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Time Series ARIMA Modeling of Fossil Fuel and Electricity Conservation Challenge for Malaysia

Mohd Zamri Ibrahim*[1], Roziah Zailan[#], Marzuki Ismail*, Mohd Safiih Lola[+], Abdul Majeed Muzathik[&]

Abstract - *Energy predicament in Malaysia ruptured due to the higher population, living standards and increase of income per capita which boosted the energy demand continuously. Hence, the final energy consumption, fossil fuels and electricity for 1996-2007 was modeled through 2016 employed the Box-Jenkins time series analysis, ARIMA method to stimulate an effort to solve the problem. The prediction models for each parameters show the increasing trends ahead. It is believed that the forecasts and the comments presented in this paper would be helpful to policy makers in Malaysia for future energy policy planning. Subsequently, the Malaysian Government is looking for Malaysia's effort to sustain its energy sector.*

Keywords – Consumption, electricity, forecasting, fossil fuel and production.

1. INTRODUCTION

The energy sector in Malaysia is formerly pioneering by 'four-fuel mix' included gas, oil, hydro and coal. The energy generation placed heavy reliance on oil for electricity production. This results in rapid depletion of its deposit. As at 2006, the reserves of oil stated at 5.25 billion barrel and fall to 3.0 billion barrels at 2007 [1]. The predictable decline in the availability of oil will almost surely lead to a dramatic increase in energy prices and lead to global economic crisis, since oil is one of the most important sources of energy in the global economy [2].

However, dependence on oil for electricity generation has declined significantly in recent years as the country places more emphasis on gas as a source of generation mix. At 2006, the natural gas remains at 87.95 trillion standard cubic feet (Tcf) and drop to 75 Tcf [1]. These resource depletion problems pose an urgent need for Malaysia to optimize the potential use of renewable energy source as an additional generation option under its newly formulated 'five fuel mix' policy [3]. The utilization of renewable energy will contribute to the improvement in the security of energy supply in the medium and long-term as these sources are available in perpetuity.

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The forecasting method analyzes the sequence of historical data in a period of time to establish the forecasting model. The ARIMA method has been extensively studied and used in the previous energy research proven to be effective in forecasting field of study. In Turkey, the ARIMA methods attempt to estimate the future primary energy demand of Turkey from 2005 to 2020 and reveals that the decrease of average annual growth rates of individual energy sources and total energy sources [4]. Later on, Turkey widens their exploration on electricity demand analysis using the same method combined with co integration method [5].

Here, the final energy consumption, production and consumption of fossil fuels and electricity in Malaysia during the period of 1996-2007 has been modeled to estimate their future trends. These kinds of predictions models are crucial to ensure the sustainable energy in Malaysia ahead. Hence, we are looking for Malaysia's endeavor in order to endure its energy resources through these forecasting models.

2. METHODOLOGY

A time series ARIMA modeling here focused on the final energy consumption, production and consumptions of fossil fuels (total petroleum, natural gas and coal and coke) as well as electricity in Malaysia. The monthly fossil fuels data from 1999 to 2007 and electricity data from 1996 to 2006 were obtained from Malaysia Energy Centre and the Department of Statistics, Malaysia. These parameters were studied through Minitab software.

Box-Jenkins ARIMA Modeling

The ARIMA, which is one of the most popular models for time series forecasting analysis, has been originated from the autoregressive model (AR), the moving average model (MA) and the combination of the AR and MA, the ARMA models [6]-[11]. The Box-Jenkins ARIMA model used to estimate and forecast the time series behavior of the final energy consumption, fossil fuels, electricity generate, etc. ARIMA stands for Autoregressive Integrated Moving Average with each term representing steps taken in the model construction. The methodology consists of a four step iterative procedure was used in this study consist of tentative identification [11], estimation of the parameters [12] and the diagnostic checking to identify adequate model [11]-[13] and forecasting stage [14].

Identification Steps

The first consideration of data being used is to ensure their stationarity. If the *n* values fluctuate with constant variation around a constant mean μ, it shows that the time series is stationary. If the data is not stationary, differencing process should be perform until the obvious pattern such as trend or seasonality in the data fade away [15].

Parameter Estimation Steps

The plot of autocorrelation function, *acf* and partial autocorrelation function, *pacf* of the stationary data were examined to identify what autoregressive or moving average terms are suggested. The acf at lag *k*, denoted by ρ_k, is defined as

$$\rho_k = \gamma_k / \gamma_0 \qquad (1)$$

γ_k is the covariance at lag *k*, while γ_0 is the variance. Since both covariance and variance are measured in the same units, ρ_k is a unitless and lies between -1 and +1 [5]. An *acf* with large spikes at initial lags that decay to zero or a *pacf* with a large spike at the first and possibly at the second lag indicates an autoregressive process. An *acf* with a large spike at the first and possibly at the second lag and a *pacf* with large spikes at initial lags that decay to zero indicate a moving average process. While if both *acf* and *pacf* exhibiting large spikes that gradually die out indicates both autoregressive and moving averages process.

Autoregressive Models (AR), Moving Average Model (MA) and Autoregressive Integrated Moving Average Models (ARIMA)

An autoregressive model of order *p*, AR (*p*) has the form of:

$$z_t = \rho_1 + \rho_2 z_{t-2} + \ldots + \rho_p z_{t-p} + \varepsilon_t \qquad (2)$$

Each AR term corresponds to the use of a lagged value of the residual in the forecasting equation for the unconditional residual. The term 'autoregressive' refers to the fact that this model expresses the current time series values z_t as a function of past time series values z_{t-1}, z_{t-2}, …, z_{t-p}. The ρ_1, ρ_2, …, ρ_3 are unknown parameters relating z_t to z_{t-1}, z_{t-2}, …, z_{t-p} and ε_t is normally distributed random error.

A moving average forecasting model uses lagged values of the forecast error to improve the current forecast. A first-order moving average term uses the most recent forecast error; a second-order term uses the forecast error from the two most recent periods and so on. The MA (q) has the form of

$$z_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q} \qquad (3)$$

Here, ε_{t-1}, ε_{t-2}, …, ε_{t-p} are the past random shocks and θ_1, θ_2, …, θ_q are unknown parameters.

The autoregressive and moving average specifications can be combined to form an ARMA (p,q) specification

$$z_t = \rho_1 z_{t-1} + \rho_2 z_{t-2} + \ldots + \rho_p z_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q} \qquad (4)$$

The point estimate for each parameter in a Box-Jenkins model is associated with its standard error and *t*-value. The parameters are tested whether it is zero (null hypothesis, H_o) or different from zero (alternative hypothesis, H_a), [4]. If the t > 1.96, we can reject $H_o : \theta_1 = 0$ in favour of $H_a : \theta_1 \neq 0$ by setting α equal to 0.05.

Diagnostic Checking

Move on, the Ljung-Box statistic was used in order to verify the adequacy of the model. The Ljung-Box statistic is

$$Q^* = T(T+2) \sum_{j=1}^{k} \tau j^2 / T - j \qquad (5)$$

The *Q*-statistic at lag *k* is a test statistic for the null hypothesis that there is no autocorrelation up to order *k*. Where τ is the *j*-th autocorrelation while T is the number of observations. If the calculated value of Q^* is larger than the $x^2_{[\alpha]}$ (chi-squire distribution) value for *k-p-q* degrees of freedom, estimated residual series does not appear to be white noise, and the model should be considered inadequate [16]. Frequently, α is chosen between 0.01 and 0.05 [14].

Forecasting Stages

The final stage for the modeling process is forecasting which give results in three different options which are forecasted values, upper and lower limits that provide a confidence interval of 95%. Any forecasted values within the confidence limit are satisfactory. Then, the accuracy of the model is checked with the mean-square error, MSE to compare fits of different ARIMA models. The lower MSE value shows the better fitting model [14].

3. RESULTS AND DISCUSSION

Due to the higher populations, living standards and increase of income per capita in Malaysia, the production and consumption of energy also boost and pose a serious threat to the environment especially related to the emissions of greenhouse gases (methane, and CO_2) and climate change. This scenario urges Malaysia to reach the sustainable energy futures to maintain economic growth and providing energy security and environmental protection.

Final Energy Consumption

Final energy consumption refers to final consumption known as the accumulation of primary consumption and secondary consumption. Primary consumption refers to inland energy form that excludes a conversion or transformation process within the country. Then, the secondary consumption meant to energy accessible from conversion processes such as petroleum products from domestic refineries [17].

The trends for final energy consumption presented in Figure 1. The higher consumption is transportation usage accounted for 2801.13 kToe in 1999 and expected to be 5495 kToe in 2016. But, industrial sector dominated at 2016 with 7602.8 kToe, which rise from 2545.6 kToe in initial year. It followed by commercial use, non-energy, residential and agriculture use accounted for 527.5, 439, 428.47 and 25.89 kToe at initial year and boost to 1444.34, 1038.7, 796.7 and 108.2 kToe by 2016 respectively. The models for each sector expressed in Table 1A (Appendix). The MSE values of each model are given in the 3rd column of the table.

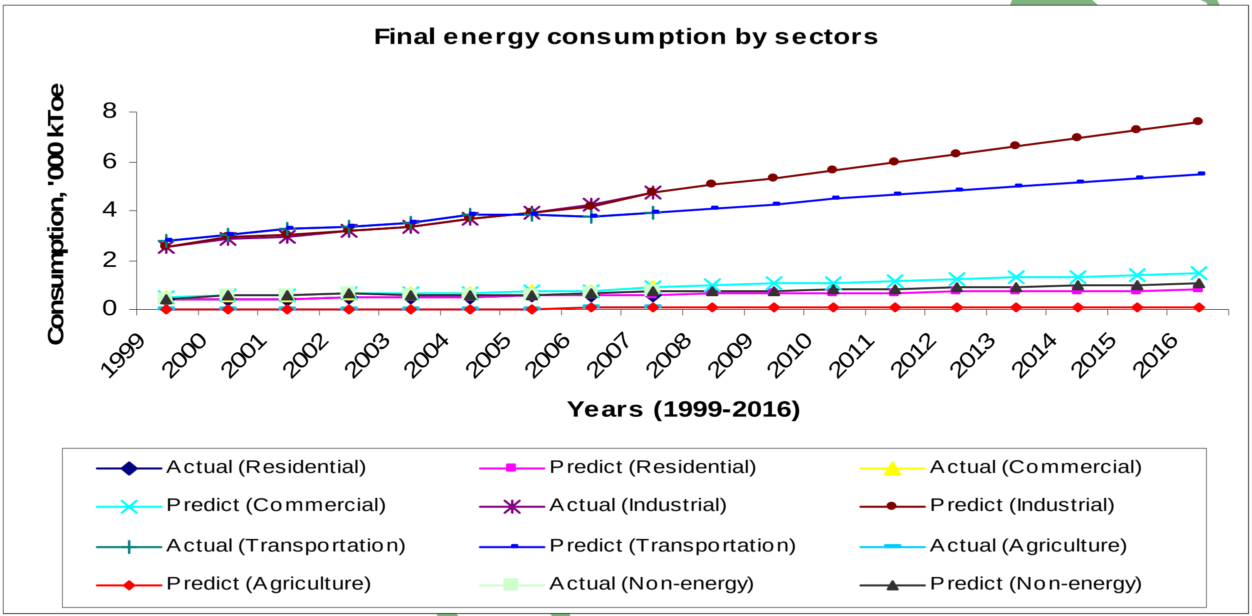

Fig. 1. Final energy consumption by sectors (1999-2016).

The industrial and transportation sectors were identified as the biggest user of fossil fuels. The industrial sector involves a wide range of activities including the extraction of natural resources, the production of raw materials and the manufacture of finished products [18]. In Malaysia, energy-intensive industries are chemical, cement and ceramic, iron and steel as well as food [3]. Certainly all these manufacturing process utilize the fossil fuels energy sources.

Whilst, the vital role of fossil fuel in transportation sector can be seen in 2003 scenario where 40% of the energy demand was consumed by the transportation sector based mainly on fossil energy (gasoline, diesel, NGV, AV gas). Petrol and diesel have the largest energy share where subsidies given to them are a major portion of the annual federal government budget. Their consumptions accounted for 87% of the total energy consumption in the transportation sector with 7734 kToe of gasoline and 4970 kToe of diesel were consumed. The total 100% use of passenger cars are powered by gasoline, while about 74% of busses and trucks are fuelled by diesel [19].

Apart from that, the commercial, non-energy, residential and agriculture use are considered as minor user of fossil fuels.

Total Petroleum Production and Consumption

Malaysia is the biggest oil producer in the region [1]. The prediction model in Figure 2 reflects the previous, recent and future pattern of production and consumption of total petroleum. Both ARIMA model needs to be differentiate at first stage as the time series data shows the non-stationary condition. The total petroleum production exhibit ARIMA (1,1,1) as the best model. The *t*-test and Chi-Square statistic during the diagnostic checking stages give off value of AR (1), |-5.84|>1.96 and MA (1), 54.60>1.96, and Q^* value equal to 13.3<18.3 at df=10. The model is as below

$$z_t = 0.571 - 0.502 z_{t-1} + \varepsilon_t - 0.983 \varepsilon_{t-1} \qquad (6)$$

Whereas, the consumption of total petroleum present ARIMA (2,1,1) to demonstrate the future event.

The *t* values are |-8.23|>1.96, |-4.91|>1.96 and 7.05>1.96 for AR (1), AR (2) and MA (1) respectively. The *Q** value is 4.2<16.9 at *df*=9. This adequate model written as

$$z_t = -3.43 - 0.502 z_{t-1} - 0.485 z_{t-2} + \varepsilon_t - 0.642 \varepsilon_{t-1} \quad (7)$$

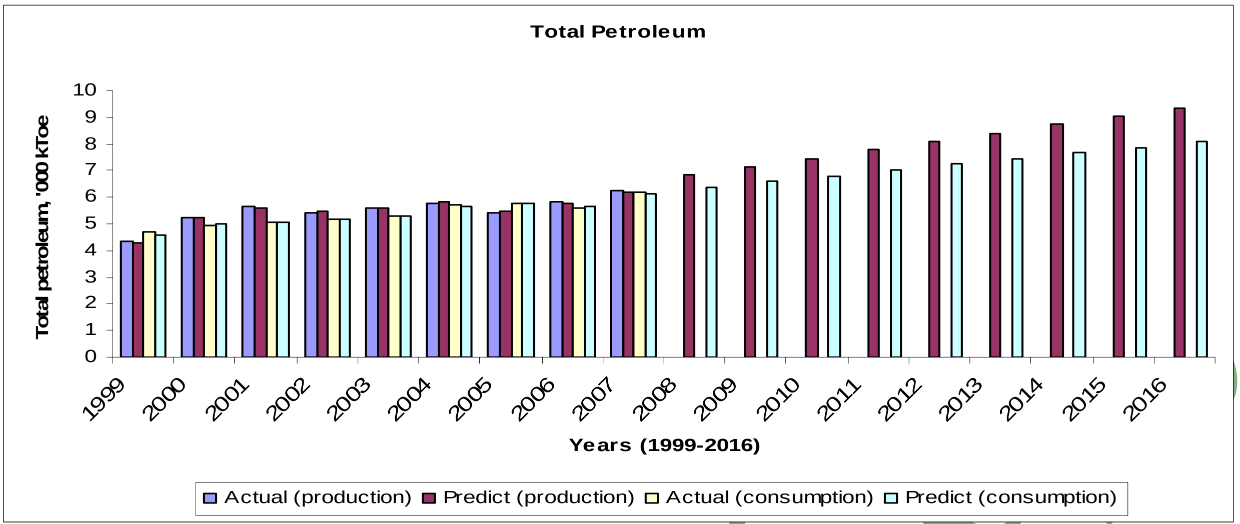

Fig. 2. Total petroleum production and consumption (1999-2016).

From the forecasting graph, the production of total petroleum expected to increase annually 6.76% from actual value of 4337.52 kToe in 1999 to 9350.15 kToe in 2016. While for the consumption, it reflects evenly 4.26% increase annually. The actual value in 1999, 4697.293 kToe rises to 8313.823 kToe in 2016.

Although Malaysia's oil production and consumption is expected to increase, the availability and reserve of oil in energy sector are lessening [1]. Malaysia is trying to ensure the sustainable production of oil to fulfill the needs by diverse strategies. Appraisal wells will continue to be drilled in small oil fields offshore and deepwater areas especially in Sabah and Sarawak. Continuous effort also will be undertaken to attract international oil company to invest in exploration activities, particularly in deepwater of more than 200 meters and ultra-deepwater of more than 1km to increase domestic petroleum reserves. Whilst, PETRONAS will continue to review its international upstream and downstream operational to meet the challenges in the global oil market [3]. However, we should bear in mind that even much effort are planned for petroleum development in future, but certainly, petroleum is unredeemable and will be scarce at last.

Total Petroleum Consumption by Sectors

From Figure 3, the higher consumption of total petroleum lead by transportation sector accounted for 2768.78 kToe in 1999 and expected to rise up to 5927.36 ktoe in 2016. It followed by industrial, commercial, non-energy usage, residential, agriculture and power station with 1266.12, 177.24, 161.8, 203.79, 26.75 and 289.9 kToe at initial year and increase to 2171.54, 534.25, 349.97, 204.94 and 122.52 at ultimate year respectively. Power station decreases the consumption from 289.9 kToe to -125.19 kToe at 2016. The models for each sector expressed in Table 2A (Appendix). The MSE values of each model are given in the 3rd column of the table.

The increase of transportation is due to the higher requirement of transportation services by the manufacturing, aquaculture and tourism industry in this country [3]. This condition will surely lead to the increase in the total pollutant emission. That situation worried the Malaysian Government and continuously introducing new initiatives in order to help keep its environment clean. One option is to install new hardware in all refineries in Malaysia to generate more products and meet new specifications [20]. But the switching to other clean energy sources may be more effective rather than spend much money in upgrading the oil refineries.

Natural Gas Production and Consumption

The Natural gas in Figure 4 also pose ARIMA (1,1,1) production as the most adequate model for its production value. The *t*-test for AR (1) and MA (1) resulting with the value of |-5.68|>1.96 and 20.34>1.96 while *Q** value equal to 4.3<18.3 at *df*=10. The model illustrates in mathematical form is

$$z_t = -0.475 - 0.49 z_{t-1} + \varepsilon_t - 0..989 \varepsilon_{t-1} \quad (8)$$

Whereas, the consumption of natural gas perform seasonal pattern of SARIMA (seasonal ARIMA) (0,1,0)(1,0,2)12 to display the future seasonal trend. The *t* value of this model is 6.07>1.96. The Akaike Information Criteria (AIC) is taken as the criteria for this model selection. The smallest AIC which is -1071.73708 determine that this is the best model. The mathematical expression is

$$z_t = z_{t-12} - 0.224 z_{t-1} + \varepsilon_t - 0.434\varepsilon_{t-1} - 0.268\varepsilon_{t-2} \quad (9)$$

The natural gas production shows 8.4% rates of annual growth. The initial value of 3911.46 kToe in 1999 rises evenly to 9493.33 kToe in 2016. In the other hand, the consumption of natural gas also ascends about 34.7% yearly which rose from 735.74 kToe to 4806.55 kToe. The higher amount of production in future will hold up by the Malaysian-Thailand Joint Authority Project that has been create by developing two gas pipelines that are connected to each country, which will split the gas production between two processing plants of each country. Besides, the construction of two LNG liquefying trains by PETRONAS would boost the capacity of the plant to 23 million metric tons per year. This project will be the largest liquefaction center in the world and hope to fulfill these fuel demands [1].

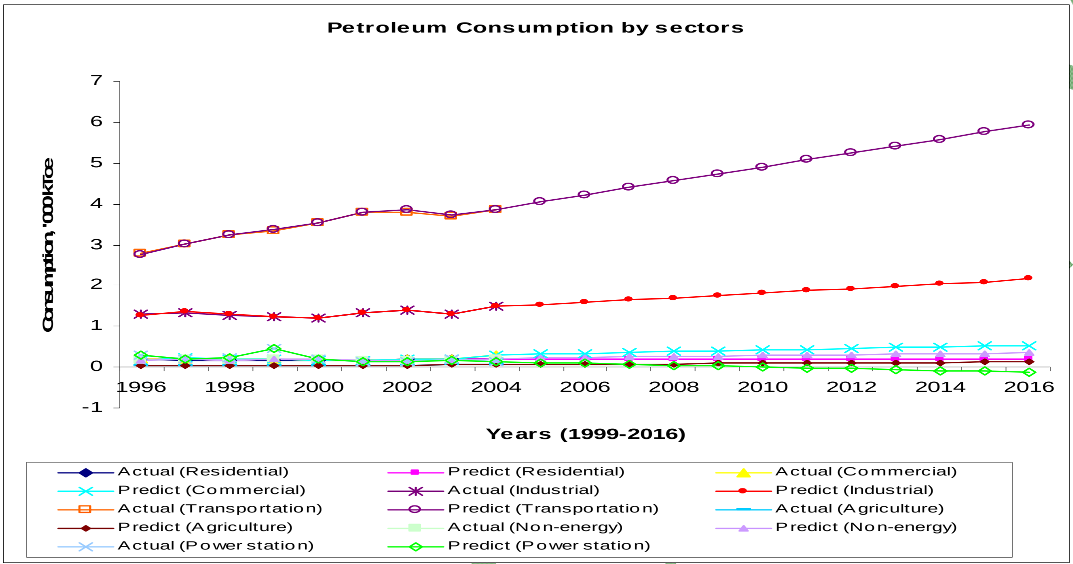

Fig. 3. Total petroleum consumption by sectors (1999-2016).

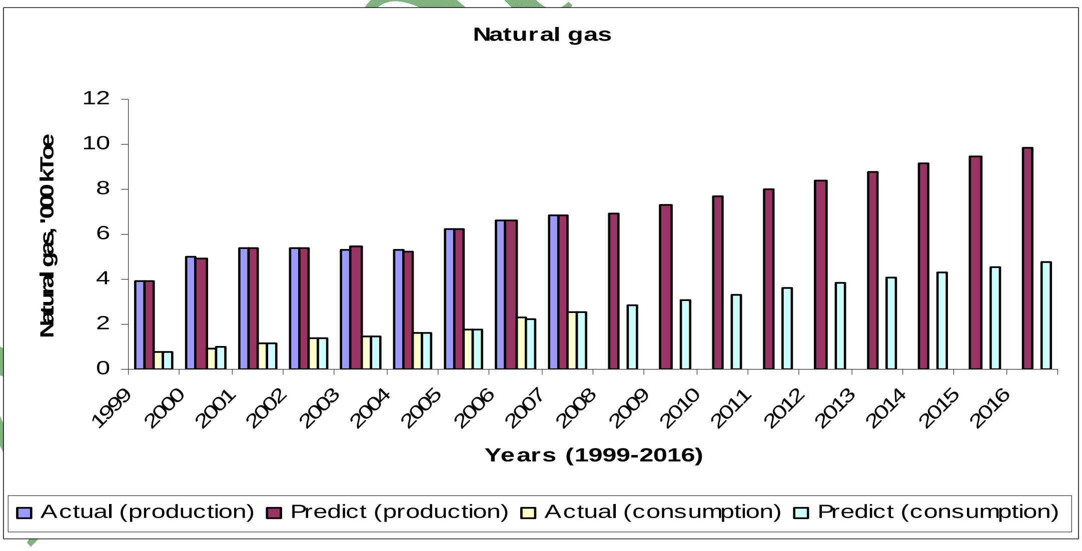

Fig. 4. Natural gas production and consumption (1999-2016).

Natural Gas Consumption by Sectors

The higher consumption of natural gas in Figure 5 dominate by power station usage accounted for 2503.191 kToe in 1999 and expected to rise up to 4091.55 kToe in 2016. It followed by non-energy usage, transportation and residential and commercial with 274.32, 3.35 and 1.39 kToe at initial year and increase to 720.89, 133.73 and 15.09 kToe at ultimate year respectively. The models for each sector expressed in Table 3A (Appendix). The MSE values of each model are given in the 3rd column of the table.

The higher consumption of natural gas dominate by power station usage accounted for 2503.191 kToe in 1999 and expected to rise up to 4091.55 kToe in 2016. It followed by non-energy usage, transportation and residential and commercial with 274.32, 3.35 and 1.39 kToe at initial year and increase to 720.89, 133.73 and 15.09 kToe at ultimate year, respectively.

In fact, the major developments that lead to the increase amount of natural gas consumption in power station are the promotion of synergy between gas and petrochemical industries leading to the establishment of three major petrochemical complexes in Gebeng, Kerteh and Tanjung Langsat [21].

The non energy usage of natural gas purposely applied in industrial sector. It become the second vital usage as industrial is the important sector in this nation. The increasing amount of non energy usage is due to the competitive price of gas as well as the development of new industrial sites and expansion of existing industries. The expansion of Natural Gas Distribution System (NGDS) from 455 km to 1365 km in an investment of 640 million hopes to meet the non energy consumption [3].

Whilst, the contribution of natural gas to transportation sector also getting improve as the implementation of natural gas vehicle (NGV) commotion to promote natural gas as vehicle fuel [21] as well as the government plan to establish other 54 NGV station during the period of 2006 to 2010 as well as incentives to encourage transport operators to convert their vehicles to NGV [3].

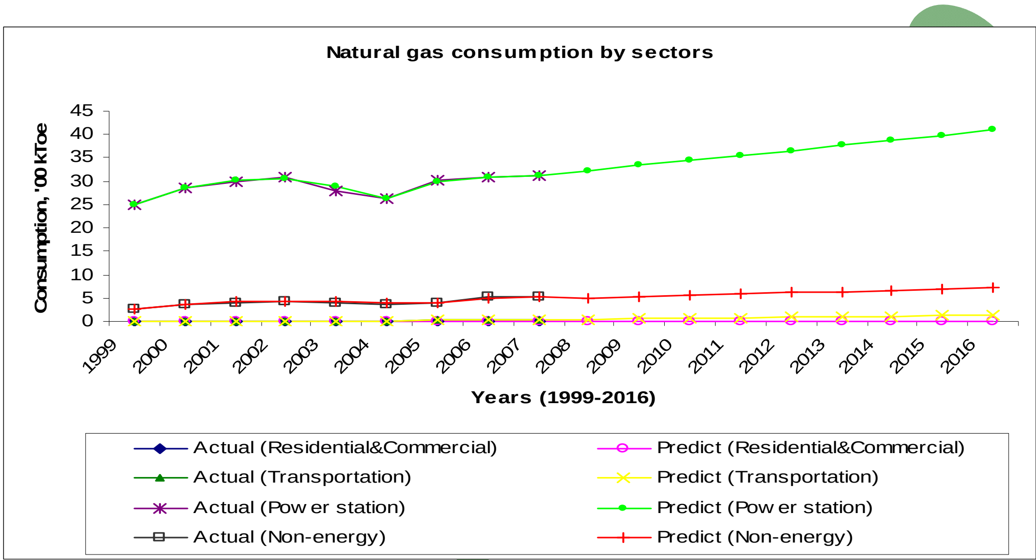

Fig. 5. Natural gas consumption by sectors (1999-2016).

Coal and Coke Production and Consumption

Coal and coke in production suit with ARIMA (3, 1, and 3) as its best model. The *t* value obtained from *t*-test for AR (1) is |-2.05|>1.96, for AR (2) is |-4.07|>1.96, for AR (3) is |-0.75|>1.96. Whilst, 2.34>1.96 for MA (1), |-7.13|>1.96 for MA (2) and 5.53>1.96 for MA (3). The Chi-Square value, Q^* is equal to 11.9<12.59 at df=6. The model expressed in mathematical form as

$$z_t = 33.657 - 0.307 z_{t-1} - 0.558 z_{t-2} - 0.11 z_{t-3} + \varepsilon_t - 0.122\varepsilon_{t-1} + 0.659\varepsilon_{t-2} - 0.639\varepsilon_{t-3} \quad (10)$$

Thus, the consumption of coal and coke match with ARIMA (1,1,1) with the *t* values of |-6.65|>1.96 for AR (1) and |218.05|>1.96 for MA (1) correspondingly. The Q^* value is 7.2< 23.2 at df=10. This selected model can be written as

$$z_t = -0.089 - 0.55 z_{t-1} + \varepsilon_t - 1.001\varepsilon_{t-1} \quad (11)$$

The prediction model in Figure 6 reflects the previous, recent and future pattern of production and consumption of coal and coke. The production of coal and coke shows 68% growth rates annually. It jumps from 300.22 ktoe at initial year to 3801.13 ktoe at 2016. While the consumption figures out 18.98% annual growth rates which mounts from 146.64 kToe at 1999 and becomes 617.23 kToe at 2016. The production of coal and coke expected to increased as Malaysia attempt to reduce the higher dependence on gas for electricity generation. Two coal-based plants were commissioned by Tenaga National Berhad (TNB) at Tanjung Bin, Johor and Jimah, Negeri Sembilan as well as Sejingkat Plant by Syarikat SESCO Berhad (SESCO) [3]. The coal and coke consumptions also will continue to increase due to the demand of cement production for construction industry [17]. Coal and coke have a good prospect due to its abundance and stable price [22].

Coal and Coke Consumption by Sectors

Coal and coke are being used only in two sectors in this country referring to industrial and power station. From Figure 7, power station consumption stand highest as it increase from 350.5 in 1999 to 3243.4 ktoe at 2016. Industrial usage also increases from 146.64 to 591.8 ktoe at ultimate year. The models for each sector expressed in Table 4A (Appendix). The MSE values of each model are given in the 3rd column of the table.

Although Malaysia put high dependence on coke in future, nevertheless, its utilization cause the emissions of green house gasses and air pollutants such as sulfur dioxide (SO_2) and oxides of nitrogen (NO_X). Recently, clean-coal technology, which includes electrostatic precipitators and flue gas desulfurization technology for air pollutants emission control, will be utilized in the new coal-fired power plants to ensure that environmental standards are met.

However, the installments of gas cleaning technology will increase the capital costs of the power plant. For instance, the installation of a wet-type flue gas desulfurization that has an efficiency of removing more than 90% of the SO_2 produced will add an additional US$ 80–150/kW to the capital cost [22].

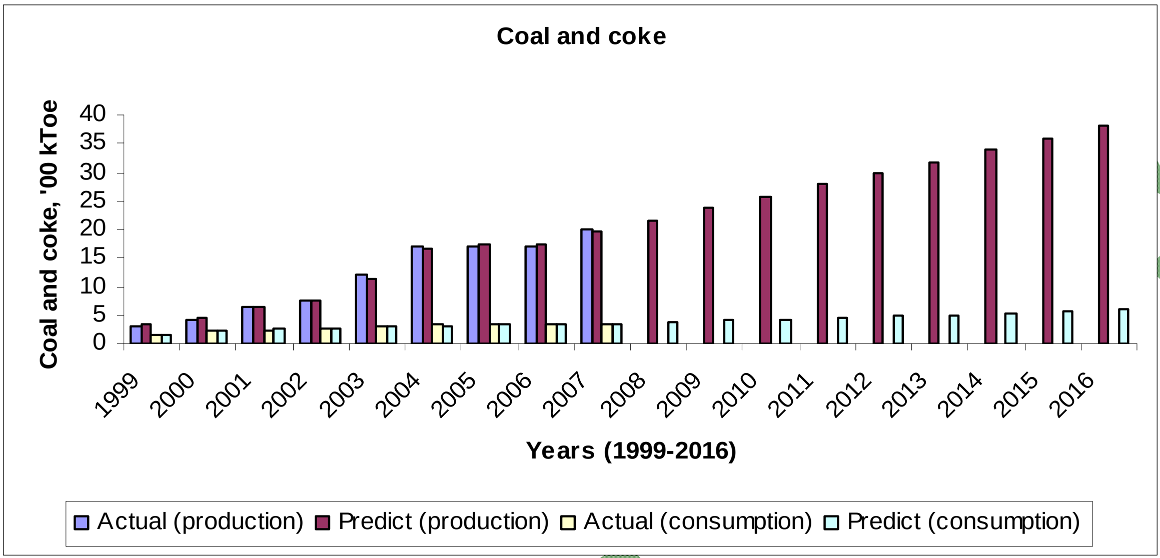

Fig. 6. Coal and coke production and consumption.

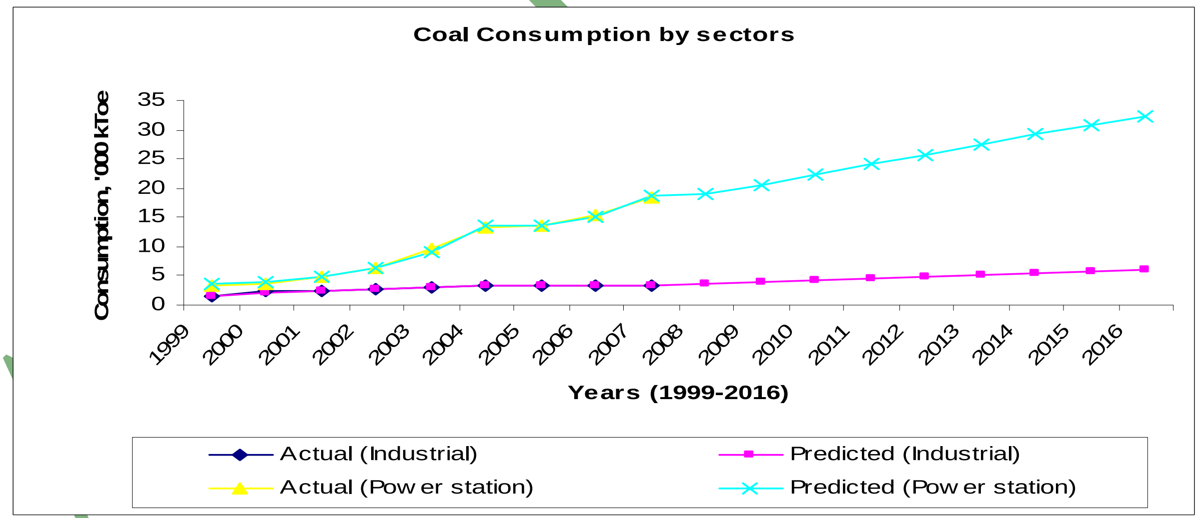

Fig. 7. Coal and coke consumption by sectors (1999-2016).

Electricity Production and Consumption

The consumption of electricity were divided into two categories which are combination of industrial, commercial and mining consumption and combination of domestic and public lighting usage. The total electricity production and both consumption in Figure 8 perform seasonal pattern of SARIMA (0,1,0) (2,1,1) 12 determining by the smallest AIC value which are 1198.2, 1159.2 and 965.3. The given mathematical expressions are:

$$z_t = z_{t-12} - 0.884z_{t-1} - 0.184z_{t-2} + \varepsilon_t \\ - 0.97\varepsilon_{t-1} \tag{12}$$

$$z_t = z_{t-12} - 0.614 z_{t-1} - 0.467 z_{t-2} + \varepsilon_t - 0.542 \varepsilon_{t-1} \tag{13}$$

$$z_t = z_{t-12} - 0.361 z_{t-1} - 0.193 z_{t-2} + \varepsilon_t - 0.994 \varepsilon_{t-1} \tag{14}$$

The average annual increment rate for production of total electricity production obtained is 21.7%. It shows an addition from actual value of 4401.62 million kWhr into 13934.27 million kWhr. It pursued by 24% growth annually of industrial, commercial and mining consumptions which mount from 3105.75 million kWhr to 10590.26 million kWhr. Subsequently, the consumption of domestic and public lighting presented 33.6 % annual growth rate with 2874.884 million kWhr from 659 million kWhr at initial year. If we accumulate both consumption amounts, it turns into 13465.14 million kWhr.

Malaysia's attempt to ensure electricity generation by diversifies the usage of coal and coke rather than dependence on gas. The electricity transmission system was further expanded with completion transmission projects to link new generation plant as well as provide connections to industrial and commercial areas included the Manjung-Air Tawar line in Peninsular Malaysia, East Coast Grid and the Northern Grid in Sabah. The implementation of rural area electrification projects also being improved to cater the future utilization [3].

Implementation of Renewable Energy in Malaysia

Besides the emphasize on maintaining the resources of fossil fuels and electricity sectors, Malaysia also put an alternative effort of promoting the Renewable energy including the solar, hydrogen energy and fuel cells technologies as it is identified as priority research by Ministry of Science and Technology, Malaysia [23].

The sources of fuel will be broadening by utilizing of renewable energy sources as an alternative fuel. This emphasis is to reduce the dependency on the petroleum products. Moreover, the price of crude oil also is expected not stable and sometimes remain high [3].

Department of Environment Malaysia also has taken a few initiatives which include the introduction of National Biofuel Policy in order to encourage the public to utilize the alternative fuel as a clean fuel source [20]. It is expected that renewable sources will contribute 350 MW of total energy supply in 2010 [3].

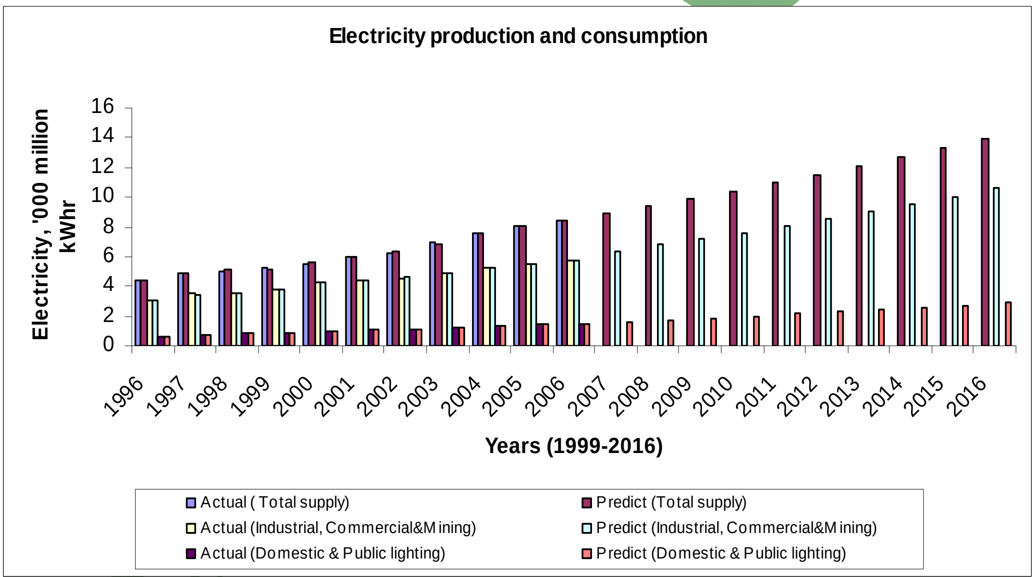

Fig. 8. Electricity production and consumption.

4. CONCLUSION

The main objective of this research have been, estimate and forecast the final energy consumption, fossil fuels and electricity demand in Malaysia using ARIMA modeling. Developing countries like Malaysia should plan very carefully about their energy demand for critical periods, such as economic crises. It is believed that the forecasts and the comments presented in this paper would be helpful to policy makers in Malaysia for future energy policy planning.

The findings of final energy as well as fossil fuels and electricity in Malaysia demonstrate that both production and consumption expected to increase in future with diverse annual growth rates. The major conclusions reached in this study are trends for final energy consumption is transportation usage expected to be 5495 kToe in 2016. But, industrial sector dominated at 2016 with 7602.8 kToe, which rise from 2545.6 kToe in 1999. It followed by commercial use, non-energy, residential and agriculture use boost to 1444.34, 1038.7, 796.7 and 108.2 kToe by 2016 respectively. The production of total petroleum expected to increase annually 6.76% from actual value of 4337.52 kToe in 1999 to 9350.15 kToe in 2016. While for the consumption, it reflects evenly 4.26% increase annually.

The actual value in 1999, 4697.293 kToe rises to 8313.823 kToe in 2016.

The natural gas production shows 8.4% rates of annual growth. The initial value of 3911.46 kToe in 1999 rises evenly to 9493.33 kToe in 2016. In the other hand, the consumption of natural gas also ascends about 34.7% yearly which rose from 735.74 kToe to 4806.55 kToe. Further, the production of coal and coke shows 68% growth rates annually. It jumps from 300.22 ktoe at initial year to 3801.13 ktoe at 2016. While the consumption figures out 18.98% annual growth rates which mounts from 146.64 kToe at 1999 and becomes 617.23 kToe at 2016. The average annual increment rate for production of total electricity production obtained is 21.7%.

ACKNOWLEDGEMENT

The authors would like to thank Malaysia Energy Centre for providing data from year 1999 to 2007 and Department of Statistics Malaysia for providing electricity data from 1996 to 2006 and the Ministry of Higher Education for grant allocation in accomplished this study.

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APPENDIX

Table 1. Models for final energy consumption.

Description	Model	MSE value (10^6)	T-test, t, > 1.96	Ljung-Box Test, Q^* /AIC	Model equation
Residential	ARIMA (1,1,1)	0.045	AR(1): |-6.12|, MA(1): 43.77	18.7<23.2 at Df =10	$Z_t = -0.004-0.517z_{t-1}+ \varepsilon_t - 0.994\varepsilon_{t-1}$
Commercial	ARIMA (1,1,1)	0.011	AR(1): |5.75|, MA(1): 886.54	5.0< 23.2 at Df = 10	$Z_t =0.036-0.49z_{t-1}+ \varepsilon_t - 1.009\varepsilon_{t-1}$
Industrial	ARIMA (1,1,1)	0.006	AR(1): |-7.80|, AR (2): | -4.45|, MA (1): 10.39	15.7<16.9 at Df = 9	$Z_t =-1.851-0.78z_{t-1} - 0.438z_{t-2} + \varepsilon_t - 0.77\varepsilon_{t-1}$
Transportation	ARIMA (1,1,1)	0.021	AR(1): | -5.93|, MA (1):25.95	10< 23.2 at Df = 10	$Z_t =-0.424-0.51z_{t-1}+ \varepsilon t - 0.98\varepsilon_{t-1}$
Agriculture	ARIMA (1,1,1)	0.010	AR(1): |-5.51| MA(1): 56.02	11.3< 23.2 at Df = 10	$Z_t =-0.015-0.478z_{t-1}+ \varepsilon_t - 0.98\varepsilon_{t-1}$
Non-energy	ARIMA (1,1,1)	0.002	AR(1): | -5.51|, MA (1):56.02	11.3< 23.2 at Df = 10	$Z_t =-0.015-0.478z_{t-1}+ \varepsilon t - 0.983\varepsilon_{t-1}$

Table 2. Models for total petroleum consumption by sectors.

Description	Model	MSE value (10^6)	T-test, t, > 1.96	Ljung-Box Test, Q^* /AIC	Model equation
Residential	ARIMA (1,1,1)	0.021	AR(1): |-5.61|, MA(1) :296.18	9<23.2 at df=10	$Z_t =0.019-0.49z_{t-1}+ \varepsilon_t - 1.016\varepsilon_{t-1}$
Commercial	ARIMA (1,1,1)	0.002	AR(1) : |-6.0|, MA (1): 1520.31	5.8<23.2 at df=10	$Z_t =0.0423-0.511z_{t-1}+ \varepsilon_t - 1.014\varepsilon_{t-1}$
Industrial	ARIMA (1,1,1)	0.016	AR(1): |-5.59|, MA(1): 28.81	12.1<23.2 at df=10	$Z_t =-0.111-0.48z_{t-1}+ \varepsilon_t - 0.976\varepsilon_{t-1}$
Transportation	ARIMA (1,1,1)	0.008	AR(1): |-5.97|, MA(1): 24.94	9.7<23.2 at df=10	$Z_t =-0.419-0.513z_{t-1}+ \varepsilon_t - 0.986\varepsilon_{t-1}$
Agriculture	ARIMA (1,1,1)	0.025	AR(1): |-5.51|, MA(1): 56.02	11.3<23.2 at df=10	$Z_t =0.015-0.48z_{t-1}+ \varepsilon_t - 0.983\varepsilon_{t-1}$
Non-energy	ARIMA (1,1,1)	0.013	AR(1): |-5.5|, MA (1): 196.33	19.1<23.2 at df=10	$Z_t =-0.02-0.48z_{t-1}+ \varepsilon_t - 0.99\varepsilon_{t-1}$
Power station	ARIMA (1,1,1)	0.003	AR (1): |-6.65| , MA (1): 218.05	7.2< 23.2 at df 10	$Z_t =-0.089-0.549z_{t-1} + \varepsilon_t - 1.001\varepsilon_{t-1}$

Table 3. Models for natural gas consumption by sectors.

Description	Model	MSE value (10^6)	T-test, t, > 1.96	Ljung-Box Test, Q^* /AIC	Model equation
Residential& Commercial	ARIMA (3,1,3)	0.007	AR(1): |-2.05|, AR(2): |-4.07|, AR(3): |-0.75|, MA (1): 2.34, MA (2):|-7.13|MA (3): 5.53	11.9<12.59 at df=6	$Z_t=33.657-0.307z_{t-1}- 0.558z_{t-2}- 0.11z_{t-3}+ \varepsilon_t - 0.122\varepsilon_{t-1}+0.659\ \varepsilon_{t-2}-0.639\ \varepsilon_{t-3}$
Transportation	SARIMA (0,0,0) (4,1,2)3	0.061	-	282.446	$Z_t =z_{t-3}-1.437z_{t-1}- 0.99z_{t-2}-0.517z_{t-3}+ \varepsilon_t - 0.332\varepsilon_{t-1}-0.647\varepsilon_{t-2}$
Non-energy	ARIMA (1,1,1)	0.004	AR (1): |-5.81| , MA (1): 30.46	14.4< 23.2 at df 10	$Z_t =-0.069-0.5z_{t-1} + \varepsilon_t - 0.98\varepsilon_{t-1}$
Power station	ARIMA (1,1,1)	0.001	AR (1): |-6.65| , MA (1): 218.05	7.2< 23.2 at df 10	$Z_t=-0.089-0.549z_{t-1} + \varepsilon_t - 1.001\varepsilon_{t-1}$

Table 4. Models for coal and coke consumption by sectors.

Description	Model	MSE value (10^5)	T-test, t, > 1.96	Ljung-Box Test, Q^* /AIC	Model equation
Industrial	ARIMA (1,1,2)	0.104	AR (1): |-7.77|, MA (1):164.1 MA (2) 2.69	11.3<16.9 at df=10	$Z_t = -0.001 - 0.636 z_{t-1} + \varepsilon_t - 0.78 \varepsilon_{t-1} - 0.274 \varepsilon_{t-2}$
Power station	ARIMA (1,1,1)	0.075	AR (1): |-5.82|, MA (1):31.09	Minimum AIC - 1071.73708	$Z_t = 0.14 - 0.503 z_{t-1} + \varepsilon_t - 0.979 \varepsilon_{t-1}$