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Predicting Future Monthly Electricity Consumption in the Philippines using Markov-Chain Grey Model

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Abstract

Objective: Electric energy consumption forecasting is important in electricity production planning, thus the aim of this study is to forecast the electricity consumption in every region in the Philippines for the next 3 years using the monthly data from 2013 up to 2018. **Methods:** The forecasting model used is the Markov-Chain Grey Model which has the merits of GM (1,1) forecasting model. The two models are compared and the forecasting results for the year 2018 up to 2021 of both models show that the Markov-Chain Grey Model is more precise than GM (1,1). **Findings:** In this study, the researchers deduce that highest electricity consumption was every second quarter of the year and during Christmas season. Moreover, lowest electricity consumption was every month of August. The reason for this significant fluctuation of demand in electricity were due to the damages caused by strong typhoon and heat index caused by phenomenal event El Nino. The predicted values of electricity consumption using Markov-Chain Grey Model in every region was forecasted to be constantly increasing in the next 3 years compared to actual monthly consumption from year 2013-2018. Mean Absolute Percentage Error (MAPE) given by the Equation $MAPE = \frac{\sum_{i=1}^{n}\left|\frac{A_i - F_i}{A_i}\right| \times 100}{n}$, where A_t is the actual value and F_t is the forecast value, was used to measure the accuracy of forecast systems. MCGM gets an almost zero MAPE value that means that it is an indicator of good forecast of values, so, Markov model prediction was better that GM (1,1). **Applications/Improvements:** For the government, this research can be used to raise awareness that demand for electricity will continue to increase over the next 3 years in order to be ready in future to prevent any power interruption. For the citizens, it can be used to disseminate knowledge for people in order to preserve energy as long as they can to reduce the likelihood of power reserve thinning.

Keywords: Demand, Forecasting Model, GM (1,1), Markov Chain Grey Model, Monthly Electricity Consumption

1. Introduction

Electricity is one of the most useful discoveries of mankind. In the Philippines, the electricity sector provides electricity through power generation, transmission and distribution. It serves as the main source of energy in Filipino households which enables the use of appliances, lighting and technologies and even for entertainment[1].

In 2013, according to the Philippines Department of Energy, the Philippines consumed 75,266 Gigawatt-hours (GWh) of electricity[2]. Of this, 27.39% went to powering residential areas, 24.31% to commercial establishments and 27.46% to the industrial sector with 72.84% of electrical energy being consumed by Luzon, 14.75% by Visayas and 12.41% by.

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In year 2015, electricity sales and consumption increased remarkably by 6.7% from 77,261 GWh in 2014 to 82,413 GWh[3]. The year 2016 is characterized by a significant increase in electricity consumption at 10% and peak demand at 8.7% attributed to several factors such as the increase in temperature and utilization of cooling equipment aggravated by the strong El Nino[4]. The residential and industrial sectors remained the major drivers of electricity consumption in the country while Luzon remained the largest on a per grid basis. Electricity consumption grew significantly from 82,413,213 MWh (2015) to 90,797,891 MWh (2016). This year's growth level increased to 10.2% compared to the 6.7% growth from 2014-2015. This increase is primarily driven by the growth of residential consumption at 12.7% from 22,747,049 MWh (2015) to 25,631,254 MWh (2016) due to high requirements for cooling system. On a per grid basis, Mindanao's electricity consumption grew the highest at 12% boosted by the own-use consumption of newly operational and large coal-fired power plants[4].

In 2017, electricity consumption in the Philippines rose 3.9% to 94.4 million MWh from 90.8 million MWh in 2016[5]. Although 74% of the total power generated is consumed in Luzon, consumption only grew 3.6% annually. Electricity consumption in Visayas and Mindanao expanded at faster rates of 5.8% and 4.0%, respectively.

In 2018, Electric cooperatives' sales in the first quarter jumped 11% amid increased demand nationwide, according to the National Electrification Administration (NEA)[6]. According to NEA Administrator Edgardo Masongsong, growth in power sales was driven by increased consumption across Luzon, Visayas and Mindanao. In the first three months of 2018, the 121 cooperatives under NEA's supervision sold a total of 4,924 GWh from 4,417 GWh in the same period in 2017. Residential consumers accounted for the biggest share of electricity consumed at 51% of total or 2,506 GWh, commercial establishments represented 24% of sales at 1,187 GWh while industrial customers had 18% or 881 GWh.

The scientific prediction for electricity consumption plays a significant role in drawing up an energy development policy and can serve as a decision-making basis and guarantee for plan in the next reconstruction of electric distribution network for each region of the Philippines. Precisely predicting for electricity consumption is important for planning and operation of electric power system. The common prediction methods include the GM (1,1) and Markov-Chain Grey Model. Above those methods mentioned, each one has its own relative merits and disadvantages. In this paper, Markov-Chain Grey Model was applied to predict electricity consumption.

In 1998, the study "Improved grey prediction models for the transpacific air passenger market" by. In[7] has applied grey theory to develop time series GM (1,1) models for predicting traffic flows in the trans-Pacific air passenger market. The original GM (1,1) models are improved by using residual modifications with Markov-chain sign estimations. Results show that these models are more reliable by posterior checks and yields more accurate prediction than multiple regression models. The results indicate that the total number of air passengers in the trans-Pacific market will increase at an average annual growth rate of approximately 11% up to the year 2000.

In year 2003, the study "Applying the Grey prediction model to the global integrated circuit industry" by[8] examines the precision of the Grey forecasting model applied to samples based on demand and sales in the global integrated circuit industry. To increase the accuracy of GM (1,1), three residual modification models are applied. Application of these models confirms that the Fourier series and Markov-chain approaches appear to perform better than GM (1,1) model. Results show that the GM is better suited to short-term predictions than to mid and long term predictions. Meanwhile, the Markov-chain residual modification model achieves reliable and precise results.

In 2005, He Y, and Huang M. published the paper entitled "A Grey-Markov Forecasting Model for the Electric Power Requirement in China"[9]. This paper presents a Grey-Markov forecasting model for forecasting the electric power requirement in China. Results show that the forecasting precisions of Grey-Markov forecasting model from 2002 to 2004 are 99.42%, 98.05% and 97.56% and those of GM (1,1) grey forecasting model are 98.53%, 94.02% and 88.48%. It shows that the Grey-Markov forecasting models have higher precision than GM (1,1) grey forecasting model.

In 2007, the paper entitled "Predictive analysis on electric-power supply and demand in China"[10] by presents a Grey–Markov forecasting model to forecast the electric-power demand in China. This paper was based on historical data of the electric-power requirement from 1985 to 2001 in China and forecasted and analyzed the electric-power supply and demand in China by the Grey–Markov forecasting model. Results show that the Grey–Markov forecasting model is more suitable to forecast the electric-power demand.

In 2008, the paper entitled "Forecast of power generation for grid-connected photovoltaic system based on grey model and Markov chain"[11] the Grey-Markov forecast model was established in grid-connected photovoltaic generation. Once the solar generation is classified in order of the time and the size, the grey forecast model can be established and the generation fitting value and the residual value can be obtained which constructs Markov forecast model. Basing on the Grey forecast GM (l, l) model and the stochastic processes Markov model, the deviation results of grey GM (l, l) model was used as the deviation transfer probability matrix of Markov model forecast. In order to increase the forecast reliability, the calculation result of GM (l, l) model was modified and limited in a forecast range which consisted of the interval and probability. The result shows that Grey-Markov model is more accurate than other forecast method.

Also, in 2008, published the paper entitled "Market Share Forecast of Electricity in City Residents' Energy Consumption based on Markov theory". Forecast have been done on market share of residential energy consumption items such as heating, cooking, cooling etc., with the use of Markov prediction theory and data from Qinhuangdao electricity market investigation. Forecast on market share at next term and at the equilibrium condition are accomplished which demonstrate the tendency of electricity as well other energy in residential energy consumption[12].

In 2009, the paper entitled "Forecasting the turning time of stock market based on Markov–Fourier grey model" by[13] presents an integration prediction method including Grey Model (GM), Fourier series and Markov state transition, known as Markov–Fourier Grey Model (MFGM), to predict the turning time of Taiwan Weighted Stock Index (TAIEX) for increasing the forecasting accuracy. The proposed Markov–Fourier Grey Model prediction approach uses the Grey Model to roughly predict the next datum from a set of the most recent data and the Fourier series to fit the residual errors produced by the Grey Model. Results show that the proposed approach MFGM has a higher forecasting accuracy than the other methods but it is only suitable for long-term operation.

In 2010, the study "Time series models (Grey-Markov, Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy consumption in India" by[14]. Applies three-time series models, namely, Grey-Markov model, Grey Model with rolling mechanism and Singular Spectrum Analysis (SSA) to forecast the consumption of conventional energy in India. Grey-Markov model has been employed to forecast crude-petroleum consumption while Grey Model with rolling mechanism to forecast coal, electricity consumption and SSA to predict natural gas consumption. For short-term forecasting, the results clearly indicate that values forecasted by these models are very much close to the real values. A comparison of projected energy demand by the models presented in this study and the Planning Commission (2002–2007) shows that these time series models can be a viable alternative to project the future energy requirements.

In the year 2011, the paper entitled "Prediction of Rural Electricity Consumption Based on Grey-Markov Model" by shows that GM-Markov has higher prediction accuracy, comparing with the GM model and this predictive method has better precision and it is practical[15].

In 2013, the paper entitled "Improvement of renewable energy supply forecasts: The case of Taiwan renewable industry"[16] presents an investigation of the annual supply value of the four renewable energies in Taiwan from 2005 to 2009. An improved grey GM (1,1) model, using a technique that combines residual modification with the Markov chain model, is proposed. Results show that the Grey-Markov model could clearly improve the forecast accuracy of the original grey forecast model. It also shows that Grey-Markov forecasting model is the best for forecasting the annual output of the semiconductor and computer industries.

In the year 2013, published the paper entitled "Energy Demand Forecast of Iran's Industrial Sector Using Markov Chain Grey Model". The major purpose of this paper was to develop the prediction model of energy demand of industrial sector in Iran. Markov-Chain Grey Model (MCGM) has been proposed to forecast such energy demand. They used the statistics data of the energy consumption of industrial sector from 1990 to 2008. Grey Model (GM) and regression model has been compared with the proposed model to find its effectiveness. The comparison reveals that the MCGM model has higher precision than those of the GM and the regression. The MCGM is then used to forecast the annual energy demand of industrial sector in Iran up to the year 2020. The results provide scientific basis for the planned development of the energy supply of industrial sector in Iran[17].

In 2014, the paper entitled "Combining Forecasts of Electricity Consumption in China with Time-varying weights updated by a High-order Markov-Chain Model" by. Proposes a time-varying-weight combining method called HM-TWA to predict the monthly electricity consumption in China. Out-of-sample tests of forecasting accuracy show the effectiveness of the proposed HM-TWA method to perform forecasting for one through eleven months ahead. The forecasting performance of HM-TWA has been compared with eight models (BPN, LSSVR, SARIMA, PSTM, PTTM, HWM, SA-WA and TSSE), results shows that HM-TWA has different degrees of improvement compared with other models for both one-month-ahead and one-year-ahead forecasting according to the three criteria (RMSE, MAE and MAPE)[18].

In 2015, the paper entitled "Forecasting China's energy demand and self-sufficiency rate by grey forecasting model and Markov model" by. In[19] proposed an optimized single variable discrete grey forecasting model and the QP-Markov model for forecasting the total amount of energy production and consumption structures. The proposed models are used to simulate China's energy production and consumption during 2006–2011 and forecast its trends in 2015 and 2020. Results show that proposed models can effectively simulate and forecast the total amounts and structures of energy production and consumption. For the energy structures, the proportions of natural gas and other new energies in the production and consumption will continue to increase. The coal and other new energies can be self-sufficient in the forthcoming decade while the self-sufficiency rates of crude oil and natural gas will continue to drop. And by comparing with regression model, results show proposed model is a little better than regression in simulating and forecasting the case.

In the year 2017, the paper entitled "Analysis and Modeling for China's Electricity Demand Forecasting Based on a New Mathematical Hybrid Method" by was published. In this paper, a new mathematical hybrid method is proposed to forecast electricity demand. In line with electricity demand feature, the framework of joint-forecasting model is established and divided into two procedures: firstly, the modified GM (1,1) model and Logistic model are used to make single forecasting. Then, the IOWHA operator is applied to combine these two single models and make joint-forecasting for China's electricity demand in 2016–2020. Forecasting results demonstrate that this new hybrid model is superior to both single-forecasting approaches and traditional joint-forecasting methods. Detailed forecasting-outcomes on electricity demand of China in 2016–2020 are discussed and displayed a slow-growth smoothly over the next fi,1 years[20].

In 2017, the paper entitled "Novel grey prediction model with nonlinear optimized time response method for forecasting of electricity consumption in China" by. In[21] proposed an optimized hybrid GM (1,1) model to improve prediction accuracy of EEC in short term, namely IRGM(1,1). As a comparison, three alternative grey prediction models are constructed to process these data. Results show that the errors of the proposed model decreases comparing with those of the three ones, and forecasting precision is improved.

In the year 2018, the paper entitled "A seasonal GM (1,1) model for forecasting the electricity consumption of the primary economic sectors". In[22] propose a Seasonal Grey Model (SGM (1,1) model) based on the accumulation operators generated by seasonal factors. They use the proposed model to carry out an empirical analysis based on the seasonal electricity consumption data of the primary industries in China from 2010 to 2016.

The results from the SGM (1,1) model are compared with those obtained using the grey model (GM(1,1)), the particle swarm optimization algorithm combines with the grey model (PSO-GM(1,1) model), and the adaptive parameter learning mechanism based seasonal fluctuation GM (1,1) model (APL-SFGM(1,1) model). The results of the comparison show that the SGM (1,1) model can effectively identify seasonal fluctuations in the electricity consumption of the primary industries and its prediction is more accurate. Results also show that the electricity consumption of China's primary industries is expected to continue increasing and show significant seasonal variation.

1.1 Conceptual Framework

1.2 Statement of the Problem

This study aims to answer the following questions:

- What are the behaviours of the graphs of monthly electricity consumption in each region in the Philippines from the year 2018 up to 2021?

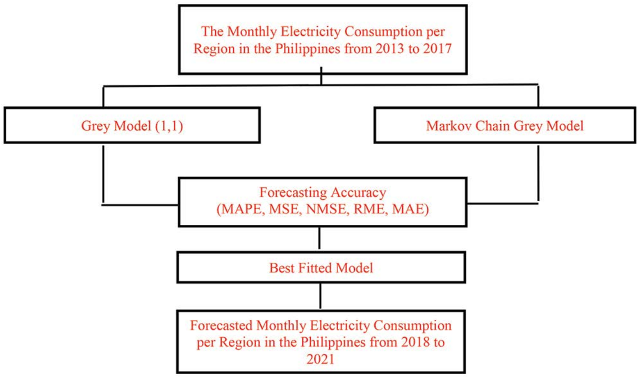

Figure 1. Conceptual framework of the study.

- National Capital Region (NCR).
- Region I.
- Cordillera Administrative Region (CAR).
- Region II.
- Region III.
- Region IV-A.
- Region IV-B.
- Region V.
- Region VI.
- Region VII.
- Region VIII.
- Region IX.
- Region X.
- Region XI.
- Region XII.
- CARAGA.
- Autonomous Region of Muslim Mindanao (ARMM).

- What are the mathematical models for the monthly electricity consumption in each region in the Philippines and which model is better?
- GM(1,1);
- Markov-Chain Grey Model;
- What will be the predicted values of electricity consumption in the Philippines for the year 2018 up to 2021?

1.3 Scope and Limitation

This study contains the monthly data of the electricity consumption in kilowatt-hour (kWh) of different regions in the Philippines from the year 2013 to 2017. The data gathered are from the Department of Energy (DOE). The data collected will be used to forecast the values of electricity consumption for 3 succeeding years from 2018 up to 2021.

2. Method

2.1 Data Gathering

The researchers gathered the data behaviors of the graphs of monthly electricity consumption in each region in the Philippines from the year 2018 up to 2021 from:

National Capital Region (NCR).

Region I.

Cordillera Administrative Region (CAR).

Region II.

Region III.

Region IV-A.

Region IV-B.

Region V.

Region VI.

Region VII.

Region VIII.

Region IX.

Region X.

Region XI.

Region XII.

CARAGA.

Autonomous Region of Muslim Mindanao (ARMM)

2.2 GM (1,1)Forecasting Model

In Grey model (1,1)[23] better known as GM (1, 1), has a time variable coefficient in which the model wasupdated into new data for model prediction or so-called Accumulated Generating Operation (AGO). The first step to do the forecasting using as GM (1, 1) is to set the original data into a sequence $x^{(0)}(k)$ with k = 1, 2, 3,…, n as follows:

$x^{(0)}=\{x^{(0)}(1), x^{(0)}(2), x^{(0)}(3),\ldots\ldots,x^{(0)}(n)\}$ (1)

The original data in Equation (1) is then arranged into a new sequence through one-time Accumulated Generating Operation (1-AGO), given by:

$x^{(1)}(k) = \{x^{(1)}(1),x^{(1)}(2), x^{(1)}(3)\ldots., x^{(1)}(n)\}$ (2)

Where and $x^{(0)}(1) = x^{(0)}(1)$ and $x^{(1)}(k) = \sum^{k}_{i=1)} x^{(0)}(i)$, k =1, 2, 3,….,n

The third step is to determine the value of , which is known as the Mean Generating Operation (MGO).

$$z^{(1)}(k)=\frac{x^{(1)}(k)+x^{(1)}(k-1)}{2}(k=2,3,4,\ldots,n) \quad (3)$$

The value of MGO in Equation (3) is used to solve the first order differential equation defined by:

$$\frac{dx^{(1)}}{dt}+ax^{(1)}(k)=bk=2,3,4,\ldots,n \quad (4)$$

Where is a developing coefficient and is a Grey input. By using the method of least squares, the parameters and can be obtained as follows:

$(a,b)^T = (B^T B)^{-1} B^T Y$ (5)

With

$$B=\begin{bmatrix}-z^{(1)}(2) & 1\\ -z^{(1)}(3) & 1\\ \vdots & \vdots\\ -z^{(1)}(n) & 1\end{bmatrix}$$

And Y = $\{x^{(0)}(2), x^{(0)}(3), x^{(0)}(4),\ldots., x^{(0)}(n)\}$

After determining the values of and , the solution of of Equation (4) was obtained as follows:

$$\hat{x}^{(1)}(k)=\left(x^{(1)}(1)-\frac{b}{a}\right)e^{-ak}+\frac{b}{a} \quad (6)$$

The prediction value using the model is which can be calculated by performing an Inverse Accumulated Generating Operation (IAGO) on Equation (6), obtaining

$$\hat{x}^{(0)}(k+1)=\left(1-e^{a}\right)\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak} \quad (7)$$

Where $\hat{x}^{(0)}(1)=x^{(0)}(1)$

2.3 Markov Chain Grey Model

After obtaining the predicted value from GM(1,1), the next step is to apply the Markov Chain[23] concept to the predicted value obtained from Equation (7). The algorithm of Markov Chain Grey model is as follows:

- Calculate the relative error between the predicted value from GM(1,1) and the original data:

$$Relative\ Error(k)=\frac{x^{(0)}(k)-\hat{x}^{(0)}(k)}{x^{(0)}(k)}\times 100 \quad (8)$$

- Determine the number of states or conditions used to identify all possible conditions of a process or system.

- Each state has a boundary notated by

  $\otimes_j = [\otimes_j-,\otimes_j,+], j = 1,2,3,\ldots, m$ (9)

  where $\otimes_j$ is the boundary of the j-th state $\otimes_{(j-)}$,is the lower bound and $\otimes_{(j+)}$ is the upper bound of the j-th state.

- Determine the interval length of each state by calculating

$$I_{(k)}=\frac{H-L}{r} \quad (10)$$

Where $I_{(k)}$ is the kth interval, H is the highest value of relative error, L is the lowest value of relative error, and r is the number of states. Therefore, it produces the boundary of each state as follows:

$\otimes_1$ = [L, $I_{(1)}$]; $\otimes_2$ = [$I_{(2)}$, $I_{(3)}$],….,$\otimes_n$ = [$I_{(n)}$), H], i = 1,2,…, n (11)

- Form a transition probability matrix using the Markov Chain concept as follows:

$$P(k)=\begin{bmatrix}P_{11}(k) & P_{12}(k) & \cdots & P_{1n}(k)\\ P_{21}(k) & P_{22}(k) & \cdots & P_{2n}(k)\\ \vdots & \vdots & \vdots & \vdots\\ P_{n1}(k) & P_{n2}(k) & \cdots & P_{nn}(k)\end{bmatrix},k=1,2,\ldots,n \quad (12)$$

$P(k)$ is the k step transition probability, while P_{ij} denotes the probability that if the process is in state i at time t, then it will switch to state j at time $t + 1$. Therefore,

$P_{ij} \geq 0$for all i,j {0, 1, 2,..} $\sum_{j=0}^{\infty} P_{ij} = 1$ and for all i {0, 1, 2,…}.

Determine the next state for the prediction based on the vector row on the transition probability matrix by time (based on the nearest time to the predicted time), then summing up the probability values obtained according to their respective states. The state that has the greatest probability is the state that is most likely for the time to be predicted.

After determining the state that has the greatest probability, then the boundary of the state will be used to predict the future data using equation below:

$$\hat{x}(k) = \hat{x}^{(0)}(k) \times \left(1 + \frac{\otimes_{(j-)} + \otimes_{(j+)}}{2}\%\right) \quad (13)$$

2.4 Forecasting Accuracy

2.4.1 Mean Absolute Percentage Error

The mean absolute percentage error (MAPE)[24] is a statistical measure of how accurate a forecast system is. It measures this accuracy as a percentage, and can be calculated as the average absolute percent error for each time period minus actual values divided by actual values. Where A_t is the actual value and F_t is the forecast value, this is given by:

$$MAPE = \frac{\sum_{i=1}^{n} \left|\frac{A_i - F_i}{A_i}\right| \times 100}{n}$$

2.4.2 Mean Absolute Error

The Mean Absolute Error (MAE)[25] is the average of all absolute errors. The formula is:

$$MAE = \frac{\sum_{i=1}^{n} |F_i - A_i|}{n}$$

2.4.3 Mean Square Error

The Mean Squared Error[26] tells you how close a regression line is to a set of points. It does this by taking the distances from the points to the regression line (these distances are the “errors”) and squaring them.

The squaring is necessary to remove any negative signs. It also gives more weight to larger differences. It’s called the mean squared error as you’re finding the average of a set of errors.

$$MSE = \frac{\sum_{i=1}^{n} (A_i - F_i)^2}{n}$$

2.4.4 Root Mean Square Error

Root Mean Square Error (RMSE)[27] is the standard deviation of the residuals (prediction errors). Residuals are a measure of how far from the regression line data points are; RMSE is a measure of how spread out these residuals are. In other words, it tells you how concentrated the data is around the line of best fit. Root mean square error is commonly used in climatology, forecasting, and regression analysis to verify experimental results.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (A_i - F_i)^2}{n}}$$

2.4.5 Normalized Mean Square Error

The NMSE (Normalized Mean Square Error)[28] is an estimator of the overall deviations between predicted and measured values. It is defined as:

$$NMSE = \frac{\sum_{i=1}^{n} (A_i - F_i)^2}{n(\bar{A} \times \bar{F})}$$

$$\bar{A} = \frac{1}{n}\sum A_t$$

$$\bar{F} = \frac{1}{n}\sum F_t$$

Where A_t is the actual data, F_t is the predicted value and is the total number of data.

3. Results and Discussions

3.1 Behavior of the Graph per Region

In this section, the researchers provided graphical representations of the actual data of the monthly electricity consumption of every region in the Philippines from the year 2013 up to 2018 that were obtained from the Department of Energy. Moreover, a discussion for every data gathered per region was interpreted.

3.1.1 NCR

In Figure 2, the electricity consumption in NCR reaches its minimum in the month of august in every year. The graph goes down when approaching the months of June, July, and August and goes up when approaching the months of April, May, and December. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on NCR. The National Grid Corporation of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

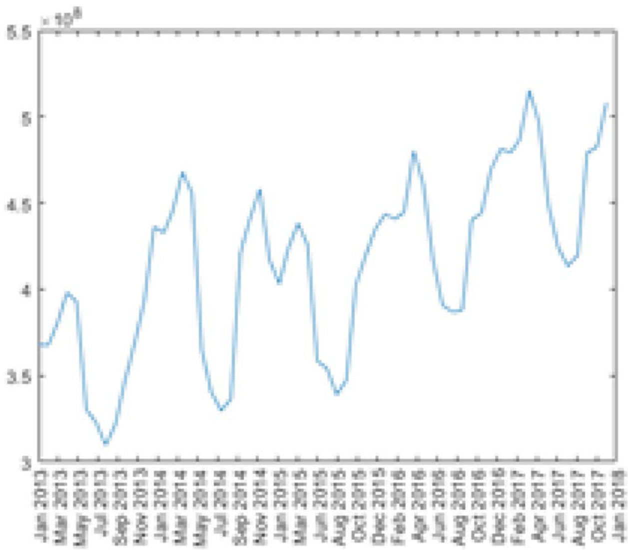

Figure 2. Monthly electricity consumption of NCR from Jan. 2013-Dec 2017.

3.1.2 Region I

In Figure 3, the monthlyelectricity consumption goes up every March, April, May, and December of the year. The electricity consumption reaches its lowest value in the month of August for each year. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Moreover, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on Region I. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

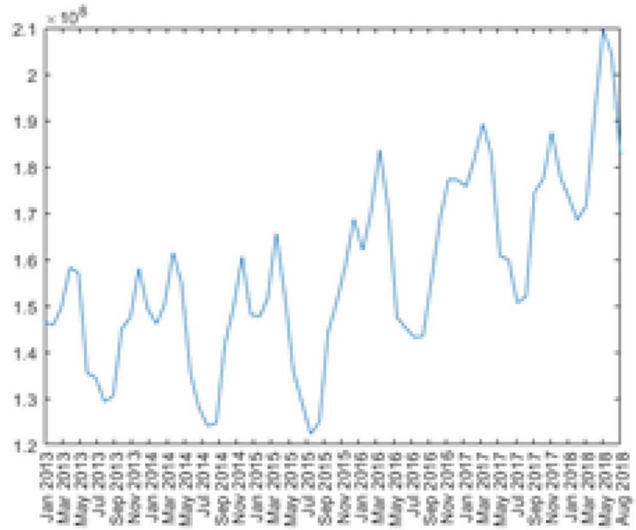

Figure 3. Monthly electricity consumption of Region I from Jan. 2013-Dec 2017.

3.1.3 CAR

In Figure 4, the monthly electricity consumption each year increases because the country's demand for power increases as the population and economy continues to grow.The graph's reaches its peak at the month of April in every year. The electricity consumption in the month of April every year is high because of it being in the summer season. As heat index increases, energy consumption also increases[29]. April 2017 has the highest monthly electricity consumption for the Cordillera Administrative Region (CAR). The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

3.1.4 Region II

In Figure 5, the graph shows a great increase during the months of March, April, and May. A decrease is observed on the months of June, July, August, and up to September of each year. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. April 2017 has the highest monthly electricity consumption on Region II. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity

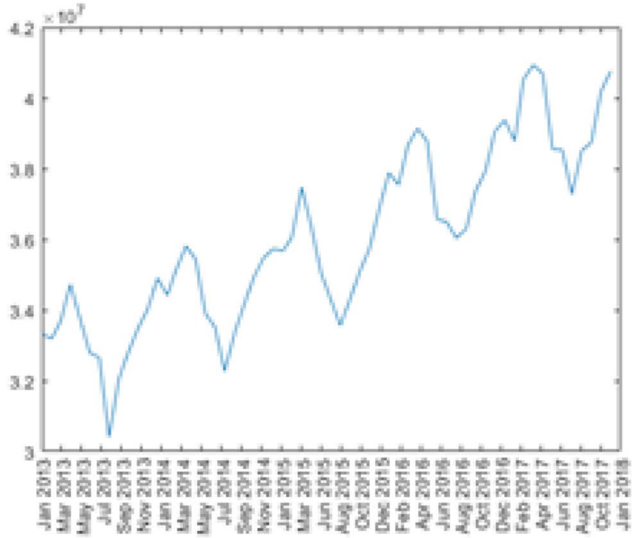

Figure 4. Monthly electricity consumption of CAR from Jan. 2013-Dec 2017.

consumption for the months of April and May for the year 2017 because of the dry season[30].

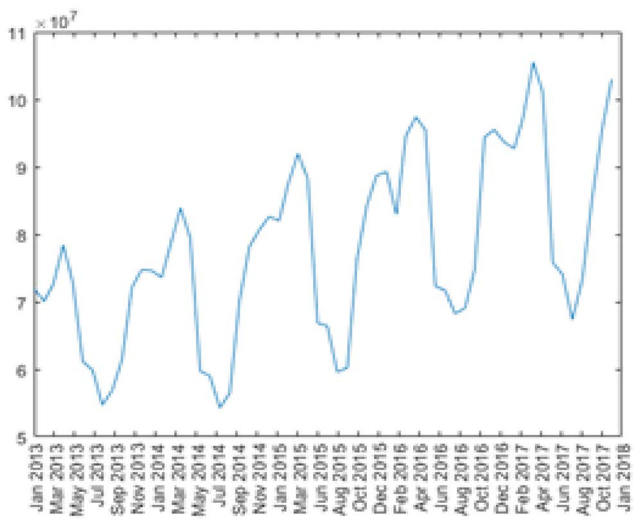

Figure 5. Monthly electricity consumption of Region II from Jan. 2013-Dec. 2017.

3.1.5 Region III

In Figure 6, the graph goes down when approaching the months of June, July, and August and goes up when approaching the months of April, May, and December. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Also, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on Region III. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

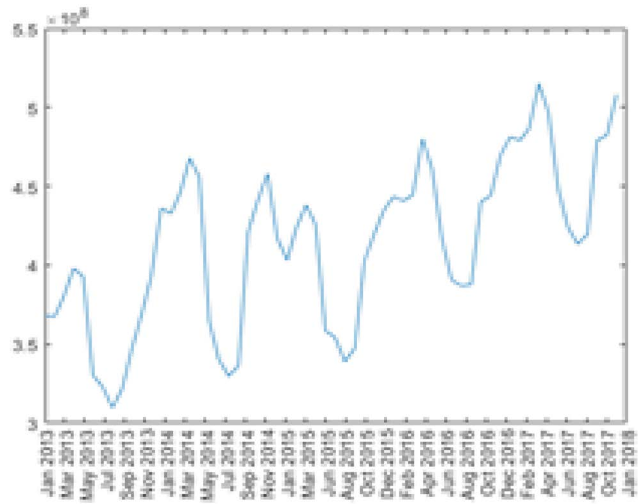

Figure 6. Monthly electricity consumption of Region III from Jan. 2013-Dec. 2017.

3.1.6 Region IV-A

In Figure 7, the graph goes up when approaching the months of April, May, and December and the graph goes down when approaching the months of July, August, and September. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Also, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights.

April 2017 has the highest monthly electricity consumption on Region IV-A. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

3.1.7 Region IV-B

In Figure 8, the graph shows an increase when approaching the months of April, May, and December while the graph decreases when approaching the months of June, July, August, and September. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases,

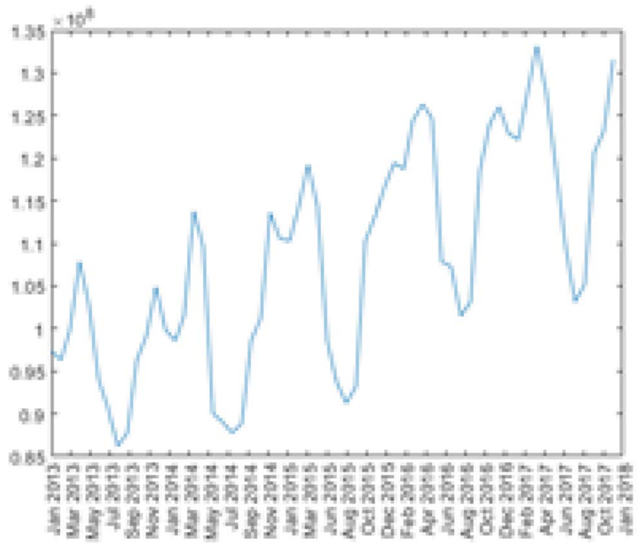

Figure 7. Monthly electricity consumption of Region IV-A from Jan. 2013-Dec. 2017.

energy consumption also increases[29]. Also, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on Region IV-B The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

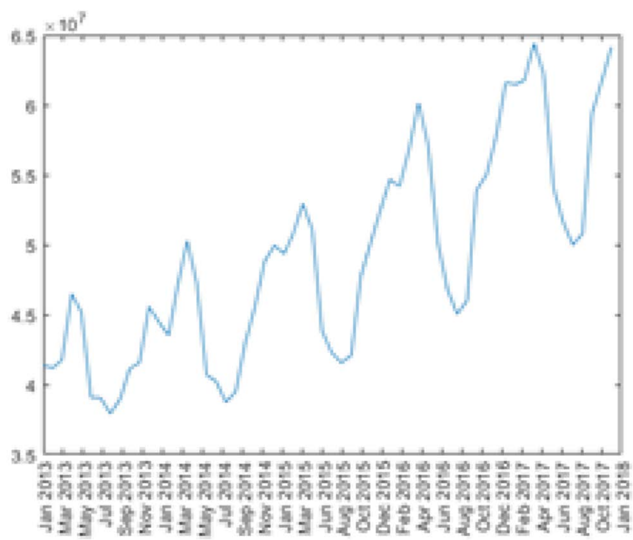

Figure 8. Monthly electricity consumption of Region IV-B from Jan. 2013-Dec. 2017.

3.1.8 Region V

In Figure 9, the graph shows an increasing function, reaching its peak every April of each year. The reason for this is that electricity demand is high during summer season, as heat index increases, energy consumption also increases[29]. But a sudden fluctuation happened when the graph approaches the month of August 2017. The graph goes up again after the month of August 2017. April 2017 has the highest monthly electricity consumption on Region V. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

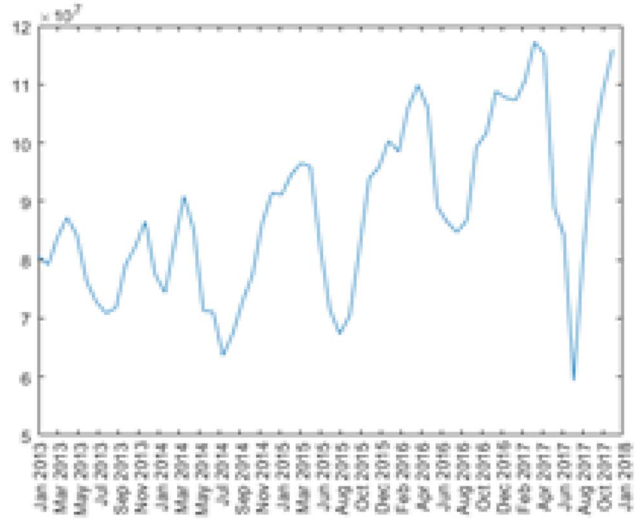

Figure 9. Monthly electricity consumption of Region V from Jan. 2013-Dec. 2017.

3.1.9 Region VI

In Figure 10, the graph goes up when approaching the months of April and December, and goes down when approaching the months of August. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Also, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on Region VI. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

3.1.10 Region VII

In Figure 11, the graph increases when approaching the months of April, May, and December and decreases when approaching the month of August. April 2017 has the highest monthly electricity consumption on Region

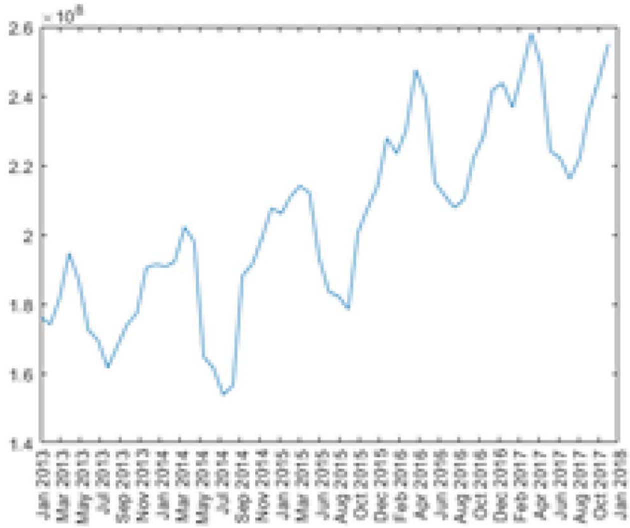

Figure 10. Monthly electricity consumption of Region VI from Jan. 2013-Dec. 2017.

VII. The reason for this is that electricity demand is high during summer season and is low during rainy season. As heat index increases, energy consumption also increases[29]. Also, electricity consumption is high in the month of December because of the high usage of energy using Christmas decorations such as Christmas lights. April 2017 has the highest monthly electricity consumption on Region VI. The National Grid Corp. of the Philippines (NGCP) recorded its highest electricity consumption for the months of April and May for the year 2017 because of the dry season[30].

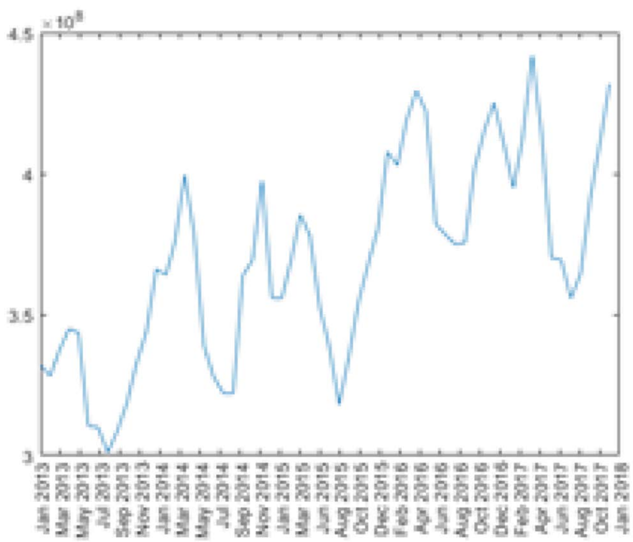

Figure 11. Monthly electricity consumption of Region VII from Jan. 2013-Dec. 2017.

3.1.11 Region VIII

In Figure 12, the graph reaches its maximum every April of each year, while the graph reaches its minimum every August of each year. This is the results of every typhoon occurred in the area of Region 8. Also, in 2013, the First Gen Hydro Power Corporation was markedly lower by PHP 2.25 billion and was the major driver of the PHP 2.71 billion decrease in our consolidated revenues[31]. April 2017 has the highest monthly electricity consumption on Region VIII. The reason was the power situation in the Visayas grid has been generally stable due to the additional capacities that went on commercial operation[32].

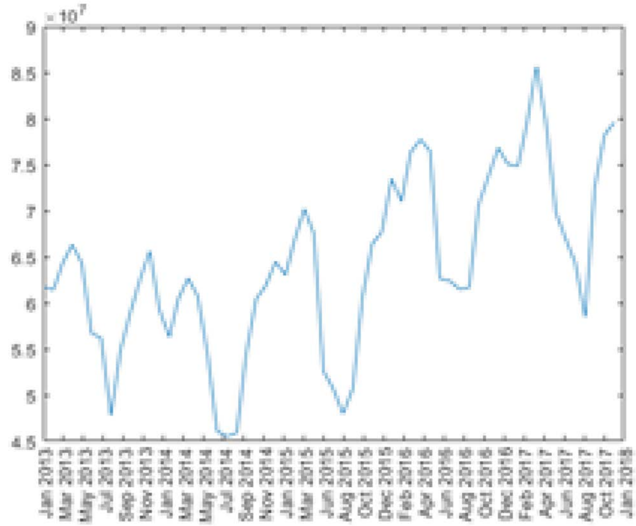

Figure 12. Monthly electricity consumption of Region VIII from Jan. 2013-Dec. 2017.

3.1.12 Region IX

In Figure 13, the graph goes up when approaching the months of April, May, and December, while the graph goes down when approaching the month of August. April 2016 and April 2017 has the highest monthly electricity consumption on Region IX. In 2014, the demand for power supply in ZAMSURECO I's franchise area is steadily increasing. Furthermore, the National Power Corporation/Power Sector Assets and Liabilities Management Corporation, the supplier of the Bulk of ZAMSURECOI's requirements, has significantly reduced its supply commitments to ZAMSURECO I by about one-third[33]. In 2015, the power shortage in Mindanao has remained a critical problem for ZAMSURECO II which continues to suffer rotating brownouts in the grid[34].

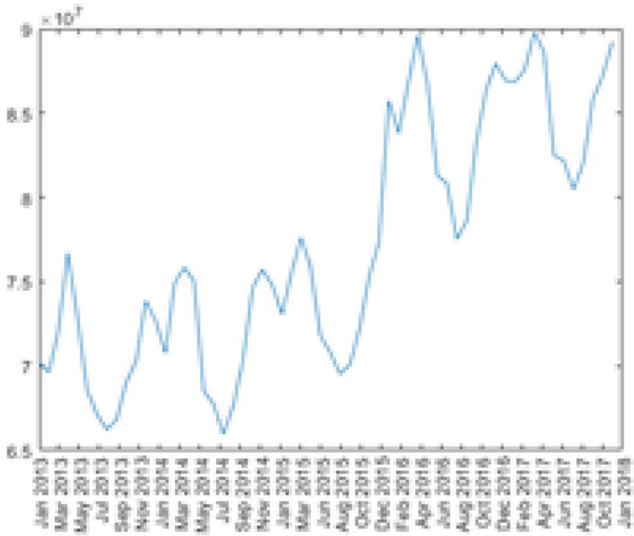

Figure 13. Monthly electricity consumption of Region IX from Jan. 2013-Dec. 2018.

3.1.13 Region X

In Figure 14, the monthly electricity consumption increases on the months of April, May, and December while it decreases when approaching the months of August and September. The electric cooperative was presently implementing two sets of daily rotating brownouts 14 hours daily due to the power shortage, which was mainly attributed to the declining generation capacity of the National Power Corporation's (NPC) hydroelectric plants[35]. The summer of 2013 has reached an all-time high hitting the mid-30's, as a result of every electric companies to increase their power supply. April 2016 has the highest monthly consumption on Region X but a sudden fluctuation happens when the graph approaches August and September 2017[36].

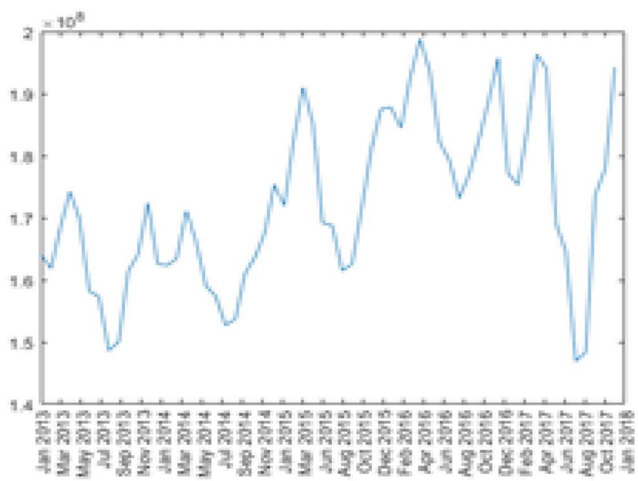

Figure 14. Monthly electricity consumption of Region X from Jan. 2013-Dec. 2017.

3.1.14 Region XI

In Figure 15, the graph goes up when approaching the months of April, May, and December while the graph goes down when approaching the months August and September. April 2017 has the highest monthly consumption on Region XI[37]. In 2014, power supply is not sufficient to meet the total power requirement and can no longer provide the required energy. PSALM has reduced the yearly supplied energy to an average of 36%[38].

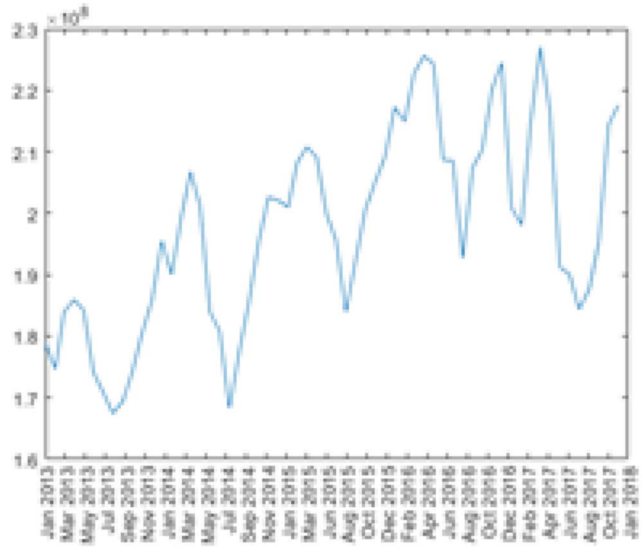

Figure 15. Monthly electricity consumption of Region XI from Jan. 2013-Dec. 2017.

3.1.15 Region XII

In Figure 16, the graph reaches its peak every April of each year and reaches its minimum every August. April 2016 has the highest monthly consumption on Region XII. In the year 2013 the daily rotational brownouts in Gen. Santos City and parts of South Cotabato and Sarangani provinces have stretched to seven hours due to a major power load cut imposed by the National Grid Corp. of the Philippines (NGCP) after the toppling of its transmission tower in North Cotabato[38].As a result of contracts to other suppliers, the problems in brown-out was resolved by increasing the electric bill for the residential consumer[39].

3.1.16 CARAGA

In Figure 17, the graph shows an increasing function, reaching its peak at every April of each year, and getting its minimum at every August of each year. April 2017 has the highest monthly consumption on CARAGA. ASELCO's power supply was not sufficient to meet its total power

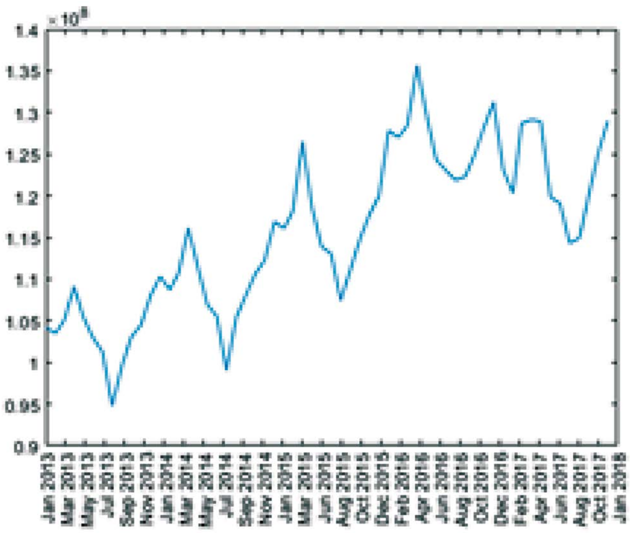

Figure 16. Monthly electricity consumption of Region XII from Jan. 2013-Dec. 2017.

requirements. ASELCO's power requirements stand at about 23 MW but its available supply amounts to about 12 MW. Thus, there is a very significant shortage of 11 MW, almost half of its power requirements. As a result, the electricity consumers and local businesses in ASELCO's franchise area suffer from daily rotational brownouts of four (4) to five (5) hours. The solution was to increase the distribution of power supplies and rates[40].

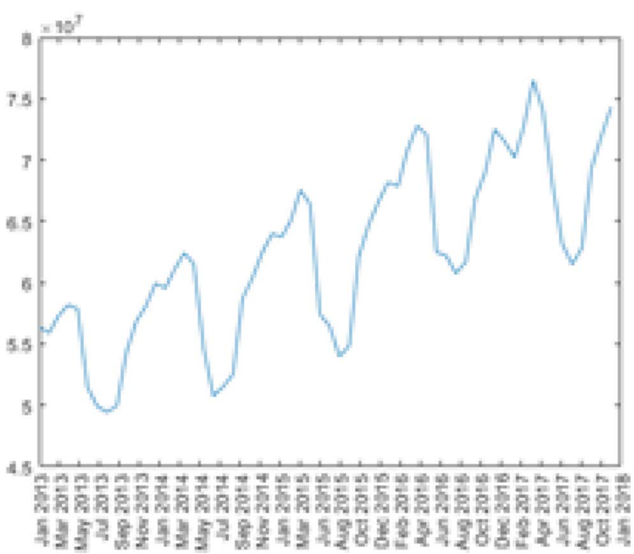

Figure 17. Monthly electricity consumption of CARAGA from Jan. 2013- Dec. 2017.

3.1.17 ARMM

In Figure 18, the graph reaches its maximum at July 2017 and reaches its minimum at September 2013. July 2017 has the highest monthly consumption on ARMM. In Mindanao, the problematic ECs are the Tawi-Tawi Electric Cooperative Inc. (Tawelco), Basilan Electric Cooperative Inc. (Baselco), Sulu Electric Cooperative Inc. (Suleco) and the Lanao Sur Electric Cooperative Inc.The Mindanao cooperatives are the biggest thorn on Petilla's side with their huge amount of debts[40].

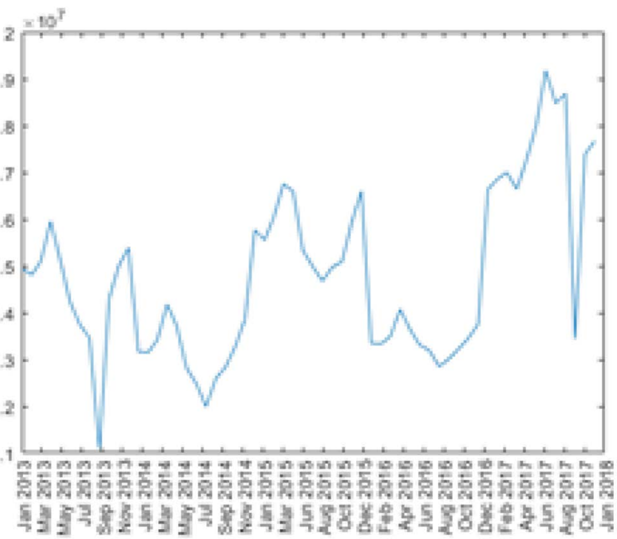

Figure 18. Monthly electricity consumption of ARMM from Jan. 2013- Dec. 2017.

3.2 Result of the Markov-Chain Grey Model

In this section, the process of GM(1,1) and Markov-Chain Grey Model were used for the monthly electricity consumption of every region in the Philippines in the year 2013 up to 2018. Also, a comparison between the actual values using the Grey Model (1,1) and Markov-Chain Grey Model of the monthly electricity consumption of the National Capital Region was presented to determine which model is best fitted based on the results of the forecasting errors. A step by step procedure was given to obtain the forecasted values as mentioned in the methodology.

The actual/original data of monthly electricity consumption for NCR, $\hat{x}^{(0)}$, is shown in Table 1:

Obtaining $x^{(1)}$ using 1-AGO(one-time accumulated generating operation), where

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1, 2, 3, \ldots, n$$

Then the value for $x^{(1)}$ is shown in Table 2:

Using the grey differential equation of GM (1,1), $x^{(0)}(k) + ax^{(1)}(k) = b$, $k = 2, 3\ldots n$, its whitening equation is obtained:

$$\frac{dx^{(1)}}{dt} + ax^{(1)}(k) = b$$

Let û be the parameters vector, $\hat{u} = (\hat{a}, \hat{b})^T = (B^T B)^{-1} B^T Y_N$, B, denotes the accumulated matrix and Y is the constant vector, so a and b can be obtained by using least square method. Where

$$B = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{pmatrix}, Y_N = \begin{pmatrix} x^{(0)} & (2) \\ x^{(0)} & (3) \\ & \vdots \\ x^{(0)} & (n) \end{pmatrix}$$

$$, z^{(1)}(k) = \frac{x^{(1)}(k) + x^{(1)}(k-1)}{2} (k = 2, 3, 4, \ldots n)$$

Then,

$$B = \begin{pmatrix} -551868325.5575 & 1 \\ -925841525.875561 & 1 \\ \vdots & \vdots \\ -27499102026.2865 & 1 \end{pmatrix}, Y_N = \begin{pmatrix} 367683635.308333 \\ 380262765.32779 \\ \vdots \\ 561810112.98 \end{pmatrix}$$

$$\Rightarrow (B^T B)^{-1} B^T Y_N = \begin{pmatrix} -0.00484671916777 \\ 356962774.120313 \end{pmatrix}$$

Therefore, a = -0.00484671916777 and = 3569627 74.120313.

The solution of the whitening equation of GM(1,1) can be obtained as follows:

$$\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{(-ak)} + \frac{b}{a}$$

Then,

$$\hat{x}^{(1)}(k+1) = \left(368026507.903333 - \left(\frac{356962774.12}{-0.0048} \right) \right) e^{-(-0.0048)(k)} + \frac{356962774.12}{-0.0048}$$

Next, applying the Inverse Accumulated Generating Operation IAGO), we have

$$\hat{x}^{(0)}(k+1) = (1 - e^{a}) \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-ak}$$

Therefore, the mathematical model for GM (1,1) is:

$$\hat{x}^{(0)}(k+1) = (1 - e^{-0.0048}) \left(368026507.903333 - \left(\frac{356962774.12}{-0.0048} \right) \right) e^{-(-0.0048)(k)}$$

The values for $\hat{x}^{(1)}(k+1)$ and $\hat{x}^{(0)}(k+1)$ are shown in Table 3:

Calculate now the relative error between the predicted value from GM (1,1) and the original data:

$$Relative\ Error(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)} \times 100$$

The Table 4 shows the relative error for each k = 1,2,…,66

Now, we will divide $\hat{x}^{(0)}$ into n states according to the relative error and determine the interval length of each state by dividing the difference of the highest value of relative error and lowest value of relative error to the number of states. We denote the states of as $\hat{x}^{(0)}$ as $\otimes_j = [\otimes_{j-}, \otimes_{j+}]$

Now, the interval length of each is:

$$I = \frac{max\{Relative\,error(k) \mid k = 2,3,..,66\} - min\{Relative\,error(k) \mid k = 2,3,...,66\}}{66}$$
$$= \frac{17.7570964424076 - (-22.6467127220183)}{65} = 0.621597064068091$$

Where I is the interval length of each state.

Then the following interval for each state is shown in Table 5:

We will now establish the transition probability from $\otimes_i$ to $\otimes_j$ as follows:

$$P_{ij}(k) = \frac{n_{ij}(k)}{n_i}, i = 1, 2, 3, \ldots, n,$$

Where $P_{ij}(k)$ is the transition probability of state $\otimes_j$ transferred from state $\otimes_i$ for k steps, k is the number of transition steps each time, n_i is the number of data in state $\otimes_i$ $n_{ij}(k)$ is the number of original data of state $\otimes_j$ transferred from state $\otimes_i$ for k steps. Then the transition probability matrix can be expressed as follow:

$$P(k)=\begin{pmatrix} P_{11}(k) & P_{12}(k) & \dots & P_{1n}(k) \\ P_{21}(k) & P_{22}(k) & \dots & P_{2n}(k) \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1}(k) & P_{n2}(k) & \dots & P_{nn}(k) \end{pmatrix}$$

P(1) =

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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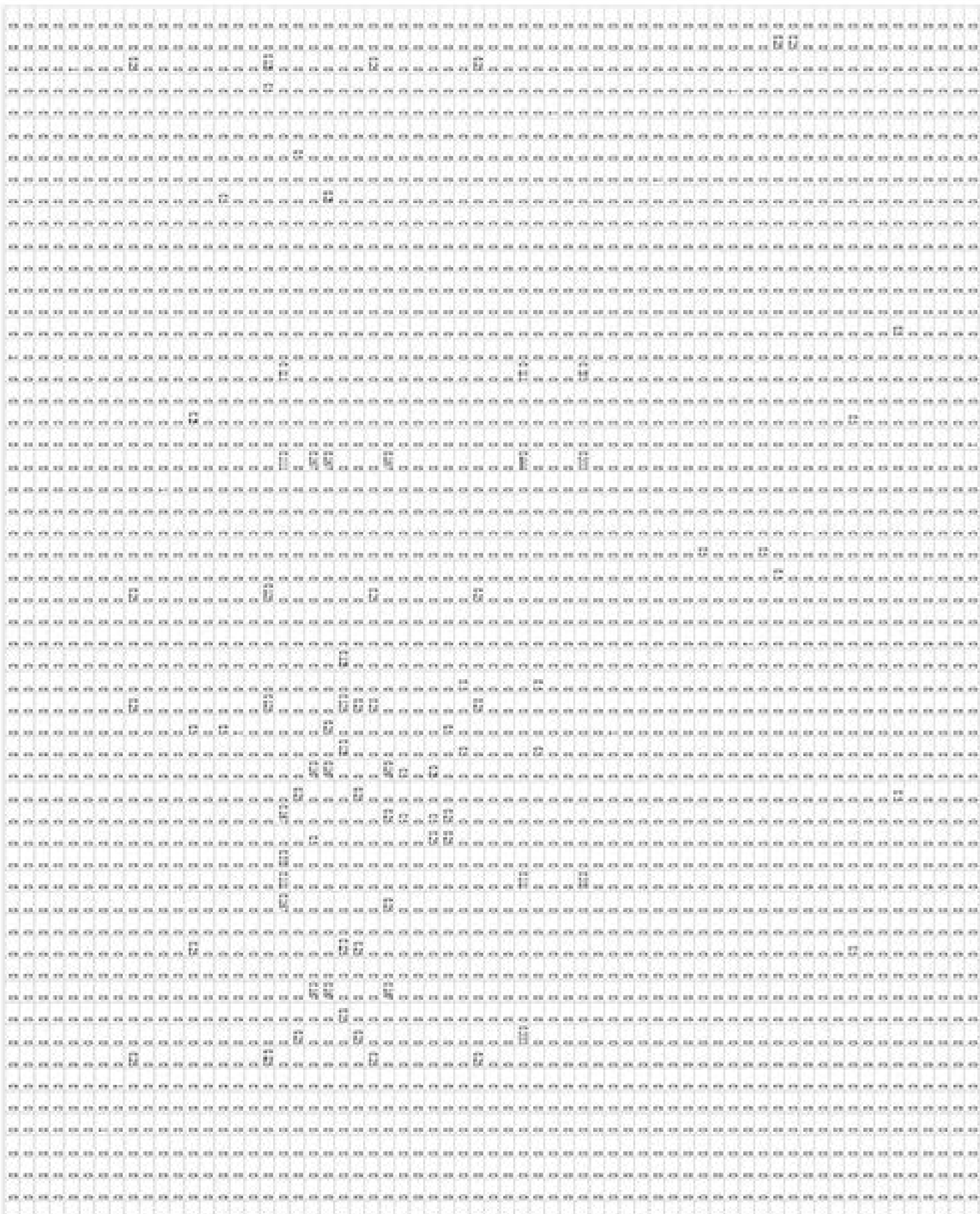
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.33333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Since 65 states are divided, then the latest 65 months of data near to prediction time are selected to make state prediction table. The transition steps are defined as 1, 2, 3, ..., 65.

The sum of all transition probability from any state to state 65 is maximal, and then the relative error of July2018 is in the state 43: (3.06,3.68], the forecast value of GM(1,1) can be calculated using the formula: $\hat{x}^{(0)}(k+1)=\left(1-e^{a}\right)\left(x^{(0)}(1)-\frac{b}{a}\right)e^{-ak}$, the forecast value of July 2018 obtained by GM(1,1) is 492,787,024.62, so the forecast value obtained by Markov Chain Grey Model is:

P(2) =



P(3) =

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0.25	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.25	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.25	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0
0.5	0	0	0	0	0	0	0	0.25	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.111	0	0	0	0.444	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.111	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0
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0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
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0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
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0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
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0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
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0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.03	0.018	0.012	0.018	0.012	0.012	0	0	0.012	0	0	0.017	0.019	0.012	0	0.018	0.019	0.035	0.012	0	0.017	0.015	0.034	0.019	0	0.012	0.021	0.017	0.038	0.076	0.026	0.022	0.035	0.035	0.024	0.012	0.012	0.011	0	0.036	0	0.012	0.019	0.03	0.019	0.019	0	0.019	0	0	0	0.019

		Initial State	Transition	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9	State 10	State 11	State 12	State 13	State 14	State 15	State 16	State 17	State 18	State 19	State 20	State 21	State 22
2018	June	57	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	50	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	April	31	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	March	31	4	0	0	0	0	0	0	0	0	0	0	0	0	0.0833	0	0	0	0	0	0	0	0	0
	February	27	5	0	0	0	0	0	0	0	0	0	0	0	0	0.0833	0	0	0	0	0	0	0	0	0
	January	31	6	0.042	0	0	0	0	0.014	0	0	0.021	0.0139	0	0.0208	0.037	0	0	0	0	0	0	0	0	0
2017	December	47	7	0.024	0	0	0	0	0.005	0	0	0.033	0.0046	0	0.033	0.0204	0.0139	0	0.0556	0	0	0	0	0	0
	November	40	8	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	October	39	9	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	September	18	10	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	August	16	11	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	July	22	12	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	June	32	13	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	May	49	14	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	April	55	15	0.012	0	0	0.016	0	0.019	0	0	0.016	0.0084	0	0.0165	0.0125	0.0069	0	0.0278	0	0.0833	0.0074	0	0	0.0139
	March	47	16	0.014	0	0	0.022	0	0.028	0	0	0.015	0.0157	0	0.0153	0.0282	0.019	0.0076	0.0233	0.0165	0.0307	0.0105	0	0	0.0147
	February	45	17	0.019	0	0	0.016	0	0.041	0	0	0.016	0.0285	0	0.0164	0.0324	0.0352	0.0147	0.0176	0.0166	0.0212	0.0085	0	0	0.0106
	January	47	18	0.014	0	0	0.016	0	0.028	0	0	0.012	0.0193	0	0.0118	0.0294	0.0244	0.0121	0.01	0.0209	0.0147	0.0097	0	0	0.0068
2016	December	44	19	0.016	0	0	0.017	0	0.031	0	0	0.014	0.0173	0	0.0138	0.0268	0.025	0.0121	0.0108	0.0195	0.0107	0.0102	0	0	0.0074
	November	36	20	0.016	0	0	0.022	0	0.028	0	0	0.017	0.0152	0	0.017	0.0249	0.0242	0.0127	0.0104	0.0192	0.0125	0.0115	0	0	0.0134
	October	35	21	0.016	0	0	0.022	0	0.028	0	0	0.017	0.0152	0	0.017	0.0249	0.0242	0.0127	0.0104	0.0192	0.0125	0.0115	0	0	0.0134
	September	14	22	0.019	0	0	0.024	0	0.033	0	0	0.018	0.0164	0	0.0185	0.0272	0.0273	0.0145	0.0108	0.0163	0.01	0.0102	0	0	0.0117
	August	15	23	0.019	0	0	0.024	0	0.033	0	0	0.018	0.0164	0	0.0185	0.0272	0.0273	0.0145	0.0108	0.0163	0.01	0.0102	0	0	0.0117
	July	17	24	0.019	0	0	0.024	0	0.033	0	0	0.018	0.0164	0	0.0185	0.0272	0.0273	0.0145	0.0108	0.0163	0.01	0.0102	0	0	0.0117
	June	29	25	0.019	0	0	0.024	0	0.033	0	0	0.018	0.0164	0	0.0185	0.0272	0.0273	0.0145	0.0108	0.0163	0.01	0.0102	0	0	0.0117
	May	46	26	0.022	0	0	0.021	0	0.034	0	0	0.019	0.018	0	0.0191	0.033	0.0296	0.0157	0.0114	0.0165	0.0102	0.0114	0	0	0.0105
	April	53	27	0.019	0	0	0.02	0	0.031	0	0	0.018	0.0163	0	0.0177	0.037	0.0287	0.0172	0.0113	0.017	0.0093	0.0113	0	0	0.0108
	March	42	28	0.02	0	0	0.02	0	0.033	0	0	0.018	0.0181	0	0.0178	0.0366	0.0296	0.0174	0.0108	0.0172	0.0104	0.0116	0	0	0.0108
	February	42	29	0.018	0	0	0.02	0	0.033	0	0	0.017	0.0183	0	0.0167	0.0361	0.029	0.0172	0.0108	0.0182	0.0108	0.012	0	0	0.0114
	January	43	30	0.019	0	0	0.022	0	0.034	0	0	0.018	0.0189	0	0.018	0.0339	0.0297	0.016	0.0108	0.0175	0.0117	0.0124	0	0	0.0118
2015	December	41	31	0.019	0	0	0.022	0	0.034	0	0	0.018	0.0189	0	0.018	0.0339	0.0297	0.016	0.0108	0.0175	0.0117	0.0124	0	0	0.0118
	November	36	32	0.02	0	0	0.02	0	0.034	0	0	0.018	0.0189	0	0.0176	0.0349	0.0293	0.0165	0.0107	0.0173	0.0116	0.0123	0	0	0.0114
	October	30	33	0.02	0	0	0.02	0	0.034	0	0	0.018	0.0189	0	0.0176	0.0349	0.0293	0.0165	0.0107	0.0173	0.0116	0.0123	0	0	0.0114
	September	4	34	0.02	0	0	0.02	0	0.034	0	0	0.018	0.0189	0	0.0176	0.0349	0.0293	0.0165	0.0107	0.0173	0.0116	0.0123	0	0	0.0114
	August	1	35	0.02	0	0	0.02	0	0.034	0	0	0.018	0.0189	0	0.0176	0.0349	0.0293	0.0165	0.0107	0.0173	0.0116	0.0123	0	0	0.0114
	July	10	36	0.02	0	0	0.02	0	0.034	0	0	0.018	0.0189	0	0.0176	0.0349	0.0293	0.0165	0.0107	0.0173	0.0116	0.0123	0	0	0.0114
	June	13	37	0.019	0	0	0.02	0	0.033	0	0	0.017	0.0186	0	0.0169	0.0358	0.0291	0.0169	0.0111	0.0177	0.0116	0.012	0	0	0.0114
	May	43	38	0.018	0	0	0.019	0	0.033	0	0	0.017	0.0187	0	0.0166	0.0367	0.0293	0.0172	0.0116	0.0178	0.0119	0.0119	0	0	0.0116
	April	48	39	0.018	0	0	0.019	0	0.033	0	0	0.017	0.0186	0	0.0165	0.0374	0.0292	0.0174	0.0116	0.0179	0.0118	0.012	0	0	0.0116
	March	44	40	0.019	0	0	0.019	0	0.033	0	0	0.017	0.0188	0	0.0167	0.0378	0.0293	0.0176	0.0113	0.0177	0.0115	0.0121	0	0	0.0114
	February	37	41	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0168	0.0377	0.0294	0.0175	0.0112	0.0176	0.0114	0.0121	0	0	0.0114
	January	43	42	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0192	0	0.0171	0.0375	0.03	0.0175	0.0114	0.0175	0.0116	0.0121	0	0	0.0116
2014	December	57	43	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0192	0	0.0171	0.0375	0.03	0.0175	0.0114	0.0175	0.0116	0.0121	0	0	0.0116
	November	53	44	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0193	0	0.0169	0.0379	0.03	0.0176	0.0115	0.0176	0.0116	0.0121	0	0	0.0116
	October	46	45	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0191	0	0.0171	0.0376	0.0298	0.0175	0.0115	0.0174	0.0116	0.0121	0	0	0.0116
	September	9	46	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0191	0	0.0171	0.0376	0.0298	0.0175	0.0115	0.0174	0.0116	0.0121	0	0	0.0116
	August	6	47	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0171	0.0376	0.0297	0.0175	0.0115	0.0174	0.0115	0.0121	0	0	0.0115
	July	13	48	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	June	26	49	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	May	61	50	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	April	65	51	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	March	59	52	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	February	56	53	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
	January	58	54	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.017	0.038	0.0298	0.0176	0.0116	0.0174	0.0115	0.0121	0	0	0.0115
2013	December	43	55	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0379	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	November	34	56	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0379	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	October	25	57	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0379	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	September	12	58	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0379	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	August	6	59	0.019	0	0	0.019	0	0.034	0	0	0.017	0.019	0	0.0169	0.0379	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	July	14	60	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0175	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	June	19	61	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0175	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	May	48	62	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	April	51	63	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	March	45	64	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	February	40	65	0.019	0	0	0.019	0	0.034	0	0	0.017	0.0189	0	0.0169	0.0378	0.0297	0.0176	0.0116	0.0175	0.0116	0.0121	0	0	0.0116
	Sum			1.1	0	0	1.111	0	1.837	0	0	1.036	1.0153	0	1.0365	2.0782	1.5146	0.8199	0.8573	0.8756	1.267	0.6449	0	0	0.683

		Initial State	Transition	State 23	State 24	State 25	State 26	State 27	State 28	State 29	State 30	State 31	State 32	State 33
2018	June	57	1	0	0	0	0	0	0	0	0	0	0	0
	May	50	2	0	0	0	0	0	0	0	0	0	0	0
	April	31	3	0	0	0	0	0.148148148	0	0	0	0.259259259	0	0
	March	31	4	0	0	0	0	0.086419753	0	0	0	0.234567901	0	0
	February	27	5	0	0	0	0	0.086419753	0	0	0	0.234567901	0	0
	January	31	6	0	0	0	0	0.054869684	0	0	0	0.133058985	0	0
2017	December	47	7	0	0	0	0	0.024119799	0	0	0	0.063042981	0.009259259	0
	November	40	8	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	October	39	9	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	September	18	10	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	August	16	11	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	July	22	12	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	June	32	13	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	May	49	14	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	April	55	15	0	0	0.0390625	0	0.021404893	0	0.00390625	0	0.054819673	0.00462963	0
	March	47	16	0	0	0.024352809	0.019383597	0.016335013	0	0.012111432	0.01018137	0.043440266	0.00996216	0
	February	45	17	0	0	0.016565033	0.015548913	0.012818906	0	0.013956111	0.008647301	0.03441059	0.008396161	0
	January	47	18	0	0	0.01420594	0.023054173	0.013019445	0	0.015094076	0.013539393	0.036414614	0.007306299	0
2016	December	44	19	0	0	0.018104377	0.018566642	0.011635033	0	0.018584186	0.02746522	0.034535705	0.012835708	0
	November	36	20	0	0	0.018396203	0.026184117	0.011448458	0	0.019722923	0.021851596	0.033778746	0.011330661	0
	October	35	21	0	0	0.018396203	0.026184117	0.011448458	0	0.019722923	0.021851596	0.033778746	0.011330661	0
	September	14	22	0	0	0.020929782	0.018669674	0.011131961	0	0.019384168	0.024666521	0.032607265	0.012420395	0
	August	15	23	0	0	0.020929782	0.018669674	0.011131961	0	0.019384168	0.024666521	0.032607265	0.012420395	0
	July	17	24	0	0	0.020929782	0.018669674	0.011131961	0	0.019384168	0.024666521	0.032607265	0.012420395	0
	June	29	25	0	0	0.020929782	0.018669674	0.011131961	0	0.019384168	0.024666521	0.032607265	0.012420395	0
	May	46	26	0	0	0.018387356	0.016861451	0.010885712	0	0.018300906	0.022755295	0.033024057	0.011853813	0
	April	53	27	0	0	0.017944622	0.017861142	0.011229579	0	0.019135275	0.024198255	0.0337857	0.011905443	0
	March	42	28	0	0	0.017966092	0.017957564	0.011069178	0	0.018178815	0.021133839	0.033496616	0.011353985	0
	February	42	29	0	0	0.017826432	0.019687421	0.011165539	0	0.018191064	0.02039872	0.033754373	0.011628155	0
	January	43	30	0	0	0.018321412	0.019005764	0.011453993	0	0.017252956	0.018420223	0.034346825	0.011428734	0
2015	December	41	31	0	0	0.018321412	0.019005764	0.011453993	0	0.017252956	0.018420223	0.034346825	0.011428734	0
	November	36	32	0	0	0.017528823	0.018649013	0.011635759	0	0.017379964	0.019029379	0.034974827	0.011736144	0
	October	30	33	0	0	0.017528823	0.018649013	0.011635759	0	0.017379964	0.019029379	0.034974827	0.011736144	0
	September	4	34	0	0	0.017528823	0.018649013	0.011635759	0	0.017379964	0.019029379	0.034974827	0.011736144	0
	August	1	35	0	0	0.017528823	0.018649013	0.011635759	0	0.017379964	0.019029379	0.034974827	0.011736144	0
	July	10	36	0	0	0.017528823	0.018649013	0.011635759	0	0.017379964	0.019029379	0.034974827	0.011736144	0
	June	13	37	0	0	0.017374278	0.019365869	0.011547728	0	0.017809361	0.019575214	0.034615818	0.011610215	0
	May	43	38	0	0	0.017206942	0.019584416	0.011590586	0	0.01778995	0.019383712	0.034577041	0.011613679	0
	April	48	39	0	0	0.016920493	0.019717508	0.01156129	0	0.017873251	0.01945366	0.034583902	0.011621863	0
	March	44	40	0	0	0.016654959	0.019242115	0.01159974	0	0.017666434	0.019101901	0.03486078	0.011622738	0
	February	37	41	0	0	0.016706213	0.019026511	0.011602838	0	0.017567013	0.018942598	0.034915341	0.011573943	0
	January	43	42	0	0	0.016947121	0.018777184	0.011548201	0	0.017322316	0.018326655	0.034677267	0.011444158	0
2014	December	57	43	0	0	0.016947121	0.018777184	0.011548201	0	0.017322316	0.018326655	0.034677267	0.011444158	0
	November	53	44	0	0	0.016799628	0.018907871	0.01154865	0	0.017405336	0.018386361	0.03463222	0.011475218	0
	October	46	45	0	0	0.016991411	0.018692595	0.011547132	0	0.017444444	0.018728256	0.034668241	0.011505725	0
	September	9	46	0	0	0.016991411	0.018692595	0.011547132	0	0.017444444	0.018728256	0.034668241	0.011505725	0
	August	6	47	0	0	0.01702475	0.018557223	0.01155311	0	0.017509563	0.01902739	0.03470656	0.011540996	0
	July	13	48	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	June	26	49	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	May	61	50	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	April	65	51	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	March	59	52	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	February	56	53	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
	January	58	54	0	0	0.016812812	0.018638119	0.011565341	0	0.017485626	0.01886924	0.03473542	0.011581306	0
2013	December	43	55	0	0	0.016846995	0.018811519	0.011572256	0	0.017525115	0.018896672	0.034726908	0.01157864	0
	November	34	56	0	0	0.016846995	0.018811519	0.011572256	0	0.017525115	0.018896672	0.034726908	0.01157864	0
	October	25	57	0	0	0.016846995	0.018811519	0.011572256	0	0.017525115	0.018896672	0.034726908	0.01157864	0
	September	12	58	0	0	0.016846995	0.018811519	0.011572256	0	0.017525115	0.018896672	0.034726908	0.01157864	0
	August	6	59	0	0	0.016843365	0.018853779	0.011571387	0	0.01752065	0.018850538	0.034720365	0.011571974	0
	July	14	60	0	0	0.016870149	0.018865858	0.011572263	0	0.017528666	0.018878237	0.034718369	0.011569096	0
	June	19	61	0	0	0.016870149	0.018865858	0.011572263	0	0.017528666	0.018878237	0.034718369	0.011569096	0
	May	48	62	0	0	0.016857021	0.018873153	0.011571548	0	0.017533637	0.018883636	0.034718503	0.01156976	0
	April	51	63	0	0	0.016857021	0.018873153	0.011571548	0	0.017533637	0.018883636	0.034718503	0.01156976	0
	March	45	64	0	0	0.016863263	0.01889393	0.011573702	0	0.017543937	0.018904942	0.034719844	0.011573868	0
	February	40	65	0	0	0.016866543	0.018908379	0.011573715	0	0.017546915	0.018903365	0.03471709	0.01157005	0
	Sum			0	0	1.192320636	0.954412517	1.15333367	0	0.911580489	0.970510624	3.094139967	0.620754835	0

		Initial State	Transition	State 34	State 35	State 36	State 37	State 38	State 39	State 40	State 41	State 42	State 43	State 44
2018	June	57	1	0	0	0	0	0	0	0	0	0	1	0
	May	50	2	0	0	0	0	0	0	0	0	0	1	0
	April	31	3	0	0	0	0	0	0	0	0	0	0.333333333	0
	March	31	4	0	0	0	0.083333333	0	0	0	0	0.083333333	0.111111111	0
	February	27	5	0	0	0	0.083333333	0	0	0	0	0.083333333	0.111111111	0
	January	31	6	0	0	0	0.037037037	0	0	0.013888889	0	0.071759259	0.086419753	0.013888889
2017	December	47	7	0	0	0.041666667	0.020447531	0	0.333333333	0.00462963	0	0.037229938	0.034979424	0.00462963
	November	40	8	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	October	39	9	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	September	18	10	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	August	16	11	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	July	22	12	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	June	32	13	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	May	49	14	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	April	55	15	0	0.010416667	0.020833333	0.01253858	0	0.166666667	0.008391204	0.03125	0.030912423	0.049655993	0.039641204
	March	47	16	0.011187168	0.012751306	0.051104892	0.014579538	0	0.064171811	0.012245954	0.016883742	0.032197481	0.07704041	0.025303821
	February	45	17	0.012587007	0.012874625	0.033589872	0.018203793	0	0.035087931	0.014068934	0.01190053	0.037976087	0.08487173	0.023622499
	January	47	18	0.015323465	0.009076332	0.031231314	0.018306848	0	0.023311132	0.040354931	0.011466338	0.03598627	0.090757632	0.021096389
2016	December	44	19	0.02125898	0.013898164	0.034986876	0.01599118	0	0.014959	0.030190036	0.01493604	0.034522288	0.077149075	0.023810824
	November	36	20	0.021890755	0.013160239	0.045375532	0.014545882	0	0.011283522	0.021788194	0.012447469	0.033068734	0.082461391	0.020768913
	October	35	21	0.021890755	0.013160239	0.045375532	0.014545882	0	0.011283522	0.021788194	0.012447469	0.033068734	0.082461391	0.020768913
	September	14	22	0.020831116	0.016488891	0.035967776	0.015408461	0	0.010272898	0.01983709	0.014482438	0.035375092	0.069629354	0.023647501
	August	15	23	0.020831116	0.016488891	0.035967776	0.015408461	0	0.010272898	0.01983709	0.014482438	0.035375092	0.069629354	0.023647501
	July	17	24	0.020831116	0.016488891	0.035967776	0.015408461	0	0.010272898	0.01983709	0.014482438	0.035375092	0.069629354	0.023647501
	June	29	25	0.020831116	0.016488891	0.035967776	0.015408461	0	0.010272898	0.01983709	0.014482438	0.035375092	0.069629354	0.023647501
	May	46	26	0.018926547	0.016357268	0.03268505	0.017710207	0	0.011747405	0.019205098	0.014922386	0.037561693	0.069910274	0.024451232
	April	53	27	0.019793558	0.014718707	0.033448565	0.018357986	0	0.011890043	0.019211858	0.018534856	0.037068958	0.070914362	0.027308756
	March	42	28	0.017987563	0.015236945	0.033824605	0.018534479	0	0.011507851	0.020481146	0.017100323	0.037694823	0.07252614	0.026455809
	February	42	29	0.017966092	0.014798236	0.036370783	0.018131535	0	0.010407437	0.020775091	0.016912303	0.036978946	0.076398515	0.026179542
	January	43	30	0.016686181	0.014981119	0.037034941	0.017845372	0	0.012736357	0.021613976	0.014800375	0.037302669	0.074881114	0.024457276
2015	December	41	31	0.016686181	0.014981119	0.037034941	0.017845372	0	0.012736357	0.021613976	0.014800375	0.037302669	0.074881114	0.024457276
	November	36	32	0.016869785	0.015123092	0.035277444	0.018072236	0	0.011623381	0.021345441	0.015197399	0.037404079	0.074510636	0.024803823
	October	30	33	0.016869785	0.015123092	0.035277444	0.018072236	0	0.011623381	0.021345441	0.015197399	0.037404079	0.074510636	0.024803823
	September	4	34	0.016869785	0.015123092	0.035277444	0.018072236	0	0.011623381	0.021345441	0.015197399	0.037404079	0.074510636	0.024803823
	August	1	35	0.016869785	0.015123092	0.035277444	0.018072236	0	0.011623381	0.021345441	0.015197399	0.037404079	0.074510636	0.024803823
	July	10	36	0.016869785	0.015123092	0.035277444	0.018072236	0	0.011623381	0.021345441	0.015197399	0.037404079	0.074510636	0.024803823
	June	13	37	0.017466922	0.014741357	0.035441145	0.018232965	0	0.011355031	0.021277755	0.016235552	0.037229332	0.075596975	0.025652006
	May	43	38	0.017381843	0.014702381	0.035454557	0.018421852	0	0.011320706	0.020855305	0.016611856	0.037269369	0.076274527	0.026000448
	April	48	39	0.017463093	0.014603192	0.035107869	0.018628115	0	0.011281782	0.020724886	0.016998901	0.03736291	0.076550052	0.026312527
	March	44	40	0.017080886	0.014674994	0.034130585	0.01881967	0	0.011365473	0.020995809	0.016897027	0.037643926	0.076051834	0.026284236
	February	37	41	0.016911714	0.014713972	0.033848268	0.018846263	0	0.011472655	0.021197951	0.016752722	0.037742213	0.07573356	0.02619085
	January	43	42	0.016477678	0.014912758	0.033734227	0.018903385	0	0.011613679	0.021231099	0.016402967	0.037981078	0.075554788	0.026012855
2014	December	57	43	0.016477678	0.014912758	0.033734227	0.018903385	0	0.011613679	0.021231099	0.016402967	0.037981078	0.075554788	0.026012855
	November	53	44	0.01658109	0.014821818	0.033647745	0.018983528	0	0.011581785	0.021201485	0.016701689	0.0379705	0.075904802	0.026267509
	October	46	45	0.016696584	0.014936829	0.033587713	0.018899097	0	0.011605916	0.021152501	0.016588472	0.03792093	0.075292366	0.026120324
	September	9	46	0.016696584	0.014936829	0.033587713	0.018899097	0	0.011605916	0.021152501	0.016588472	0.03792093	0.075292366	0.026120324
	August	6	47	0.016821852	0.014962555	0.033413563	0.018893897	0	0.011617383	0.021108936	0.016727793	0.037900083	0.074965143	0.026219565
	July	13	48	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	June	26	49	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	May	61	50	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	April	65	51	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	March	59	52	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	February	56	53	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
	January	58	54	0.016758229	0.01493372	0.033210184	0.019007118	0	0.011544242	0.021068612	0.016826559	0.037973478	0.075321445	0.02632651
2013	December	43	55	0.016827088	0.014866932	0.033547645	0.018948439	0	0.011571128	0.021029546	0.016859427	0.03787813	0.07552179	0.026329933
	November	34	56	0.016827088	0.014866932	0.033547645	0.018948439	0	0.011571128	0.021029546	0.016859427	0.03787813	0.07552179	0.026329933
	October	25	57	0.016827088	0.014866932	0.033547645	0.018948439	0	0.011571128	0.021029546	0.016859427	0.03787813	0.07552179	0.026329933
	September	12	58	0.016827088	0.014866932	0.033547645	0.018948439	0	0.011571128	0.021029546	0.016859427	0.03787813	0.07552179	0.026329933
	August	6	59	0.016814453	0.01484884	0.033609414	0.018943859	0	0.011573638	0.021036864	0.016855872	0.03786978	0.07560387	0.026328199
	July	14	60	0.016835562	0.014847654	0.033668603	0.01891872	0	0.011576148	0.021050562	0.016831846	0.03784747	0.075590568	0.026302586
	June	19	61	0.016835562	0.014847654	0.033668603	0.01891872	0	0.011576148	0.021050562	0.016831846	0.03784747	0.075590568	0.026302586
	May	48	62	0.016841305	0.014841183	0.03366147	0.018926727	0	0.011578648	0.02104386	0.016855245	0.03784849	0.075608584	0.02632144
	April	51	63	0.016841305	0.014841183	0.03366147	0.018926727	0	0.011578648	0.02104386	0.016855245	0.03784849	0.075608584	0.02632144
	March	45	64	0.016860416	0.014834272	0.033705579	0.018918364	0	0.011581863	0.021029498	0.016868078	0.03783197	0.075626861	0.0263261
	February	40	65	0.01686496	0.014827191	0.033729594	0.018914824	0	0.011585938	0.021034788	0.016871461	0.03782549	0.075647992	0.026327972
	Sum			0.868423084	0.821709848	1.958708773	1.228795753	0	2.331576772	1.146078895	1.047170583	2.379373736	6.850911919	1.603967641

		Initial State	Transition	State 45	State 46	State 47	State 48	State 49	State 50	State 51	State 52	State 53	State 54	State 55
2018	June	57	1	0	0	0	0	0	0	0	0	0	0	0
	May	50	2	0	0	0	0	0	0	0	0	0	0	0
	April	31	3	0	0	0	0	0	0.148148	0	0	0	0	0
	March	31	4	0	0	0	0	0	0.08642	0	0	0	0	0
	February	27	5	0	0	0	0	0	0.08642	0	0	0	0	0
	January	31	6	0.020833	0.020833	0.041667	0.020833	0	0.05487	0	0	0.034722	0	0
2017	December	47	7	0.013696	0.012153	0.024306	0.016782	0	0.02412	0	0	0.016782	0	0.001543
	November	40	8	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	October	39	9	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	September	18	10	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	August	16	11	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	July	22	12	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	June	32	13	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	May	49	14	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	April	55	15	0.012056	0.049045	0.017216	0.008391	0.002315	0.021405	0.005064	0	0.02228	0	0.00598
	March	47	16	0.015941	0.041805	0.02473	0.015811	0.006772	0.016335	0.006653	0	0.029729	0	0.007306
	February	45	17	0.0198	0.032933	0.039913	0.028582	0.009245	0.012819	0.007562	0	0.033728	0	0.007647
	January	47	18	0.044646	0.032707	0.059335	0.024391	0.008243	0.013019	0.007183	0	0.032773	0	0.008915
2016	December	44	19	0.033327	0.037521	0.045577	0.024184	0.009246	0.011635	0.008269	0	0.037115	0	0.009639
	November	36	20	0.026271	0.038193	0.040838	0.024318	0.00985	0.011448	0.010201	0	0.038246	0	0.010419
	October	35	21	0.026271	0.038193	0.040838	0.024318	0.00985	0.011448	0.010201	0	0.038246	0	0.010419
	September	14	22	0.024317	0.039861	0.037629	0.024859	0.011379	0.011132	0.010064	0	0.039351	0	0.010242
	August	15	23	0.024317	0.039861	0.037629	0.024859	0.011379	0.011132	0.010064	0	0.039351	0	0.010242
	July	17	24	0.024317	0.039861	0.037629	0.024859	0.011379	0.011132	0.010064	0	0.039351	0	0.010242
	June	29	25	0.024317	0.039861	0.037629	0.024859	0.011379	0.011132	0.010064	0	0.039351	0	0.010242
	May	46	26	0.024472	0.03698	0.036668	0.024326	0.011068	0.010886	0.00997	0	0.038152	0	0.011074
	April	53	27	0.023023	0.036407	0.034562	0.024667	0.011902	0.01123	0.010594	0	0.037846	0	0.011409
	March	42	28	0.022394	0.036382	0.034559	0.023972	0.011628	0.011069	0.010882	0	0.037339	0	0.011519
	February	42	29	0.02176	0.036496	0.034665	0.02411	0.011519	0.011166	0.011197	0	0.037038	0	0.01152
	January	43	30	0.021853	0.036873	0.0344	0.022922	0.011387	0.011454	0.011151	0	0.03671	0	0.011466
2015	December	41	31	0.021853	0.036873	0.0344	0.022922	0.011387	0.011454	0.011151	0	0.03671	0	0.011466
	November	36	32	0.022639	0.035892	0.035327	0.024042	0.011834	0.011636	0.01148	0	0.036712	0	0.011784
	October	30	33	0.022639	0.035892	0.035327	0.024042	0.011834	0.011636	0.01148	0	0.036712	0	0.011784
	September	4	34	0.022639	0.035892	0.035327	0.024042	0.011834	0.011636	0.01148	0	0.036712	0	0.011784
	August	1	35	0.022639	0.035892	0.035327	0.024042	0.011834	0.011636	0.01148	0	0.036712	0	0.011784
	July	10	36	0.022639	0.035892	0.035327	0.024042	0.011834	0.011636	0.01148	0	0.036712	0	0.011784
	June	13	37	0.022268	0.035785	0.035102	0.024203	0.011688	0.011548	0.011273	0	0.036806	0	0.011577
	May	43	38	0.021809	0.035579	0.03468	0.024288	0.011629	0.011591	0.011071	0	0.036637	0	0.011418
	April	48	39	0.021904	0.0353	0.034699	0.02434	0.011566	0.011561	0.011026	0	0.036608	0	0.011459
	March	44	40	0.022429	0.034952	0.03515	0.024462	0.01167	0.0116	0.011211	0	0.036491	0	0.011683
	February	37	41	0.022579	0.034971	0.035278	0.024399	0.011683	0.011603	0.011279	0	0.036463	0	0.011743
	January	43	42	0.022151	0.035149	0.034913	0.024091	0.011576	0.011548	0.011146	0	0.0364	0	0.01162
2014	December	57	43	0.022151	0.035149	0.034913	0.024091	0.011576	0.011548	0.011146	0	0.0364	0	0.01162
	November	53	44	0.022004	0.035001	0.034801	0.024224	0.011572	0.011549	0.01106	0	0.036392	0	0.011563
	October	46	45	0.022133	0.035195	0.034772	0.024085	0.011563	0.011547	0.011075	0	0.036466	0	0.011592
	September	9	46	0.022133	0.035195	0.034772	0.024085	0.011563	0.011547	0.011075	0	0.036466	0	0.011592
	August	6	47	0.022193	0.035226	0.034735	0.024119	0.011591	0.011553	0.011075	0	0.036516	0	0.011615
	July	13	48	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	June	26	49	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	May	61	50	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	April	65	51	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	March	59	52	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	February	56	53	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
	January	58	54	0.022171	0.034993	0.034765	0.024243	0.011586	0.011565	0.011028	0	0.036452	0	0.011606
2013	December	43	55	0.022102	0.035058	0.034714	0.024212	0.011576	0.011572	0.011032	0	0.036455	0	0.011581
	November	34	56	0.022102	0.035058	0.034714	0.024212	0.011576	0.011572	0.011032	0	0.036455	0	0.011581
	October	25	57	0.022102	0.035058	0.034714	0.024212	0.011576	0.011572	0.011032	0	0.036455	0	0.011581
	September	12	58	0.022102	0.035058	0.034714	0.024212	0.011576	0.011572	0.011032	0	0.036455	0	0.011581
	August	6	59	0.02209	0.03506	0.034722	0.024214	0.011574	0.011571	0.011037	0	0.036447	0	0.011578
	July	14	60	0.022093	0.035091	0.034728	0.024204	0.011574	0.011572	0.011042	0	0.036457	0	0.011575
	June	19	61	0.022093	0.035091	0.034728	0.024204	0.011574	0.011572	0.011042	0	0.036457	0	0.011575
	May	48	62	0.022094	0.035079	0.034726	0.024208	0.011572	0.011572	0.011039	0	0.036455	0	0.011575
	April	51	63	0.022094	0.035079	0.034726	0.024208	0.011572	0.011572	0.011039	0	0.036455	0	0.011575
	March	45	64	0.022083	0.035089	0.03471	0.024202	0.011569	0.011574	0.011035	0	0.036458	0	0.01157
	February	40	65	0.022077	0.035095	0.034709	0.0242	0.011567	0.011574	0.011035	0	0.036458	0	0.011568
	Sum			1.28504	2.223882	2.000418	1.311291	0.581386	1.153334	0.574207	0	2.062158	0	0.608136

		Initial State	Transition	State 56	State 57	State 58	State 59	State 60	State 61	State 62	State 63	State 64	State 65
2018	June	57	1	0	0	0	0	0	0	0	0	0	0
	May	50	2	0	0	0	0	0	0	0	0	0	0
	April	31	3	0	0.111111	0	0	0	0	0	0	0	0
	March	31	4	0	0.148148	0.083333	0	0	0	0	0	0	0
	February	27	5	0	0.148148	0.083333	0	0	0	0	0	0	0
	January	31	6	0.027778	0.099023	0.037037	0.083333	0	0	0	0	0	0
2017	December	47	7	0.009259	0.049533	0.020448	0.048611	0	0	0	0	0	0
	November	40	8	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	October	39	9	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	September	18	10	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	
	August	16	11	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	July	22	12	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	June	32	13	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	May	49	14	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	April	55	15	0.016782	0.037417	0.012539	0.024306	0	0	0	0	0	0.03125
	March	47	16	0.01684	0.037251	0.01458	0.018334	0	0.011103	0	0	0	0.023054
	February	45	17	0.023444	0.030313	0.018204	0.016207	0	0.012665	0	0	0	0.016766
	January	47	18	0.01926	0.032981	0.018307	0.01458	0	0.018334	0	0	0	0.01684
2016	December	44	19	0.01775	0.032679	0.015991	0.018878	0	0.024191	0	0	0	0.019334
	November	36	20	0.016643	0.031708	0.014546	0.018443	0	0.021389	0	0	0	0.024306
	October	35	21	0.016643	0.031708	0.014546	0.018443	0	0.021389	0	0	0	0.024306
	September	14	22	0.01833	0.030164	0.015408	0.02181	0	0.023039	0	0	0	0.02297
	August	15	23	0.01833	0.030164	0.015408	0.02181	0	0.023039	0	0	0	0.02297
	July	17	24	0.01833	0.030164	0.015408	0.02181	0	0.023039	0	0	0	0.02297
	June	29	25	0.01833	0.030164	0.015408	0.02181	0	0.023039	0	0	0	0.02297
	May	46	26	0.019058	0.029657	0.01771	0.021614	0	0.02083	0	0	0	0.020416
	April	53	27	0.017548	0.029609	0.018358	0.020012	0	0.021417	0	0	0	0.019785
	March	42	28	0.018711	0.029325	0.018534	0.019874	0	0.019687	0	0	0	0.019736
	February	42	29	0.018534	0.029739	0.018132	0.018711	0	0.019736	0	0	0	0.019874
	January	43	30	0.019314	0.029978	0.017845	0.019526	0	0.01798	0	0	0	0.021218
2015	December	41	31	0.019314	0.029978	0.017845	0.019526	0	0.01798	0	0	0	0.021218
	November	36	32	0.019213	0.029919	0.018072	0.019618	0	0.018508	0	0	0	0.020163
	October	30	33	0.019213	0.029919	0.018072	0.019618	0	0.018508	0	0	0	0.020163
	September	4	34	0.019213	0.029919	0.018072	0.019618	0	0.018508	0	0	0	0.020163
	August	1	35	0.019213	0.029919	0.018072	0.019618	0	0.018508	0	0	0	0.020163
	July	10	36	0.019213	0.029919	0.018072	0.019618	0	0.018508	0	0	0	0.020163
	June	13	37	0.018833	0.029901	0.018233	0.018959	0	0.019183	0	0	0	0.019754
	May	43	38	0.018777	0.029941	0.018422	0.018631	0	0.019242	0	0	0	0.019278
	April	48	39	0.018627	0.029943	0.018628	0.018547	0	0.019389	0	0	0	0.018993
	March	44	40	0.018774	0.029875	0.01882	0.018812	0	0.019092	0	0	0	0.018807
	February	37	41	0.018876	0.029834	0.018846	0.018926	0	0.018937	0	0	0	0.018873
	January	43	42	0.01922	0.029712	0.018903	0.01902	0	0.018422	0	0	0	0.019069
2014	December	57	43	0.01922	0.029712	0.018903	0.01902	0	0.018422	0	0	0	0.019069
	November	53	44	0.019132	0.029722	0.018984	0.018859	0	0.018564	0	0	0	0.018881
	October	46	45	0.019064	0.029732	0.018899	0.019064	0	0.018699	0	0	0	0.019044
	September	9	46	0.019064	0.029732	0.018899	0.019064	0	0.018699	0	0	0	0.019044
	August	6	47	0.018984	0.02974	0.018894	0.019142	0	0.018884	0	0	0	0.019032
	July	13	48	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	June	26	49	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	May	61	50	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	April	65	51	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	March	59	52	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	February	56	53	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
	January	58	54	0.019	0.029744	0.019007	0.019043	0	0.018839	0	0	0	0.018815
2013	December	43	55	0.018941	0.029785	0.018948	0.018959	0	0.018884	0	0	0	0.018872
	November	34	56	0.018941	0.029785	0.018948	0.018959	0	0.018884	0	0	0	0.018872
	October	25	57	0.018941	0.029785	0.018948	0.018959	0	0.018884	0	0	0	0.018872
	September	12	58	0.018941	0.029785	0.018948	0.018959	0	0.018884	0	0	0	0.018872
	August	6	59	0.018945	0.029787	0.018944	0.018933	0	0.018864	0	0	0	0.018879
	July	14	60	0.018941	0.029792	0.018919	0.018935	0	0.018876	0	0	0	0.01891
	June	19	61	0.018941	0.029792	0.018919	0.018935	0	0.018876	0	0	0	0.01891
	May	48	62	0.018932	0.029794	0.018927	0.018928	0	0.018885	0	0	0	0.018895
	April	51	63	0.018932	0.029794	0.018927	0.018928	0	0.018885	0	0	0	0.018895
	March	45	64	0.018916	0.029802	0.018918	0.018919	0	0.018904	0	0	0	0.018901
	February	40	65	0.018913	0.029804	0.018915	0.018909	0	0.018906	0	0	0	0.018906
	Sum			1.113594	2.364233	1.228796	1.285535	0	0.958533	0	0	0	1.207629

$$492{,}787{,}024.62\times\left(1+\frac{3.46036396884151+4.08196103290961}{2}\%\right)=511370824.098922$$

Then the forecasting value of original data sequence is obtained by:

$$\hat{x}(k)=\hat{x}^{(0)}(k)\times\left(1+\frac{\otimes_{j-}+\otimes_{j+}}{2}\%\right)$$

Then the mathematical model for the MCGM of monthly electricity consumption of NCR is:

$$\hat{x}(k)=\hat{x}^{(0)}(k)\times\left(1+\frac{3.46036396884151+4.08196103290961}{2}\%\right)$$

The forecast values from January 2013 to June 2018 are also calculated by Markov Chain Grey Model (see Table 6).

We will now solve the following for the forecasting accuracy: Mean Square Error (MSE), Root Mean Square Error (RMSE), Normalized Mean Square Error (NMSE), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE).

For the Mean Square Error:

$$MSE=\frac{1}{n}\sum_{i=1}^{n}\left(A_i-F_i\right)^2$$

Where *n = sample size, y = observed values*, and $\tilde{y}$ *= forecasts.*

GM(1,1):

MCGM(1,1)

Then the MSE for GM (1,1) and MCGM of monthly electricity consumption from January 2013 to June 2018 are:

$$GM(1,1):\quad MSE=\frac{1}{66}\sum_{i=1}^{66}[x^{(0)}(i)-\hat{x}^{(0)}(i)]^2=1622803285137450$$

$$MCGM(1,1):\quad MSE=\frac{1}{66}\sum_{i=1}^{66}\left[x^{(0)}(i)-\hat{x}(i)\right]^2=35954337846890.2$$

For the Root Mean Square Error:

RMSE = (*MSE*)$^{1/2}$

Then the RMSE for GM (1,1) and MCGM of monthly electricity consumption from January 2013 to June 2018 are:

$$GM(1,1):\quad RMSE=\left[\frac{1}{66}\sum_{i=1}^{66}(x^{(0)}(i)-\hat{x}^{(0)}(i))^2\right]^{1/2}=40284032.632514$$

$$MCGM(1,1):\ RMSE=[\frac{1}{66}\sum_{i=1}^{66}\left(x^{(0)}(i)-\hat{x}(i)\right)^2]^{1/2}=5996193.61319247$$

For the Normalized Mean Square Error:

$$NMSE=\frac{\sum_{i=1}^{n}(A_t-F_t)^2}{n\left(\bar{A}\times\bar{F}\right)}$$

Where *n = sample size, y = observed values*, and $\tilde{y}$ *= forecasts* $\bar{y}$ *= mean of the observed values*, and $\tilde{y}$ *= mean of the forecasted values.*

Then the NMSE for GM (1,1) and MCGM of monthly electricity consumption from January 2013 to June 2018 are:

$$GM(1,1):NMSE=\frac{\sum_{i=1}^{66}\left[x^{(0)}(i)-\hat{x}^{(0)}(i)\right]^2}{66\left(\overline{x^{(0)}}\times\overline{\hat{x}^{(0)}}\right)}$$

$$=\frac{\sum_{i=1}^{66}\left[x^{(0)}(i)-\hat{x}^{(0)}(i)\right]^2}{66(420909198.223887\times419923427.796618)}$$

$$=0.009181367$$

$$MCGM(1,1):NMSE$$

$$=\frac{\sum_{i=1}^{66}\left[x^{(0)}(i)-\hat{x}^{(0)}(i)\right]^2}{66\left(\overline{x^{(0)}}\times\hat{X}\right)}$$

$$=\frac{\sum_{i=1}^{66}\left[x^{(0)}(i)-\hat{x}^{(0)}(i)\right]^2}{66(420909198.223887\times416803737.180564)}$$

$$=0.00020494214343992$$

For the Mean Absolute Percentage Error:

$$MAPE=\frac{1}{n}\sum_{i=1}^{n}\left|\frac{A_i-F_i}{A_i}\right|\times100$$

Then the MAPE for GM (1,1) and MCGM of monthly electricity consumption from January 2013 to June 2018 are:

$$GM(1,1): \qquad MAPE = \frac{}{66}\sum^{66}\left|\frac{x^{(0)}(i) \quad \hat{x}^{(0)}(i)}{x^{(\ )}(i)}\right| \times 100 = 8.35200235177034$$

$$MCGM(1,1): MAPE = \frac{}{66}\sum^{66}\left|\frac{x^{(\ )}(i) \quad \hat{x}(i)}{\hat{x}(i)}\right| \times 100 = 1.07394173903827$$

For the Mean Absolute Error:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|F_i - A_i\right|$$

Then the MAE for GM (1,1) and MCGM of monthly electricity consumption from January 2013 to June 2018 are:

$$GM(1,1): \qquad MAE = \frac{1}{66}\sum_{i=1}^{66}\left|x^{(0)}(i) - \hat{x}^{(0)}(i)\right| = 33974305.8325304$$

$$MCGM(1,1): MAE = \frac{1}{66}\sum_{i=1}^{66}\left|x^{(0)}(i) - \hat{x}(i)\right| = 4227582.03151131$$

Table 1. Actual data of the National Capital Region

k		k		k		k		k	
1	368,026,507.90	15	5,615,697,933.68	29	11,338,776,539.61	43	17,072,284,836.84	57	23,365,745,197.05
2	735,710,143.21	16	6,083,660,114.95	30	11,697,255,018.35	44	17,459,207,003.56	58	23,844,775,296.23
3	1,115,972,908.54	17	6,539,285,276.18	31	12,051,589,661.85	45	17,847,054,186.68	59	24,327,222,679.00
4	1,514,059,499.61	18	6,903,894,594.39	32	12,390,692,740.79	46	18,287,264,889.55	60	24,835,161,966.09
5	1,906,847,784.63	19	7,244,372,693.70	33	12,738,128,985.57	47	18,731,392,185.73	61	25,298,127,347.99
6	2,237,134,694.68	20	7,574,124,886.62	34	13,140,662,007.21	48	19,200,806,941.30	62	25,752,309,728.57
7	2,560,291,609.25	21	7,910,543,335.76	35	13,560,378,631.07	49	19,682,102,024.29	63	26,218,020,430.26
8	2,870,148,867.99	22	8,331,635,278.42	36	13,995,126,073.88	50	20,161,205,828.81	64	26,685,284,542.22
9	3,192,010,650.41	23	8,773,145,184.39	37	14,438,654,425.83	51	20,647,631,355.39	65	27,218,196,969.80
10	3,539,219,037.52	24	9,231,117,812.62	38	14,879,403,352.55	52	21,162,813,546.21	66	27,780,007,082.78
11	3,908,261,772.63	25	9,648,016,839.14	39	15,323,883,084.24	53	21,659,922,272.42		
12	4,301,309,518.23	26	10,051,265,533.32	40	15,803,768,142.46	54	22,108,318,131.88		
13	4,737,346,468.98	27	10,474,898,303.09	41	16,264,630,162.48	55	22,532,587,345.05		
14	5,170,211,112.79	28	10,912,994,948.09	42	16,681,481,847.90	56	22,946,028,969.15		

Table 2. 1-AGO of the actual data of the National Capital Region

k	Actual Data ($x^{(0)}(k)$)	k	Actual Data ($x^{(0)}(k)$)	K	Actual Data ($x^{(0)}(k)$)	k	Actual Data ($x^{(0)}(k)$)	k	Actual Data ($x^{(0)}(k)$)
1	368,026,507.90	**15**	445,486,820.89	**29**	425,781,591.52	**43**	390,802,988.94	**57**	419,716,227.90
2	367,683,635.31	**16**	467,962,181.27	**30**	358,478,478.74	**44**	386,922,166.72	**58**	479,030,099.18
3	380,262,765.33	**17**	455,625,161.22	**31**	354,334,643.50	**45**	387,847,183.13	**59**	482,447,382.77
4	398,086,591.07	**18**	364,609,318.21	**32**	339,103,078.94	**46**	440,210,702.87	**60**	507,939,287.09
5	392,788,285.02	**19**	340,478,099.31	**33**	347,436,244.78	**47**	444,127,296.18	**61**	462,965,381.90
6	330,286,910.05	**20**	329,752,192.91	**34**	402,533,021.64	**48**	469,414,755.57	**62**	454,182,380.58
7	323,156,914.57	**21**	336,418,449.14	**35**	419,716,623.86	**49**	481,295,082.99	**63**	465,710,701.69
8	309,857,258.74	**22**	421,091,942.67	**36**	434,747,442.81	**50**	479,103,804.52	**64**	467,264,111.96
9	321,861,782.42	**23**	441,509,905.96	**37**	443,528,351.96	**51**	486,425,526.58	**65**	532,912,427.58
10	347,208,387.12	**24**	457,972,628.23	**38**	440,748,926.72	**52**	515,182,190.82	**66**	561,810,112.98
11	369,042,735.11	**25**	416,899,026.52	**39**	444,479,731.69	**53**	497,108,726.21		
12	393,047,745.60	**26**	403,248,694.18	**40**	479,885,058.23	**54**	448,395,859.46		
13	436,036,950.75	**27**	423,632,769.77	**41**	460,862,020.02	**55**	424,269,213.17		
14	432,864,643.81	**28**	438,096,645.00	**42**	416,851,685.42	**56**	413,441,624.10		

Table 3. $\hat{x}^{(1)}(k+1)$ and $\hat{x}^{(0)}(k+1)$ values of Table 1

	$\hat{x}^{(1)}(k+1)$	$\hat{x}^{(0)}(k+1)$		$\hat{x}^{(1)}(k+1)$	$\hat{x}^{(0)}(k+1)$
1	368,026,507.90	368,026,507.90	**34**	13,231,312,326.98	419,949,871.01
2	729,822,489.82	359,617,273.24	**35**	13,652,404,213.64	421,990,190.53
3	1,093,286,243.13	361,364,467.84	**36**	14,075,437,208.10	424,040,422.92
4	1,458,425,455.75	363,120,151.14	**37**	14,500,420,258.27	426,100,616.32
5	1,825,247,851.06	364,884,364.41	**38**	14,927,362,353.35	428,170,819.14
6	2,193,761,188.03	366,657,149.08	**39**	15,356,272,523.94	430,251,080.00
7	2,563,973,261.38	368,438,546.79	**40**	15,787,159,842.28	432,341,447.78
8	2,935,891,901.80	370,228,599.39	**41**	16,220,033,422.43	434,441,971.57
9	3,309,524,976.03	372,027,348.94	**42**	16,654,902,420.46	436,552,700.73
10	3,684,880,387.12	373,834,837.68	**43**	17,091,776,034.66	438,673,684.82
11	4,061,966,074.52	375,651,108.07	**44**	17,530,663,505.71	440,804,973.69
12	4,440,790,014.28	377,476,202.79	**45**	17,971,574,116.88	442,946,617.38
13	4,821,360,219.23	379,310,164.69	**46**	18,414,517,194.24	445,098,666.22
14	5,203,684,739.13	381,153,036.87	**47**	18,859,502,106.86	447,261,170.75
15	5,587,771,660.84	383,004,862.62	**48**	19,306,538,267.00	449,434,181.77
16	5,973,629,108.53	384,865,685.43	**49**	19,755,635,130.28	451,617,750.33
17	6,361,265,243.77	386,735,549.01	**50**	20,206,802,195.93	453,811,927.73
18	6,750,688,265.79	388,614,497.30	**51**	20,660,049,006.97	456,016,765.49
19	7,141,906,411.60	390,502,574.43	**52**	21,115,385,150.40	458,232,315.43
20	7,534,927,956.18	392,399,824.75	**53**	21,572,820,257.42	460,458,629.58
21	7,929,761,212.68	394,306,292.82	**54**	22,032,364,003.63	462,695,760.24
22	8,326,414,532.53	396,222,023.45	**55**	22,494,026,109.22	464,943,759.96
23	8,724,896,305.68	398,147,061.61	**56**	22,957,816,339.20	467,202,681.55
24	9,125,214,960.77	400,081,452.55	**57**	23,423,744,503.57	469,472,578.07
25	9,527,378,965.26	402,025,241.69	**58**	23,891,820,457.60	471,753,502.85
26	9,931,396,825.66	403,978,474.69	**59**	24,362,054,101.93	474,045,509.46
27	10,337,277,087.70	405,941,197.45	**60**	24,834,455,382.88	476,348,651.75
28	10,745,028,336.50	407,913,456.06	**61**	25,309,034,292.61	478,662,983.82
29	11,154,659,196.73	409,895,296.86	**62**	25,785,800,869.33	480,988,560.04
30	11,566,178,332.86	411,886,766.40	**63**	26,264,765,197.54	483,325,435.03
31	11,979,594,449.26	413,887,911.47	**64**	26,745,937,408.21	485,673,663.68
32	12,394,916,290.45	415,898,779.06	**65**	27,229,327,679.03	488,033,301.17
33	12,812,152,641.25	417,919,416.42	**66**	27,714,946,234.58	490,404,402.91

Table 4. Relative Errors of GM (1,1) of the monthly electricity consumption of NCR

k	Relative Error(k)	k	Relative Error(k)	k	Relative Error(k)	k	Relative Error(k)	k	Relative Error(k)	k	Relative Error(k)
1	-	12	3.96	23	9.82	34	-4.33	45	-14.21	56	-13
2	2.19	13	13.01	24	12.64	35	-0.54	46	-1.11	57	-11.85
3	4.97	14	11.95	25	3.57	36	2.46	47	-0.71	58	1.52
4	8.78	15	14.03	26	-0.18	37	3.93	48	4.26	59	1.74
5	7.1	16	17.76	27	4.18	38	2.85	49	6.17	60	6.22
6	-11.01	17	15.12	28	6.89	39	3.2	50	5.28	61	-3.39
7	-14.01	18	-6.58	29	3.73	40	9.91	51	6.25	62	-5.9
8	-19.48	19	-14.69	30	-14.9	41	5.73	52	11.05	63	-3.78
9	-15.59	20	-19	31	-16.81	42	-4.73	53	7.37	64	-3.94
10	-7.67	21	-17.21	32	-22.65	43	-12.25	54	-3.19	65	8.42
11	-1.79	22	5.91	33	-20.29	44	-13.93	55	-9.59	66	12.71

Table 5. Intervals for each state

State	Lower bound	Upper bound	State	Lower bound	Upper bound	State	Lower bound	Upper bound
1	-22.64671272	-22.02511566	**23**	-8.971577313	-8.349980248	**45**	4.703558097	5.325155161
2	-22.02511566	-21.40351859	**24**	-8.349980248	-7.728383184	**46**	5.325155161	5.946752225
3	-21.40351859	-20.78192153	**25**	-7.728383184	-7.10678612	**47**	5.946752225	6.568349289
4	-20.78192153	-20.16032447	**26**	-7.10678612	-6.485189056	**48**	6.568349289	7.189946353
5	-20.16032447	-19.5387274	**27**	-6.485189056	-5.863591992	**49**	7.189946353	7.811543417
6	-19.5387274	-18.91713034	**28**	-5.863591992	-5.241994928	**50**	7.811543417	8.433140481
7	-18.91713034	-18.29553327	**29**	-5.241994928	-4.620397864	**51**	8.433140481	9.054737545
8	-18.29553327	-17.67393621	**30**	-4.620397864	-3.9988008	**52**	9.054737545	9.67633461
9	-17.67393621	-17.05233915	**31**	-3.9988008	-3.377203736	**53**	9.67633461	10.29793167
10	-17.05233915	-16.43074208	**32**	-3.377203736	-2.755606672	**54**	10.29793167	10.91952874
11	-16.43074208	-15.80914502	**33**	-2.755606672	-2.134009608	**55**	10.91952874	11.5411258
12	-15.80914502	-15.18754795	**34**	-2.134009608	-1.512412544	**56**	11.5411258	12.16272287
13	-15.18754795	-14.56595089	**35**	-1.512412544	-0.89081548	**57**	12.16272287	12.78431993
14	-14.56595089	-13.94435383	**36**	-0.89081548	-0.269218416	**58**	12.78431993	13.40591699
15	-13.94435383	-13.32275676	**37**	-0.269218416	0.352378649	**59**	13.40591699	14.02751406
16	-13.32275676	-12.7011597	**38**	0.352378649	0.973975713	**60**	14.02751406	14.64911112
17	-12.7011597	-12.07956263	**39**	0.973975713	1.595572777	**61**	14.64911112	15.27070819
18	-12.07956263	-11.45796557	**40**	1.595572777	2.217169841	**62**	15.27070819	15.89230525
19	-11.45796557	-10.8363685	**41**	2.217169841	2.838766905	**63**	15.89230525	16.51390231
20	-10.8363685	-10.21477144	**42**	2.838766905	3.460363969	**64**	16.51390231	17.13549938
21	-10.21477144	-9.593174377	**43**	3.460363969	4.081961033	**65**	17.13549938	17.75709644
22	-9.593174377	-8.971577313	**44**	4.081961033	4.703558097	**66**	17.75709644	18.37869351

Table 6. Markov-Chain Grey Model Prediction for the monthly electricity consumption of NCR

Year	Month		Year	Month	
2018	July	511,370,824.10	2020	January	557,987,162.15
	August	513,855,310.82		February	560,698,133.57
	September	516,351,868.37		March	563,422,276.21
	October	518,860,555.41		April	566,159,654.05
	November	521,381,430.86		May	568,910,331.39
	December	523,914,553.94		June	571,674,372.85
2019	January	526,459,984.16		July	574,451,843.37
	February	529,017,781.32		August	577,242,808.17
	March	531,588,005.48		September	580,047,332.84
	April	534,170,717.04		October	582,865,483.24
	May	536,765,976.66		November	585,697,325.58
	June	539,373,845.31		December	588,542,926.38
	July	541,994,384.24	2021	January	591,402,352.48
	August	544,627,655.02		February	594,275,671.06
	September	547,273,719.50		March	597,162,949.60
	October	549,932,639.84		April	600,064,255.95
	November	552,604,478.50		May	602,979,658.24
	December	555,289,298.25		June	605,909,224.97

3.2.1 Mathematical Models

- Mathematical Model for CAR

GM (1, 1): $$\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0035}\right)\left(x^{(0)}(1)+\frac{32328124.41}{0.0035}\right)e^{0.0035k},\quad (k=1,2,\ldots,n)$$

MCGM: $$\hat{y}=\hat{x}^{(0)}(k+1)\left(1-\frac{2.0890+1.8366}{2}\%\right)$$

- Mathematical Model for Region I

GM (1, 1): $$\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0045}\right)\left(x^{(0)}(1)+\frac{133789408.31}{0.0045}\right)e^{0.0045k},\quad (k=1,2,\ldots,n)$$

MCGM: $$\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{6.24176+6.84404}{2}\%\right)$$

- Mathematical Model for Region II

GM (1, 1): $$\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0055}\right)\left(x^{(0)}(1)+\frac{65353105.06}{0.0055}\right)e^{0.0055k},\quad (k=1,2,\ldots,n)$$

MCGM: $$\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{9.67+10.55}{2}\%\right)$$

- Mathematical Model for Region III

GM (1, 1): $$\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0046}\right)\left(x^{(0)}(1)+\frac{359272055.97}{0.0046}\right)e^{0.0046k},\quad (k=1,2,\ldots,n)$$

MCGM: $$\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{11.4402+12.1185}{2}\%\right)$$

- Mathematical Model for Region IV-A

GM (1, 1): $$\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0047}\right)\left(x^{(0)}(1)+\frac{93526613.77}{0.0047}\right)e^{0.0047k},\quad (k=1,2,\ldots,n)$$

MCGM: $$\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{9.7674+10.2885}{2}\%\right)$$

- Mathematical Model for Region IV-B

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0070}\right)\left(x^{(0)}(1)+\frac{39468039.76}{0.0070}\right)e^{0.0070k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{11.3305+11.8766}{2}\%\right)$

- Mathematical Model for Region V

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0055}\right)\left(x^{(0)}(1)+\frac{74173640.36}{0.0055}\right)e^{0.0055k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{10.2145+11.6700}{2}\%\right)$

- Mathematical Model for Region VI

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0064}\right)\left(x^{(0)}(1)+\frac{167813119.16}{0.0064}\right)e^{0.0064k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{10.2428+10.8593}{2}\%\right)$

- Mathematical Model for Region VII

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0039}\right)\left(x^{(0)}(1)+\frac{327277575.19}{0.0039}\right)e^{0.0039k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{3.0344+3.5324}{2}\%\right)$

- Mathematical Model for Region VIII

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0053}\right)\left(x^{(0)}(1)+\frac{54298015.27}{0.0053}\right)e^{0.0053k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{9.8056+10.6602}{2}\%\right)$

- Mathematical Model for Region IX

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0045}\right)\left(x^{(0)}(1)+\frac{67007156.6662}{0.004}\right)e^{0.004k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{2.0884+2.4682}{2}\%\right)$

- Mathematical Model for Region X

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0022}\right)\left(x^{(0)}(1)+\frac{161096979.11}{0.0022}\right)e^{0.0022k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{-0.4341+0.1678}{2}\%\right)$

- Mathematical Model for Region XI

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0029}\right)\left(x^{(0)}(1)+\frac{180969303.57}{0.0029}\right)e^{0.00292k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{6.6928+7.1215}{2}\%\right)$

- Mathematical Model for Region XII

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0038}\right)\left(x^{(0)}(1)+\frac{102908578.74}{0.0038}\right)e^{0.00389k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1+\frac{8.5888+8.9914}{2}\%\right)$

- Mathematical Model for CARAGA

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0050}\right)\left(x^{(0)}(1)+\frac{53418651.68}{0.0049}\right)e^{0.0049k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1-\frac{3.1825+2.7348}{2}\%\right)$

- Mathematical Model for ARMM

GM (1, 1): $\hat{x}^{(0)}(k+1)=\left(1-e^{-0.0034}\right)\left(x^{(0)}(1)+\frac{13275822.76}{0.0034}\right)e^{0.0034k},$
$(k=1,2,\ldots,n)$

MCGM: $\hat{y}=\hat{x}^{(0)}(k+1)\left(1-\frac{4.4158+3.7429}{2}\%\right)$

- Mathematical Model for NCR

GM (1, 1): $\hat{x}^{(0)}(k+1) = \left(1 - e^{-0.0046}\right)\left(x^{(0)}(1) + \frac{359272055.97}{0.0046}\right)e^{0.0046k},$

$(k = 1, 2, \ldots, n)$

MCGM: $\hat{y} = \hat{x}^{(0)}(k+1)\left(1 + \frac{11.4402 + 12.1185}{2}\%\right)$

3.2.2 Comparison of GM (1, 1) and Markov Models

According to Table 7, the value of RMSE, MSE, MAE, and NRMSE of GM(1,1) is higher than the Markov's. Based on the MAPE of the two models, the value of Markov is nearly zero. Hence, a good forecast of values is obtained. From the information from the table above, the prediction from the Markov model is better than the prediction of the GM (1,1) model.

3.3 The Actual Data and the Forecasted Data

The Figures of graphs contain blue lines that represent the actual data and red lines which represent the predicted values of Markov-Chain Grey Model for the year 2018 to 2021. The tables below contain the predicted values of the MCGM in KWH for the year 2018 to 2021.

3.3.1 NCR

Based on Figure 19, we can see that the predicted values of NCR from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates (see Table 8).

3.3.2 Region I

Based on Figure 20, we can see that the predicted values of Region I from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates (see Table 9).

3.3.3 CAR

Based on Figure 21, we can see that the predicted values of CAR from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2018 to December 2020 graphs like a line because the state used for predicting these values is constant (see Table 10).

Table 7. Forecasting errors between GM (1,1) and Markov-Chain Grey Model

Model	(RMSE)	(MSE)	(MAPE)	(MAE)	(NMSE)
GM (1, 1)	40284032.632514	1622803285137450	8.352002	33974305.8325304	0.00918136719580996
MCGM	5996193.61319247	35954337846890.2	1.073942	4227582.03151131	0.00020494214343992

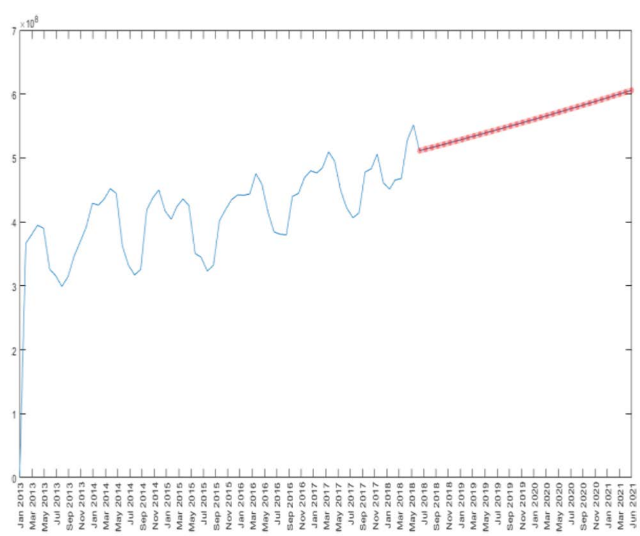

Figure 19. Graph of actual and predicted values of monthly electricity consumption for NCR.

Table 8. Forecasted values of monthly electricity consumption for NCR

2018		January	February	March	April	May	June
	MCGM						
		July	August	September	October	November	December
	MCGM	511,370,824.10	513,855,310.82	516,351,868.37	518,860,555.41	521,381,430.86	523,914,553.94
2019		January	February	March	April	May	June
	MCGM	526,459,984.16	529,017,781.32	531,588,005.48	534,170,717.04	536,765,976.66	539,373,845.31
		July	August	September	October	November	December
	MCGM	541,994,384.24	544,627,655.02	547,273,719.50	549,932,639.84	552,604,478.50	555,289,298.25
2020		January	February	March	April	May	June
	MCGM	557,987,162.15	560,698,133.57	563,422,276.21	566,159,654.05	568,910,331,39	571,674,372.85
		July	August	September	October	November	December
	MCGM	574,451,843.37	577,242,808.17	580,047,332.84	582,865,483.24	585,6973,25.58	588,542,926.38
2021		January	February	March	April	May	June
	MCGM	591,402,352.48	594,275,671.06	597,162,949.60	600,064,255.95	602,979,658.24	605,909,224.97

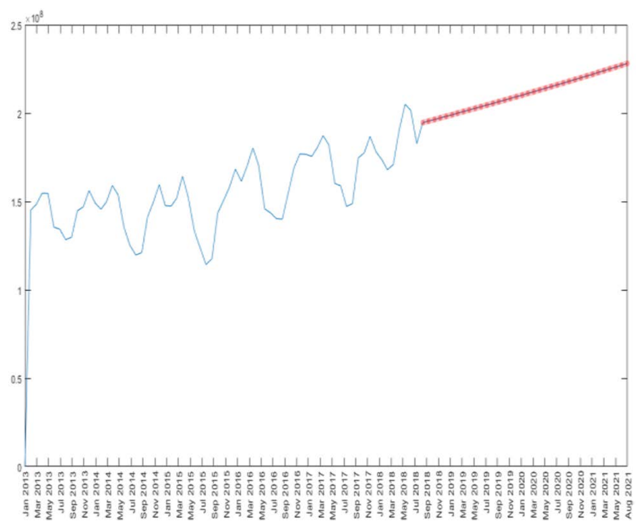

Figure 20. Graph of actual and predicted values of monthly electricity consumption for Region I.

Table 9. Forecasted values of monthly electricity consumption for Region I

2018		January	February	March	April	May	June
	MCGM						
		July	August	September	October	November	December
	MCGM			194,608,816.90	195,494,183.60	196,383,578.24	197,277,019.16
2019		January	February	March	April	May	June
	MCGM	198,174,524.77	199,076,113.54	199,981,804.07	200,891,615.00	201,805,565.09	202,723,573.17
		July	August	September	October	November	December
	MCGM	203,645,958.15	204,572,439.04	205,503,134.93	206,438,064.99	207,377,248.48	208,320,704.75

2020		January	February	March	April	May	June
	MCGM	209,268,453.26	210,220,513.51	211,176,905.13	212,137,647.83	213,102,761.39	214,072,265.71
		July	August	September	October	November	December
	MCGM	215,046,180.76	216,024,526.61	217,007,323.40	217,994,591.40	218,986,350.95	219,982,622.47
2021		January	February	March	April	May	June
	MCGM	220,983,426.50	221,988,783.66	222,998,714.66	224,013,240.31	225,032,381.51	226,056,159.26
		July	August	September	October	November	December
	MCGM	227,084,594.65	228,117,708.88				

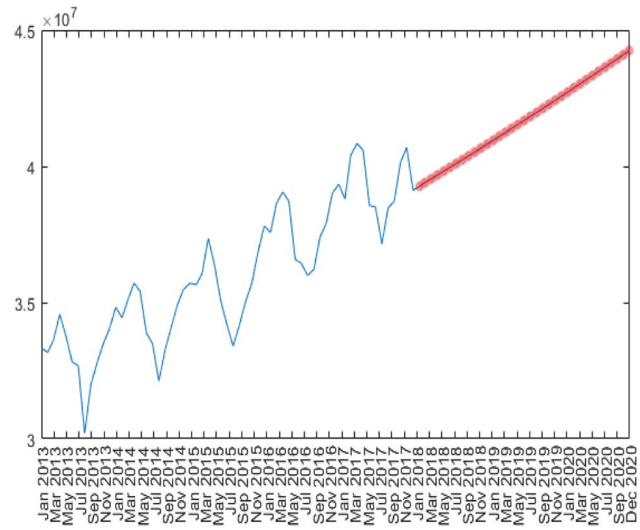

Figure 21. Graph of actual and predicted values of monthly electricity consumption for CAR.

Table 10. Forecasted values of monthly electricity consumption for CAR

2018		January	February	March	April	May	June
	MCGM	39,123,726.58	39,261,768.63	39,400,297.74	39,539,315.63	39,678,824.02	39,818,824.64
		July	August	September	October	November	December
	MCGM	39,959,319.24	40,100,309.55	40,241,797.32	40,383,784.31	40,526,272.27	40,669,262.99
2019		January	February	March	April	May	June
	MCGM	40,812,758.22	40,956,759.76	41,101,269.38	41,246,288.89	41,391,820.07	41,537,864.74
		July	August	September	October	November	December
	MCGM	41,684,424.70	41,831,501.78	41,979,097.80	42,127,214.58	42,275,853.97	42,425,017.82
2020		January	February	March	April	May	June
	MCGM	42,574,707.97	42,724,925.27	42,875,674.60	43,026,954.82	43,178,768.81	43,331,118.45
		July	August	September	October	November	December
	MCGM	43,484,005.63	43,637,432.25	43,791,400.22	43,945,911.43	44,100,967.82	44,256,571.30

3.3.4 Region II

Based on Figure 22, we can see that the predicted values of Region II from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The forecasted values for the months of June in the year 2021 is lower than the peak of June 2018 (see Table 11).

3.3.5 Region III

Based on Figure 23, we can see that the predicted values of Region III from year 2018 to 2021 increases compared

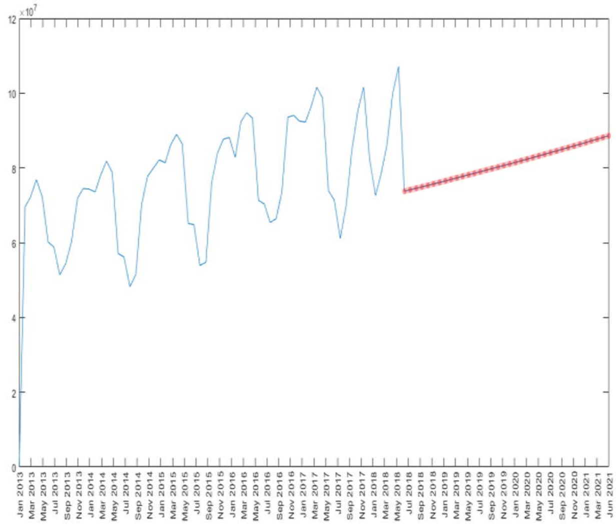

Figure 22. Graph of actual and predicted values of monthly electricity consumption for Region II.

Table 11. Forecasted values of monthly electricity consumption for Region II

2018		January	February	March	April	May	June
	MCGM						
		July	August	September	October	November	December
	MCGM	73,777,433.98	74,165,034.56	74,554,671.45	74,946,355.36	75,340,097.04	75,735,907.30
2019		January	February	March	April	May	June
	MCGM	76,133,797.01	76,533,777.09	76,935,858.52	77,340,052.35	77,746,369.67	78,154,821.63
		July	August	September	October	November	December
	MCGM	78,565,419.46	78,978,174.42	79,393,097.86	79,810,201.15	80,229,495.76	80,650,993.19
2020		January	February	March	April	May	June
	MCGM	81,074,705.02	81,500,642.89	81,928,818.48	81,928,818.48	82,791,929.93	83,226,889.48
		July	August	September	October	November	December
	MCGM	83,664,134.17	84,103,675.98	84,545,526.98	84,989,699.32	85,436,205.18	85,885,056.83
2021		January	February	March	April	May	June
	MCGM	86,336,266.58	86,789,846.83	87,245,810.03	87,704,168.70	88,164,935.42	88,628,122.85

to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for July 2018 to June 2021 graphs like a line because the state used for predicting these values is constant (see Table 12).

3.3.6 Region IV-A

Based on Figure 24, we can see that the predicted values of Region IV-A from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for July 2018 to June 2021 graphs like a line because the state used for predicting these values is constant (see Table 13).

3.3.7 Region IV-B

Based on Figure 25, we can see that the predicted values of Region IV-B from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2018 to December 2020 graphs like a line because the state used for predicting these values is constant (see Table 14).

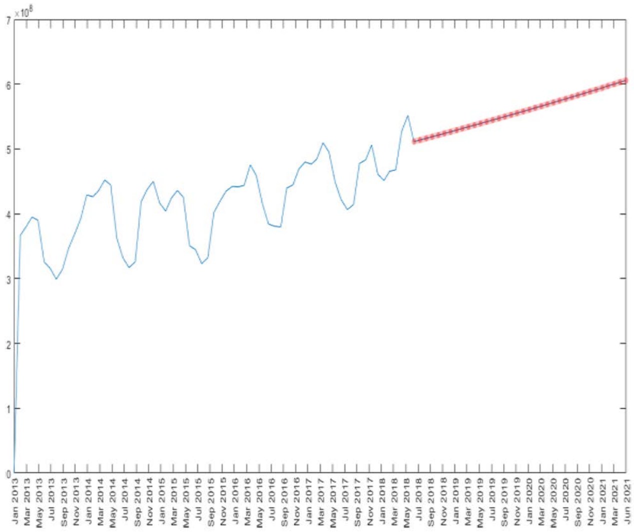

Figure 23. Graph of actual and predicted values of monthly electricity consumption for Region III.

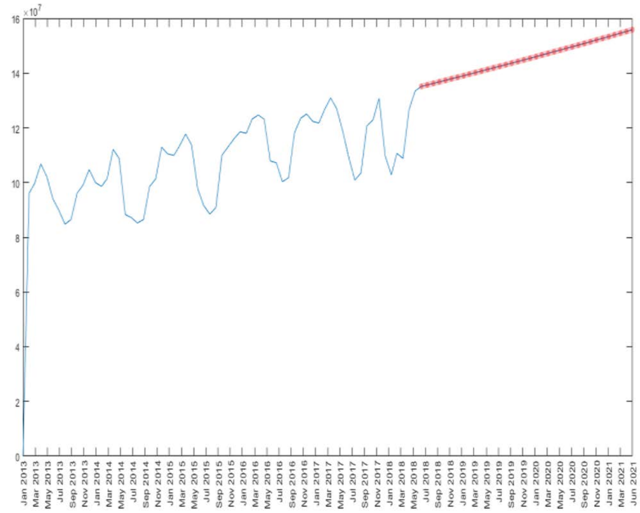

Figure 24. Graph of actual and predicted values of monthly electricity consumption for Region IV.

Table 12. Forecasted values of monthly electricity consumption for Region III

2018		January	February	March	April	May	June
	MCGM						
		July	August	September	October	November	December
	MCGM	511,370,824.10	513,855,310.82	516,351,868.37	518,860,555.41	521,381,430.86	523,914,553.94
2019		January	February	March	April	May	June
	MCGM	526,459,984.16	529,017,781.32	531,588,005.48	534,170,717.04	536,765,976.66	539,373,845.31
		July	August	September	October	November	December
	MCGM	541,994,384.24	544,627,655.02	547,273,719.50	549,932,639.84	552,604,478.50	555,289,298.25
2020		January	February	March	April	May	June
	MCGM	557,987,162.15	560,698,133.57	563,422,276.21	566,159,654.05	568,910,331.39	571,674,372.85
		July	August	September	October	November	December
	MCGM	574,451,843.37	577,242,808.17	580,047,332.84	582,865,483.24	585,697,325.58	588,542,926.38
2021		January	February	March	April	May	June
	MCGM	591,402,352.48	594,275,671.06	597,162,949.60	600,064,255.95	602,979,658.24	605,909,224.97

Table 13. Forecasted values of monthly electricity consumption for Region IV - A

2018		January	February	March	April	May	June
	MCGM						
		July	August	September	October	November	December
	MCGM	135,136,607.98	135,688,460.32	136,242,566.25	136,798,934.95	137,357,575.68	137,918,497.71
2019		January	February	March	April	May	June
	MCGM	138,481,710.36	139,047,222.97	139,615,044.95	140,185,185.72	140,757,654.76	141,332,461.56
		July	August	September	October	November	December
	MCGM	141,909,615.69	142,489,126.71	143,071,004.26	143,655,258.01	144,241,897.65	144,830,932.93

2020		January	February	March	April	May	June
	MCGM	145,422,373.63	146,016,229.57	146,612,510.63	147,211,226.69	147,812,387.71	148,416,003.66
		July	August	September	October	November	December
	MCGM	149,022,084.58	149,630,640.53	150,241,681.62	150,855,218.00	151,471,259.84	152,089,817.40
2021		January	February	March	April	May	June
	MCGM	152,710,900.94	153,334,520.77	153,960,687.26	154,589,410.80	155,220,701.83	155,854,570.84

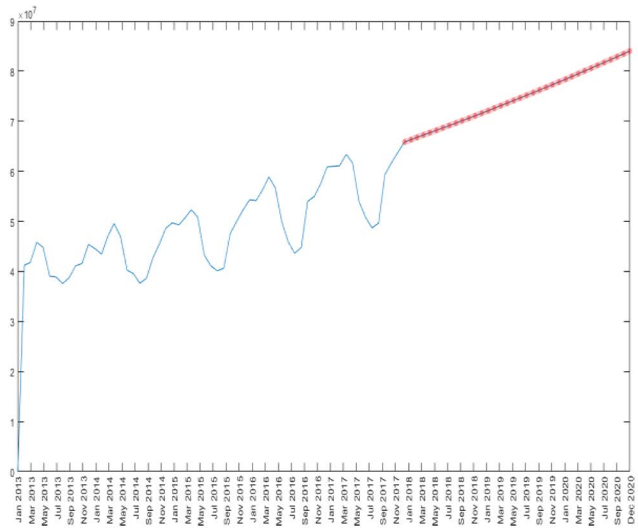

Figure 25. Graph of actual and predicted values of monthly electricity consumption for Region IV-B.

Table 14. Forecasted values of monthly electricity consumption for Region IV - B

2018		January	February	March	April	May	June
	MCGM	65,854,877.66	66,315,433.47	66,779,210.18	67,246,230.30	67,716,516.53	68,190,091.71
		July	August	September	October	November	December
	MCGM	68,666,978.83	69,147,201.06	59,530,781.72	70,117,744.30	70,608,112.45	71,101,909.99
2019		January	February	March	April	May	June
	MCGM	71,599,160.90	72,099,889.33	72,604,119.60	73,111,876.21	73,623,183.81	74,138,067.23
		July	August	September	October	November	December
	MCGM	73,111,876.21	73,623,183.81	74,138,067.23	74,656,551.50	75,178,661.78	75,704,423.43
2020		January	February	March	April	May	June
	MCGM	76,233,862.00	76,767,003.19	77,303,872.91	77,844,497.22	78,388,902.39	78,937,114.85
		July	August	September	October	November	December
	MCGM	79,489,161.23	80,045,068.34	80,604,863.19	81,168,572.97	81,736,225.04	82,307,846.99

3.3.8 Region V

Based on Figure 26, we can see that the predicted values of Region V from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2018 to December 2020 graphs like a line because the state used for predicting these values is constant (see Table 15).

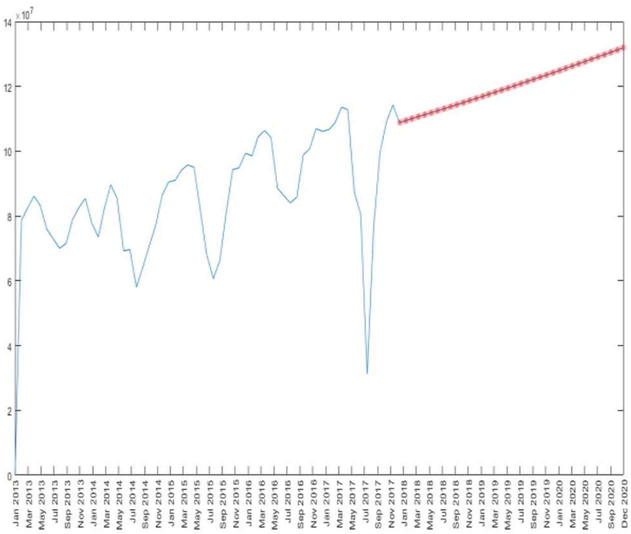

Figure 26. Graph of actual and predicted values of monthly electricity consumption for Region V.

3.3.9 Region VI

Based on Figure 27, we can see that the predicted values of Region VI from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for October 2018 to September 2021 graphs like a line because the state used for predicting these values is constant (see Table 16).

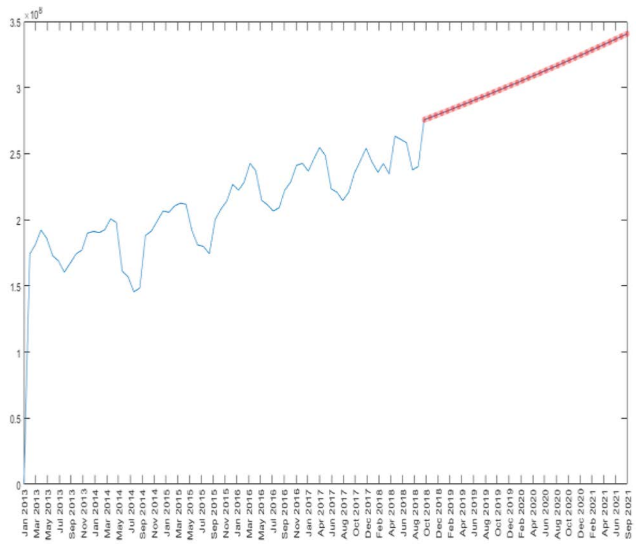

Figure 27. Graph of actual and predicted values of monthly electricity consumption for Region VI.

Table 15. Forecasted values of monthly electricity consumption for Region V

2018		January	February	March	April	May	June
	MCGM	108,851,920.13	109,453,030.68	110,057,460.74	110,665,228.63	111,276,352.78	111,890,851.73
		July	August	September	October	November	December
	MCGM	112,508,744.11	113,130,048.66	113,754,784.23	114,382,969.77	115,014,624.32	115,649,767.04
2019		January	February	March	April	May	June
	MCGM	116,288,417.20	116,930,594.16	117,576,317.40	118,225,606.50	118,878,481.16	119,534,961.17
		July	August	September	October	November	December
	MCGM	120,195,066.45	120,858,817.01	121,526,232.99	122,197,334.63	122,8,142.2172	123,550,676.39
2020		January	February	March	April	May	June
	MCGM	124,232,957.57	124,919,006.49	125,608,843.96	126,302,490.91	126,999,968.37	127,701,297.49
		July	August	September	October	November	December
	MCGM	128,406,499.55	129,115,595.93	129,828,608.13	130,545,557.79	131,266,466.64	131,991,356.56

Table 16. Forecasted values of monthly electricity consumption for Region VI

2018		July	August	September	October	November	December
	MCGM				275,605,757.23	277,279,945.64	278,964,304.03
2019		January	February	March	April	May	June
	MCGM	437,750,902.62	438,956,327.46	440,165,071.66	441,377,144.35	442,592,554.69	443,811,311.88
		July	August	September	October	November	December
	MCGM	445,033,425.14	446,258,903.71	447,487,756.84	448,719,993.84	449,955,624.03	451,194,656.74
2020		January	February	March	April	May	June
	MCGM	452,437,101.35	453,682,967.25	454,932,263.86	456,185,000.64	457,441,187.04	458,700,832.58
		July	August	September	October	November	December
	MCGM	459,963,946.78	461,230,539.19	462,500,619.38	463,774,196.96	465,051,281.57	466,331,882.86
2021		January	February	March	April	May	June
	MCGM	467,616,010.51	468,903,674.23	470,194,883.76	471,489,648.87	472,787,979.34	474,089,885.00
		July	August	September	October	November	December
	MCGM	475,395,375.68	476,704,461.27	478,017,151.66			

3.3.10 Region VII

Based on Figure 28, we can see that the predicted values of Region VII from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for October 2018 to September 2021 graphs like a line because the state used for predicting these values is constant (see Table 17).

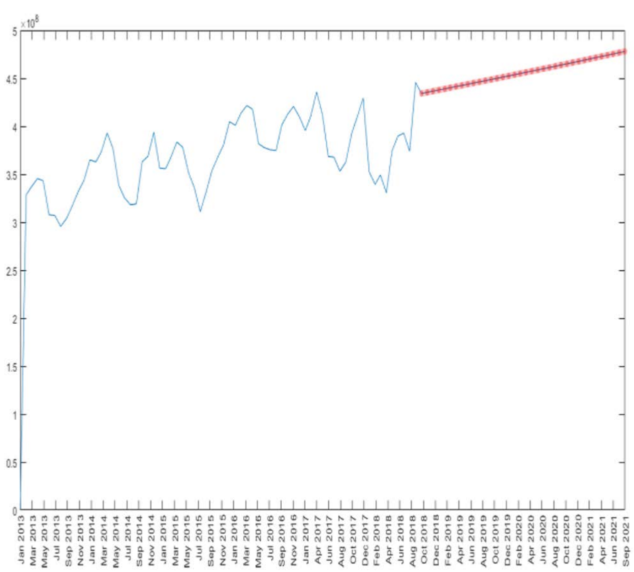

Figure 28. Graph of actual and predicted values of monthly electricity consumption for Region VII.

3.3.11 Region VIII

Based on Figure 29, we can see that the predicted values of Region VIII from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for October 2018 to September 2021 graphs like a line because the state used for predicting these values is constant (see Table 18).

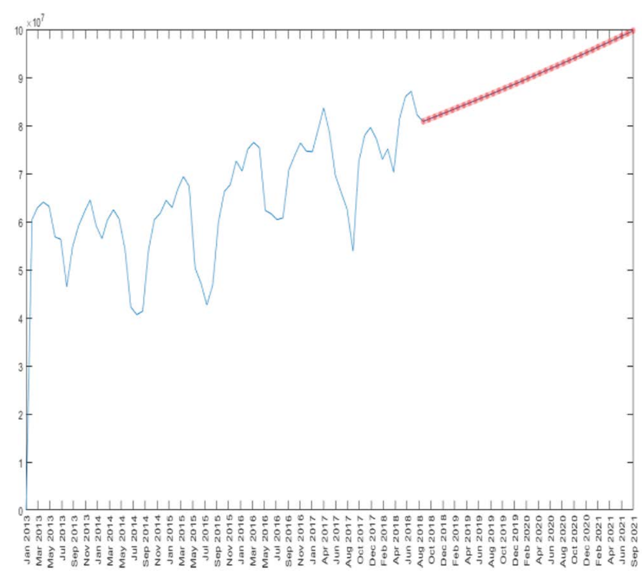

Figure 29. Graph of actual and predicted values of monthly electricity consumption for Region VIII.

Table 17. Forecasted values of monthly electricity consumption for Region VII

2018		July	August	September	October	November	December
	MCGM				434,154,453.16	435,349,974.55	436,548,788.01
2019		January	February	March	April	May	June
	MCGM	437,750,902.62	438,956,327.46	440,165,071.66	441,377,144.35	442,592,554.69	443,811,311.88
		July	August	September	October	November	December
	MCGM	445,033,425.14	446,258,903.71	447,487,756.84	448,719,993.84	449,955,624.03	451,194,656.74
2020		January	February	March	April	May	June
	MCGM	452,437,101.35	453,682,967.25	454,932,263.86	456,185,000.64	457,441,187.04	458,700,832.58
		July	August	September	October	November	December
	MCGM	459,963,946.78	461,230,539.19	462,500,619.38	463,774,196.96	465,051,281.57	466,331,882.86
2021		January	February	March	April	May	June
	MCGM	467,616,010.51	468,903,674.23	470,194,883.76	471,489,648.87	472,787,979.34	474,089,885.00
		July	August	September	October	November	December
	MCGM	475,395,375.68	476,704,461.27	478,017,151.66			

Table 18. Forecasted values of monthly electricity consumption for Region VIII

2018		July	August	September	October	November	December
	MCGM				81,325,352.84	81,801,150.20	82,279,731.24
2019		January	February	March	April	May	June
	MCGM	82,761,112.23	83,245,309.57	83,732,339.72	84,222,219.26	84,714,964.86	85,210,593.29
		July	August	September	October	November	December
	MCGM	85,709,121.42	86,210,566.20	86,714,944.71	87,222,274.11	87,732,571.65	88,245,854.72
2020		January	February	March	April	May	June
	MCGM	88,762,140.77	89,281,447.37	89,803,792.20	90,329,193.02	90,857,667.73	91,389,234.30
		July	August	September	October	November	December
	MCGM	91,923,910.82	92,461,715.49	93,002,666.61	93,546,782.58	94,094,081.93	94,644,583.28
2021		January	February	March	April	May	June
	MCGM	95,198,305.36	95,755,267.01	96,315,487.18	96,878,984.95	97,445,779.49	98,015,890.08
		July	August	September	October	November	December
	MCGM	98,589,336.13	99,166,137.15	99,746,312.76			

3.3.12 Region IX

Based on Figure 30, we can see that the predicted values of Region IX from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for September 2018 to August 2021 graphs like a line because the state used for predicting these values is constant (see Table 19).

3.3.13 Region X

Based on the Figure 31, we can see that the predicted values of Region X from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2019 to December 2021 graphs like a line because the state used for predicting these values is constant (see Table 20).

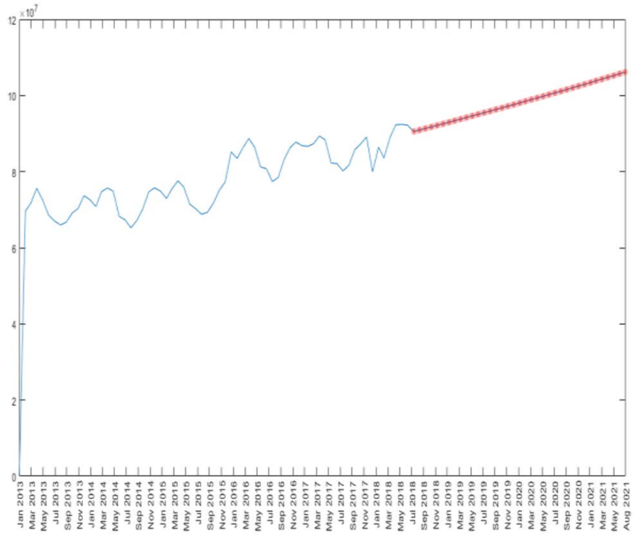

Figure 30. Graph of actual and predicted values of monthly electricity consumption for Region IX.

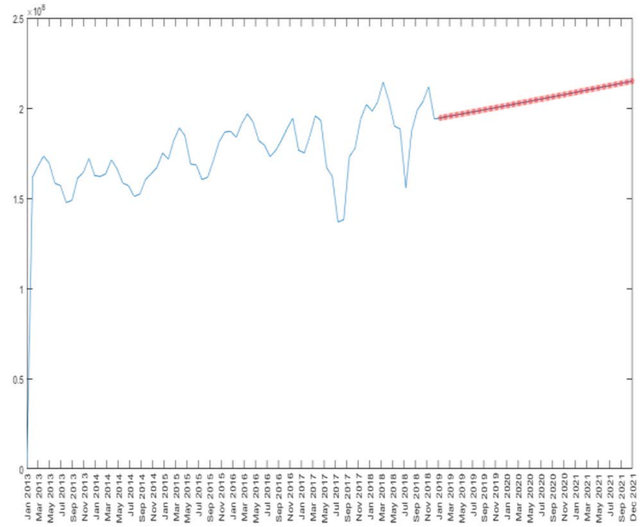

Figure 31. Graph of actual and predicted values of monthly electricity consumption for Region X.

Table 19. Forecasted values of monthly electricity consumption for Region IX

2018		July	August	September	October	November	December
	MCGM			90,944,059.50	91,347,498.76	91,752,721.74	92,159,754.36
2019		January	February	March	April	May	June
	MCGM	92,568,586.60	92,979,232.47	93,391,700.02	93,805,997.32	94,222,132.50	94,640,113.71
		July	August	September	October	November	December
	MCGM	95,059,949.14	95,481,647.01	95,905,215.58	97,187,228.70	97,187,228.70	97,187,228.70
2020		January	February	March	April	May	June
	MCGM	97,618,363.45	98,051,410.76	98,486,379.13	98,923,277.07	99,362,113.15	99,802,895.96
		July	August	September	October	November	December
	MCGM	100,245,634.13	100,690,336.35	101,137,011.32	101,585,667.80	102,036,314.58	102,488,960.48
2021		January	February	March	April	May	June
	MCGM	102,943,614.38	103,400,285.17	103,858,981.82	104,319,713.30	104,782,488.65	105,247,316.92
		July	August	September	October	November	December
	MCGM	105,714,207.23	106,183,168.73				

Table 20. Forecasted values of monthly electricity consumption for Region X

2019		January	February	March	April	May	June
	MCGM	193,941,169.66	194,512,857.96	195,086,231.46	195,661,295.10	196,238,053.89	196,816,512.81
		July	August	September	October	November	December
	MCGM	197,396,676.88	197,978,551.13	198,562,140.58	199,147,450.31	199,734,485.38	200,323,250.88
2020		January	February	March	April	May	June
	MCGM	200,913,751.90	201,505,993.57	202,099,981.01	202,695,719.38	203,293,213.82	203,892,469.53
		July	August	September	October	November	December
	MCGM	204,493,491.68	205,096,285.50	205,700,856.19	206,307,209.00	206,915,349.18	207,525,282.01

2021		January	February	March	April	May	June
	MCGM	208,137,012.75	208,750,546.72	209,365,889.23	209,983,045.61	210,602,021.20	211,222,821.38
		July	August	September	October	November	December
	MCGM	211,845,451.51	212,469,917.00	213,096,223.24	213,724,375.68	214,354,379.75	214,986,240.90

3.3.14 Region XI

Based on Figure 32, we can see that the predicted values of Region XI from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2019 to December 2021 graphs like a line because the state used for predicting these values is constant (see Table 21).

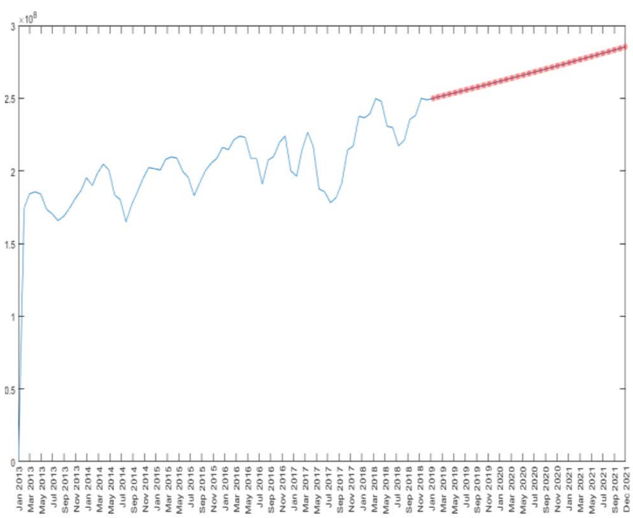

Figure 32. Graph of actual and predicted values of monthly electricity consumption for Region XI.

3.3.15 Region XII

Based on Figure 33, we can see that the predicted values of Region XII from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2019 to December 2021 graphs like a line because the state used for predicting these values is constant (see Table 22).

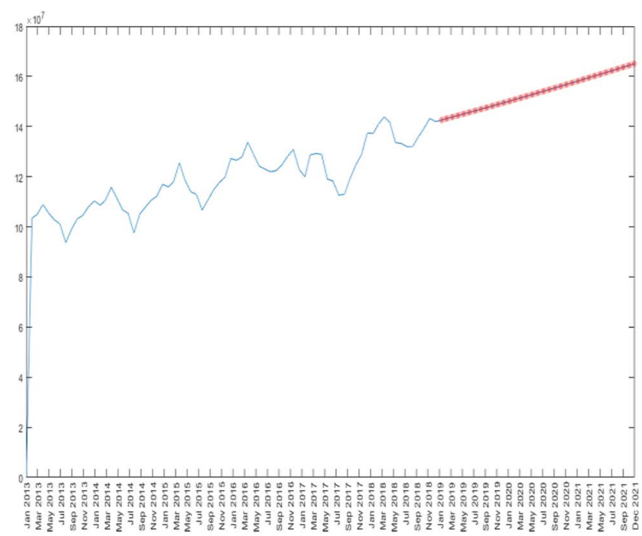

Figure 33. Graph of actual and predicted values of monthly electricity consumption for REGION XII.

Table 21. Forecasted values of monthly electricity consumption for Region XI

2019		January	February	March	April	May	June
	MCGM	248,861,569.45	249,835,876.40	250,813,997.82	251,795,948.64	252,781,743.86	253,771,398.51
		July	August	September	October	November	December
	MCGM	254,764,927.72	255,762,346.66	256,763,670.54	257,768,914.66	258,778,094.37	259,791,225.08
2020		January	February	March	April	May	June
	MCGM	260,808,322.24	261,829,401.40	262,854,478.15	263,883,568.12	264,916,687.04	265,953,850.68
		July	August	September	October	November	December
	MCGM	266,995,074.87	268,040,375.51	269,089,768.56	270,143,270.05	271,200,896.05	272,252,552.72
2021		January	February	March	April	May	June
	MCGM	273,328,586.26	274,398,682.95	215,472,959.14	276,551,461.21	277,634,175.64	218,721,128.95
		July	August	September	October	November	December
	MCGM	279,812,337.75	280,907,818.70	282,007,588.51	283,111,663.98	284,220,061.97	285,332,799.40

Table 22. Forecasted values of monthly electricity consumption for Region XII

2019		January	February	March	April	May	June
	MCGM	141,957,151.22	142,570,989.16	143,187,481.41	143,806,639.43	144,428,474.75	145,052,998.96
		July	August	September	October	November	December
	MCGM	145,680,223.68	146,310,160.59	146,942,821.41	147,578,217.92	148,216,361.96	148,857,265.40
2020		January	February	March	April	May	June
	MCGM	149,500,940.18	150,147,398.27	150,795,551.72	151,448,712.61	152,103,593.08	152,761,305.32
		July	August	September	October	November	December
	MCGM	153,421,861.58	154,085,274.16	154,751,555.41	155,420,111.72	156,092,773.57	156,767,735.46
2021		January	February	March	April	May	June
	MCGM	157,445,615.95	158,126,427.68	158,810,183.30	159,496,895.56	160,186,577.24	160,879,241.17
		July	August	September	October	November	December
	MCGM	161,574,900.26	162,273,567.45	162,975,255.76	163,679,978.24	164,387,748.01	165,098,578.26

3.3.16 CARAGA

Based on Figure 34, we can see that the predicted values of CARAGA from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for April 2018 to March 2021 graphs like a line because the state used for predicting these values is constant (see Table 23).

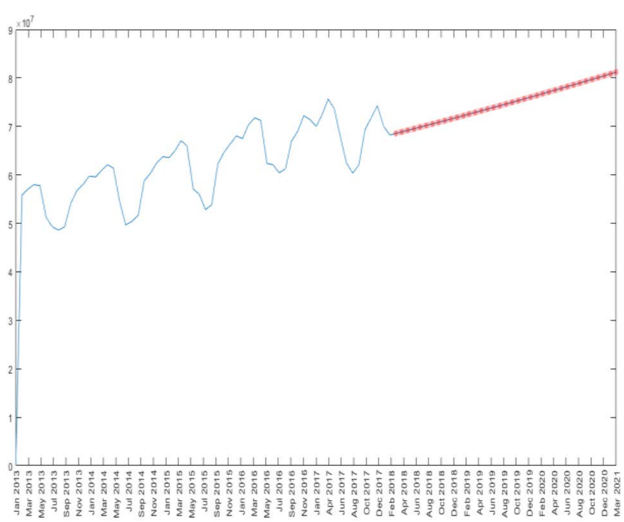

Figure 34. Graph of actual and predicted values of monthly electricity consumption for CARAGA

3.3.17 ARMM

Based on Figure 35, we can see that the predicted values of ARMM from year 2018 to 2021 increases compared to the actual value where the monthly electricity consumption from the year 2013 to 2018 fluctuates. The predicted values of the MCGM for January 2018 to December 2020 graphs like a line because the state used for predicting these values is constant (see Table 24).

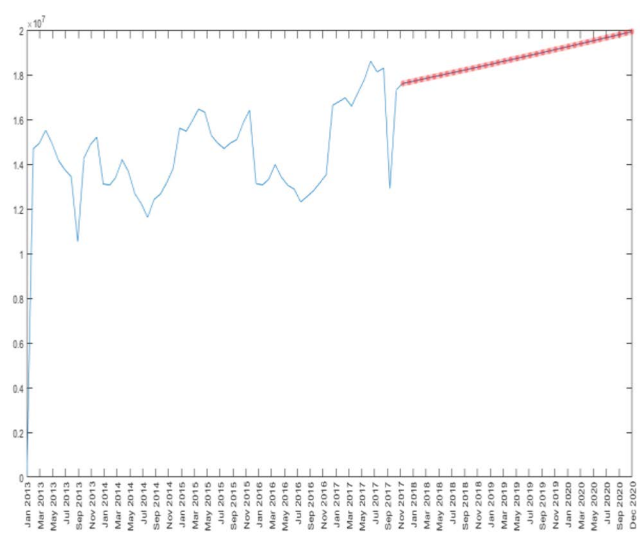

Figure 35. Graph of actual and predicted values of monthly electricity consumption for ARMM.

Table 23. Forecasted values of monthly electricity consumption for CARAGA

2018		January	February	March	April	May	June
	MCGM				68,869,706.00	69,195,192.39	69,522,217.08
		July	August	September	October	November	December
	MCGM	69,850,787.31	70,180,910.41	70,512,593.72	70,845,844.59	71,180,670.45	71,517,078.74
2019		January	February	March	April	May	June
	MCGM	71,855,076.93	72,194,6n.54	72,535,873.12	72,878,686.25	73,223,119.56	73,569,180.70
		July	August	September	October	November	December
	MCGM	73,916,877.37	74,266,217.30	74,617,208.24	74,969,858.01	75,324,174.45	75,680,165.42
2020		January	February	March	April	May	June
	MCGM	76,037,838.86	76,397,202.70	76,758,264.93	77,121,033.59	77,485,516.73	77,851,722.47
		July	August	September	October	November	December
	MCGM	91,923,910.82	92,461,715.49	93,002,666.61	93,546,782.58	94,094,081.93	94,644,583.28
2021		January	February	March	April	May	June
	MCGM	78,219,658.94	78,589,334.32	78,960,756.83	79,333,934.72	79,708,876.30	80,085,589.90
		July	August	September	October	November	December
	MCGM	80,464,083.89	80,844,366.69	81,226,446.75			

Table 24. Forecasted values of monthly electricity consumption for ARMM

2018		January	February	March	April	May	June
	MCGM	17,669,925.96	17,730,847.51	17,791,979.10	17,853,321.46	17,914,875.31	17,976,641.38
		July	August	September	October	November	December
	MCGM	18,038,620.41	18,100,813.12	18,163,220.26	18,225,842.57	18,288,680.78	18,351,735.64
2019		January	February	March	April	May	June
	MCGM	18,415,007.90	18,478,498.31	18,542,207.62	18,606,136.58	18,670,285.95	18,734,656.49
		July	August	September	October	November	December
	MCGM	18,799,248.97	18,864,064.14	18,929,102.78	18,994,365.66	19,059,853.55	19,125,567.23
2020		January	February	March	April	May	June
	MCGM	19,191,507.47	19,257,675.05	19,324,070.77	19,390,695.40	19,457,549.74	19,524,634.57
		July	August	September	October	November	December
	MCGM	19,591,950.70	19,659,498.91	19,721,280.02	19,795,294.81	19,863,544.11	19,932,028.71

4. Conclusions

This study is centered on forecasting the monthly electricity consumption for every region in the Philippines for the year 2018 up to 2021 using the current data of monthly electricity consumption of each region in the Philippines from 2013 up to 2018. Through the use of Markov-Chain Grey Model, we have seen that the behavior of the graph of the data is fluctuating - more often, the increase and decrease of the graph happen in the same month. Yet, the forecasted values increase linearly because of the states that affect the prediction. Furthermore, based on the computations of the forecasting errors, the Markov-Chain Grey Model is a better model in forecasting than the GM (1,1).

5. Recommendations

The researchers recommend to use forecasting models such as Autoregressive Integrated Moving Average (ARIMA) and Integrated Spatio-temporal and compare it to Markov-Chain Grey Markov model to assess for better accuracy.

6. References

1. Why is Electricity Important? 2019. https://www.enotes.com/homework-help/why-electricity-important-1116629
2. Philippine Power Statistics. 2018. https://www.doe.gov.ph/philippine-power-statistics
3. Philippine Power Situation. 2015. https://www.doe.gov.ph/electric-power/2015-philippine-power-situation
4. Philippine Power Situation Report. 2016. https://www.doe.gov.ph/electric-power/2016-philippine-power-situation-report
5. Electricity consumption across regions up by nearly 4% in 2017. 2018. https://www.bworldonline.com/electricity-consumption-up-by-nearly-4-in-2017/
6. Electric coops report stronger sales nationwide. 2018. https://business.inquirer.net/253145/electric-coops-report-stronger-sales-nationwide.
7. Hsu C, Wen Y. Improved grey prediction models for the trans-pacific air passenger market. Transportation Planning and Technology. 2007; 22(2):87–107. https://doi.org/10.1080/03081069808717622
8. Hsu C. Applying the grey prediction model to the global integrated circuit industry. Technological Forecasting and Social Change. 2003; 70(6):563–74. https://doi.org/10.1016/S0040-1625(02)00195-6
9. He Y, Huang M. A Grey-Markov Forecasting Model for the electric power requirement in China. Mexican International Conference on Artificial Intelligence; 2005. p. 574–82. https://doi.org/10.1007/11579427_58
10. Huang M, He Y, Cen H. Predictive analysis on electric-power supply and demand in China. Renewable Energy. 2007; 32(7):1165–74. https://doi.org/10.1016/j.renene.2006.04.005
11. Li YZ, Luan R, Niu JC. Forecast of power generation for grid-connected photovoltaic system based on grey model and Markov chain. 2008 3rd IEEE Conference on Industrial Electronics and applications; 2008. p. 1729–33. PMCid: PMC3667673. https://doi.org/10.1109/ICIEA.2008.4582816
12. Zhao W, Wang W, Wang Y, Zhao Y. Market share forecast of electricity in city residents' energy consumption based on Markov theory. 2008 Third International Conference on Electric Utility Deregulation and Restructuring and Power Technologies; 2008. p. 1–2.
13. Hsu YT, Liu MC, Yeh J, Hung HF. Forecasting the turning time of stock market based on Markov-Fourier grey model. Expert Systems with Applications. 2009; 36(4):8597–603. https://doi.org/10.1016/j.eswa.2008.10.075
14. Kumar U, Jain VK. Time series models (Grey-Markov, Grey Model with rolling mechanism and singular spectrum analysis) to forecast energy consumption in India. Energy. 2010; 35(4):1709–16. https://doi.org/10.1016/j.energy.2009.12.021
15. Prediction of rural electricity consumption based on Grey Markov model. 2011. https://ieeexplore.ieee.org/document/5986976
16. Sun CC. Improvement of renewable energy supply forecasts: The case of Taiwan renewable industry. African Journal of Business Management. 2013; 7(16):1436–44.
17. Kazemi A, Modarres M, Mehregan M. Energy demand forecasting of industrial sectors in Iran using a Markov Chain Grey Model. International Journal of Humanities. 2013; 20:1–12.
18. Zhao W, Wang J, Lu H. Combining forecasts of electricity consumption in China with time-varying weights updated by a high-order Markov Chain Model. Omega. 2014; 45:80–91. https://doi.org/10.1016/j.omega.2014.01.002
19. Yuan CQ, Yang YJ. Forecasting China's energy demand and self-sufficiency rate by grey forecasting model and Markov model. International Journal of Electrical Power and Energy Systems. 2015; 66:1–8. https://doi.org/10.1016/j.ijepes.2014.10.028
20. Analysis and modeling for China's electricity demand forecasting based on a New Mathematical Hybrid Method. 2017. https://www.researchgate.net/publication/314977360_Analysis_and_Modeling_for_China's_Electricity_Demand_Forecasting_Based_on_a_New_Mathematical_Hybrid_Method
21. Xu N, Dang Y, Gong Y. Novel grey prediction model with nonlinear optimized time response method for forecasting of electricity consumption in China. Energy. 2017; 118:473–80. https://doi.org/10.1016/j.energy.2016.10.003
22. Wang ZX, Li Q, Pei LL. A seasonal GM (1,1) model for forecasting the electricity consumption of the primary economic sectors. Energy. 2018; 154:522–34. https://doi.org/10.1016/j.energy.2018.04.155
23. Ismail Z. Forecasting gold prices using multiple linear regression method. American Journals of Applied Sciences. 2009; 6(8):1509–14. https://doi.org/10.3844/ajassp.2009.1509.1514
24. Statistics How To: Mean Absolute Percentage error (MAPE). 2017. https://www.statisticshowto.datasciencecentral.com/mean-absolute-percentage-error-mape/
25. Statistics How To: Absolute Error and Mean Absolute Error (MAE). 2016. https://www.statisticshowto.datasciencecentral.com/absolute-error
26. Statistics How To: Mean Squared Error: Definition and example. 2013. https://www.statisticshowto.datasciencecentral.com/mean-squared-error

27. Statistics How To: RMSE: Root Mean Square Error. 2016. https://www.statisticshowto.datasciencecentral.com/rmse/
28. Normalised Mean Square Error. 2018. https://rem.jrc.ec.europa.eu/RemWeb/atmes2/20b.htm
29. Weather fluctuations, gender affect household's energy consumption-PIDS study. 2019. https://pids.gov.ph/press-releases/325
30. Power Grid operator flags spike in demand. 2019. https://www.bworldonline.com/power-grid-operator-flags-spike-in-demand/
31. Energy in the Philippines. 2018. https://en.wikipedia.org/wiki/Energy_in_the_Philippines
32. Energy Development Corporation: Good is why we've taken the lead. 2018. https://www.energy.com.ph/wp-content/uploads/2014/05/EDC-2013-Performance-Report.pdf
33. Power supply and demand highlights. 2017. https://www.doe.gov.ph/electric-power/2017-power-supply-and-demand-highlights-january-december-2017
34. Legal Information Archive: In The Matter of the Application for Approval of the Power Sales Agreement (PSA) between Zamboanga Del Sur I Electric Cooperative, Inc. (Zamsureco I) and Sarangani Energy Corporation (SEC), with prayer for provisional authority. 2018. http://lia.erc.gov.ph/documents/1682
35. Legal information archive : In the matter of the application for approval of the supplement to the Energy Supply Agreement (ESA) between Zamboanga Del Sur Ii Electric Cooperative, Inc. (Zamsureco II) and Therma Marine, Incorporated (TMI), with motion for Provisional Authority and Motion for Confidential Treatment of Information. 2015. http://lia.erc.gov.ph/documents/1742
36. Socoteco explores addt'l 30 MW to help shorten brownouts. 2013. https://www.mindanews.com/top-stories/2013/03/socoteco-explores-addtl-30-mw-to-help-shorten-brownouts/
37. Press Reader. 2018. https://www.pressreader.com/
38. Legal Information Archive: Legal Information Archive: In the matter of the application for approval of the Power Sales Agreement (PSA) between Davao Del Sur Electric Cooperative, Inc. and Hedcor Tudaya, Inc., with prayer for provisional authority. 2018. http://lia.erc.gov.ph/documents/1340
39. Power outages in GenSan, vicinity extend to 7 hours. 2013. https://www.mindanews.com/top-stories/2013/10/power-outages-in-gensan-vicinity-extend-to-7-hours/
40. Power Rate Increase. 2016. http://www.sukelco.com.ph/index.php/2016/03/14/power-rate-increase/