and ARIMA (0,1,1) x ARIMA $(0,1,1)_{12}$. However, ARIMA (0,1,1) x ARIMA $(0,1,1)_{12}$ model outperformed ARIMA (0,1,1) x ARIMA $(0,0,2)_{12}$ model in terms of the mean error between the actual and the forecasted values.

In Brunei, [3] investigated the electricity consumption pattern of the residence at Lambak Kanan National Housing Scheme. Findings show that high consumption of electricity and monthly electricity cost include electrical appliances, air-conditioners, fluorescent lamps, and water heaters. With this, there is a challenge in electricity conservation even if

the households are aware of the high consumption. Due to the low price of electricity, the high monthly electricity bill is still affordable and households tend to neglect its effects. It was deduced that the challenges of energy conservation among households in the country would be the existing low energy-efficient technologies built-in households, lack of knowledge on the principles of energy conservation, and being content on the cheap electricity price. With these challenges, there is a call for the decision-makers in Brunei to create measures or programs to establish the implementation and enforcement of energy conservation policies, develop alternative renewable energy sources to augment the consumption, and prioritize energy-efficient air-conditioners to all manufacturers.

Moreover, developing countries are rapidly increasing electricity energy consumption since they foster economic growth currently [4]. Technology and population growth are among the factors that increase electricity consumption. Based on the results, there are 32 developing countries considered together with their corresponding gross domestic product (GDP), price of oil, and electricity consumption. Findings show a significant relationship among these variables.

2.2 Studies related to Forecasting Electrical Energy Consumption

Yasmeen, F. *et. al.,* [1] forecast the electrical energy consumption in Pakistan. In their study, they forecast the electricity from January 1990 through December 2011 using linear and nonlinear modeling techniques. The models include ARIMA, Seasonal ARIMA (SARIMA), and ARCH/GARCH. Based on the results, the ARIMA (3,1,2) model is the most appropriate model for forecasting the electricity consumption of Pakistan. The monthly behavior of their forecast values depicts that the electricity consumption is more for the summer season and this demand is expected to increase in the future over time. This research justified that Pakistan has been facing a severe imbalance between energy and energy supply. During the past 25 years, the energy supply in Pakistan has been increased by around 40 times, but still, the demand outstrips supply.

Others [5], forecasted electricity consumption in New Zealand using economic and demographic variables. The influence of selected economic and demographic variables on the annual electricity consumption in New Zealand has been investigated. The study uses the gross domestic product, the average price of electricity, and the population of New Zealand during the period 1965-1999. Models are developed using multiple linear regression analysis. Findings show that electricity consumption correlated effectively with all variables. Forecasts made using these models were compared with some available national forecasts. The forecasts are also compared with the forecasts of the previously developed Logistic model.

3. METHODOLOGY

Forecasting with Autoregressive Integrated Moving Average

1. Collect data of Cagayan de Oro City's monthly electric consumption from CEPALCO from the year 2007 – 2014.

The data gathered from the Cagayan de Oro City will be used for constructing time series models specifically ARIMA and MFNN process.

2. Test for Seasonality

In testing for seasonality, it assures that the data did not possess any seasonal behavior. The test was also conducted because the study was focused on nonseasonal ARIMA modeling.

3. Identify Presence of Stationarity

The time series plot of data is used to discuss if the stationarity of the data exists. If the time series varies about s fixed level and has a constant mean and constant variance, then the data is said to be stationary, otherwise, the data is nonstationary.

4. Select the Best Model for Forecasting

Model selection in the Box –Jenkins framework was performed to try to identify potential ARIMA processes which might provide a good fit to the data. Looking at the measure of accuracy values has led to model selection tools using the mean absolute percentage error (MAPE).

5. Forecast the Monthly Electricity Consumption of Cagayan de Oro City

The model with the least mean absolute percentage error was used to forecast the monthly electricity consumption of Cagayan de Oro City for 2015-2019.

4. RESULTS AND FINDINGS

Electricity consumption forecasting is an important issue for electricity distributors and providers. Having reliable electricity consumption forecasting information will make a better financial decision.

The data used for this study are the monthly electricity consumption from January 2007 to December 2014 that was gathered from Cagayan Electric Power and Light Company (CEPALCO) including the number of customers and energy price and the monthly temperature was taken from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

Table 4.1: Summary of MAPE of all the ARIMA Models in Electricity Consumption

Residential		Commercial		Industrial	
The Models	**MAPE**	**The Models**	**MAPE**	**The Models**	**MAPE**
(1,1,1)	2.7379	(1,1,1)	3.4037	**(1,1,1)**	**3.2139**
(1,1,2)	2.7288	(1,1,4)	3.4107	(1,1,2)	3.2143
(1,1,10)	2.5168	(4,1,1)	3.4088	(1,1,6)	3.5019
(2,1,1)	2.7185	(4,1,4)	3.3517	(1,1,8)	3.4993
(2,1,2)	2.7139	**(4,1,10)**	3.4019	(1,1,9)	3.5082
(2,1,10)	2.7139	(10,1,1)	3.4319	(6,1,1)	3.5181
(3,1,1)	2.7157	**(10,1,10)**	**3.337**	(6,1,9)	3.663
(3,1,2)	2.7187			(10,1,1)	3.564
(3,1,10)	2.5854			**(10,1,6)**	3.4817
(3,1,7)	2.5786			**(10,1,9)**	3.4776
(4,1,1)	2.7100				
(4,1,2)	2.6958				
(4,1,7)	2.5647				
(4,1,10)	2.5228				
(6,1,1)	2.6651				
(6,1,2)	2.6149				
(6,1,7)	2.5862				
(6,1,10)	2.5862				
(10,1,1)	2.6204				
(10,1,2)	2.5984				
(10,1,7)	**2.3948**				

Table 4.1 shows the parameters estimate of the given autoregressive lag and moving average lag of the forecasting ARIMA models. The models (10,1,7), (10,1,10), and (1,1,1) have the least Mean Absolute Percentage Error values in Residential, Commercial, and Industrial sectors of 2.3948, 3.337, and 3.2139 respectively.

Table 4.2: Forecasted Monthly Electricity Consumption for the years 2015 to 2019 (Residential) using ARIMA

Residential	2015	2016	2017	2018	2019
Month	Predicted	Predicted	Predicted	Predicted	Predicted
January	15606044	16131339	16820067	17200097	17691510
February	15671242	16417555	16645620	17195887	17842053
March	16048944	16076235	16740542	17381558	17840938
April	15473101	16349340	16909917	17303241	17842553
May	16103289	16397030	16753953	17363803	17983865
June	15821383	16220908	16923229	17508058	17955312
July	15780749	16536754	17015813	17420201	17997965
August	16209921	16496748	16887177	17529083	18115368
September	15941252	16385578	17086532	17621633	18076685
October	15965985	16661080	17104615	17549429	18154703
November	16215639	16557804	17033407	17691326	18239857
December	16009348	16551896	17247359	17731414	18206638

Table 4.3: Forecasted Monthly Electricity Consumption for the years 2015 to 2019 (Commercial) using ARIMA

Commercial	2015	2016	2017	2018	2019
Month	Predicted	Predicted	Predicted	Predicted	Predicted
January	15837659	16903358	18018214	19066753	19430663
February	16455219	17316355	17752255	18417923	19804502
March	16439834	16894598	17640392	19010551	19967859
April	15799103	17342524	18352591	18784913	19767026
May	16511917	17381676	18115888	18926296	19794976
June	16192459	17126803	18270269	19146976	19928577
July	16439920	17181598	18310537	19176537	19800110
August	16600852	17328048	17998305	19276334	20565270
September	16599831	17272706	18501855	19587212	20148903
October	16669100	18055967	18413281	18984909	20219842
November	16904740	17480863	18349525	19364746	20609165
December	16287121	17684420	18923242	19842318	20391031

Table 4.4: Forecasted Monthly Electricity Consumption for the years 2015 to 2019 (Industrial) using ARIMA

Industrial	2015	2016	2017	2018	2019
Month	Predicted	Predicted	Predicted	Predicted	Predicted
January	10979203	11074878	11170526	11266175	11361824
February	10987195	11082848	11178497	11274146	11369794
March	10995170	11090819	11186468	11282116	11377765
April	11003141	11098790	11194438	11290087	11385736
May	11011112	11106760	11202409	11298058	11393707
June	11019082	11114731	11210380	11306029	11401677
July	11027053	11122702	11218351	11313999	11409648
August	11035024	11130673	11226321	11321970	11417619
September	11042995	11138643	11234292	11329941	11425589
October	11050965	11146614	11242263	11337912	11433560
November	11058936	11154585	11250234	11345882	11441531
December	11066907	11162556	11258204	11353853	11449502

Forecasted values, present in Tables 4.2 to 4.4, of the three sectors under electricity consumption, are then obtained. Notice that the three sectors, namely the residential, commercial, and industrial are observed to have increasing behavior. In connection with this, electricity consumption in Cagayan de Oro City is more likely to increase for the next five years.

Validation of Forecast Results

The Mean Absolute Percentage Error (MAPE) was used for assessing the forecast accuracy of ARIMA models. The values of the actual and forecasted monthly electricity consumption of the three sectors are shown in table 4.5.

Table 4.5: Comparing the Actual and Predicted values of 2015 Residential, Commercial and Industrial Sectors

	RESIDENTIAL			COMMERCIAL			INDUSTRIAL		
MONTH	ACTUAL	ARIMA	MAPE	ACTUAL	ARIMA	MAPE	ACTUAL	ARIMA	MAPE
January	16,034,560	15,606,044	2.672452503	15,033,012	15,837,659	5.352533	10,677,129	10,979,203	2.829169
February	14,357,794	15,671,242	9.147979139	14,832,016	16,455,219	10.94391	11,254,437	10,987,195	2.374548
March	15,366,303	16,048,944	4.442454376	15,099,639	16,439,834	8.875676	10,211,202	10,995,170	7.677529
April	16,416,773	15,473,101	5.748218605	15,611,495	15,799,103	1.20173	10,950,685	11,003,141	0.47902
May	17,722,507	16,103,289	9.136506477	17,262,079	16,511,917	4.345722	11,727,484	11,011,112	6.108488
June	17,362,757	15,821,383	8.877472627	17,106,330	16,192,459	5.342297	12,250,980	11,019,082	10.05551
July	16,662,664	15,780,749	5.29276111	16,108,440	16,439,920	2.057803	11,348,854	11,027,053	2.835537
August	16,723,676	16,209,921	3.072021965	16,401,263	16,600,852	1.216912	11,911,033	11,035,024	7.354601
September	18,580,154	15,941,252	14.2027994	17,737,464	16,599,831	6.41373	12,145,488	11,042,995	9.077387
October	16,377,604	15,965,985	2.513304144	16,436,830	16,669,100	1.413107	11,884,974	11,050,965	7.01734
November	17,587,868	16,215,639	7.802133835	17,182,051	16,904,740	1.613957	12,007,881	11,058,936	7.902685
December	16,377,604	16,009,348	2.248534035	16,436,830	16,287,121	0.910814	11,884,974	11,066,907	6.883204

Table 4.5 shows the validation in forecasting accuracy of the models obtained using ARIMA, actual data are compared with the predicted values in the forecasting process using mean absolute percentage error (MAPE). Results show the difference of values of the given errors of the residential, commercial, and industrial sectors with the mean of 6.263053184, 4.140683, and 5.646711 in the ARIMA model, respectively. In carrying out predictions for electricity consumption, the method with the smallest MAPE is selected to pick the most accurate model.

5. CONCLUSIONS & RECOMMENDATIONS

This study demonstrates the capability application of ARIMA to forecast electricity consumption. It investigates the relationship between predicted values for a current year based on the previous year's estimates. The study considers actual monthly electricity consumption data over the period between 2007 and 2014, to access the proposed forecasting models.

To evaluate the forecasting accuracy of the models obtained using ARIMA, actual data is compared with the predicted values obtained in the forecasting process using mean absolute percentage error (MAPE). In carrying out predictions for electricity consumption, the method with the smallest MAPE is selected to pick the most accurate and reliable method.

After obtaining the results of ARIMA, it shows that ARIMA accumulates less absolute percentage error. The reason why ARIMA performed well is that the nature or behavior of the data that have been gathered contains linear trends although the data are fluctuating still the behavior is

increasing which implies that the data of the monthly electricity consumption are more likely linear. Hence, the more the behavior of the data becomes linear, the more ARIMA is effective in forecasting.

The researcher recommends the following for further improvement of the study: (1) use another statistical method and (2) consider other parameters to predict electricity consumption.

REFERENCES

[1] Yasmeen, F., & Sharif, M. (2014, April). Forecasting Electricity Consumption for Pakistan. *International Journal of Emerging Technology and Advanced Engineering, 4*(4), 496-503.

[2] Maranga, J. V. (2011). *Modeling of Electricity Consumption of Davao del Sur Using Seasonal Arima.* University of Southeastern Philippines, Digos City, Davao de Sur.

[3] Ahmad, A., & Othman, H. M. (2014). Electricity Consumption in Brunei Darussalam: Challenges in Energy Conservation. *International Energy Journal, 14*, 155-166.

[4] Kamaludin, M. (2013, May). Electricity Consumption in Developing Countries. *Asian Journal of Social Sciences and Humanities, 2*(2), 84-90.

[5] Mohamed, Z., & Bodger, P. (2005). Forecasting Electricity Consumption in New Zealand Using Economic and Demographic variables. *Elsevier (Science and Direct), 30*(2005), 1833-1843.