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Electricity Consumption and Economic Growth: A Revisit Study of Their Causality in Malaysia

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Abstract. *The role of electricity towards the economy becomes crucial in many countries including in Malaysia. It becomes necessary to investigate whether electricity consumption contributes to economic growth in order to make appropriate energy policies. The purpose of this research is to examine the long run and causal relationships between electric power consumption and real GDP. This paper applies to the error-correction model. The results indicate that electricity consumption has a positive impact on economic growth. Besides that, there was unidirectional Granger causality running from electricity consumption to real GDP but not vice versa. This paper suggests that Malaysia is becoming an energy-dependent country. The government should emphasize on formulating energy strategies so as to avoid adverse effects on economic growth.*

Keywords: *electricity consumption, economic growth, granger causality*

JEL Classification: C39, D19, O40

Abstrak. *Peran listrik terhadap ekonomi menjadi sangat penting di banyak negara termasuk di Malaysia. Menjadi perlu untuk menyelidiki apakah konsumsi listrik berkontribusi pada pertumbuhan ekonomi untuk membuat kebijakan energi yang tepat. Tujuan dari penelitian ini adalah untuk menguji hubungan jangka panjang dan kausal antara konsumsi daya listrik dan PDB riil. Penelitian ini menerapkan model koreksi kesalahan (ECM). Hasil menunjukkan bahwa konsumsi listrik memiliki dampak positif pada pertumbuhan ekonomi. Selain itu, ada kausalitas Granger searah yang berjalan dari konsumsi listrik ke PDB riil tetapi tidak sebaliknya. Makalah ini menunjukkan bahwa Malaysia menjadi negara yang bergantung pada energi. Pemerintah harus menekankan pada merumuskan strategi energi untuk menghindari dampak buruk pada pertumbuhan ekonomi.*

Kata Kunci: *konsumsi daya listrik, pertumbuhan ekonomi, kausalitas granger*

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Introduction

Electricity is one of the basic elements of the daily routine of human's life (i.e., personal usage to industrial production). Most often, it is claimed that the amount of electricity consumption is directly attributed to the economic growth of a particular country. Due to the expansion of the global economy as well as the increase of income per capita, more demands are created for electrical-based equipment. Even in the rural area, people are eagerly connecting to the electric grid, gaining access to road transportation, and purchasing energy-used assets like electrical appliances and vehicles. These activities are also common for small, medium and large manufacturing industries, which are heavily relying on energy i.e., electricity, and thus contributing to the GDP. Given the possibility of the contribution of electricity consumption on economic growth, many scholars have extensively conducted the study on electricity consumption and economic growth nexus over the past two decades. Many studies have investigated the relationship between electricity consumption and economic growth due to the complex links between these two variables (Ciarreta & Zarraga, 2010).

However, the majority of empirical studies have come up with mixed and ambiguous results. For example, Masih & Masih (1996), Erol & Yu (1987) and Cheng & Lai (1997) find that there is positive and unidirectional causality running from income to electricity consumption where the country does not rely on electricity consumption for economic development. The country thus can adopt energy preservation policies without any harmful effect on economic growth. On the other hand, several studies such as by Asafu-Adjaye (2000), Yang (2000), and Glasure & Lee B (1997) observed that there is a unidirectional causality between electricity consumption to income. Thus, it is confirmed that the country is highly dependent on energy consumption for economic growth. As a result, energy preservation policies may cause harm and conflict with economic growth (Narayan & Singh, 2007). Many works of literature have studied the causal relationship between these two variables, particularly in developed economies. However, there are only a few studies that have been conducted for emerging markets, particularly in the context of Malaysia. Therefore, to contribute to the existing literature, this paper attempts to examine the long-run relationship between electricity consumption and economic growth in Malaysia.

Malaysia has become one of the leading countries that have achieved higher growth of per capita energy consumption particularly electricity over the last few years (Pusat Tenaga Malaysia, 2004). Malaysia has experienced rapid economic growth with the increasing demand for electricity. This is due to the rapid development of industrialization, urbanization and population growth. Electricity consumption rises with an average of 2,533 GWh per year. The electricity consumption was 3,464 GWh in 1971 and increased to 94,278 GWh in 2008. By 2030, the demand for electricity in Malaysia will be increased with a total of 274 TWh. To ensure the sustainability of energy resources, the policymakers are required to continuously review and formulate energy policy (Mohamed and Lee, 2006).

Malaysia is gifted with fossil sources, one of the sources of energy that are well to meet the local demand. However, in recent years there is a significant growth recorded in the energy demand. For example, in 2004 the growth of electricity demand was 9.1 percent and above the gross domestic product (GDP) growth which was only 7.5 percent (Pusat Tenaga Malaysia,

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2004). Furthermore, Gan & Li (2008) also projected that in 2030, the total primary energy consumption would triple, while the final energy demand is projected to reach 116 mega ton of oil equivalent (Mtoe) by 2020 based on 8.1 percent annual growth rate (Keong, 2005). Indeed, according to the projection by Keong (2005)), almost 50 percent of the projected energy demands of 116Mtoe would be absorbed by the industrial sectors. Thus, the continuous demand of energy and the high dependency on electricity demand by the manufacturing sectors attract the concern of policymaker since the formulation of inappropriate energy policies would negatively affect the particular sectors and consequently to the country's growth.

In the case of Malaysia, there are few studies that examined the relationship between electricity consumption and economic growth. The results can be classified into three groups: (i) two of the studies established a bi-directional causality (Tang, 2008; Yoo, 2005), (ii) two found unidirectional (Ang, 2008; Lee, 2005), and (iii) the other found no causality (Masih & Masih, 1996). On the whole, the findings show mixed evidence of electricity consumption and economic growth causality in Malaysia. These differences are mainly due to the nature of data, period and method of study.

There are two strands of the empirical literature on the direction of the causal relationship between electricity consumption and economic growth. The first strand of empirical literature focused on past studies which are conducted in different countries context, while the second strand of the empirical literature is focused on the Malaysian perspective. Faisal et al., (2018) confirms a long-run relationship between electricity consumption and its regressors. The empirical estimation indicates the existence of a positive and statistically significant impact of economic growth, trade and urbanization on electricity consumption for Iceland, not only in the long-run but also in the short-run. Furthermore, electricity consumption converges to its long-run position with 45.63% speed of adjustment using the channels of urbanization, trade and economic growth. The results of Granger causality imply the presence of a feedback causal relationship between urbanization and electricity consumption in the long-run, thus validating the feedback hypothesis. Additionally, no causal relationship was found between electricity usage and economic growth, which confirms the neutrality hypothesis.

Raza et al., (2016) conclude the positive impact of electricity consumption on economic growth of South Asian countries. Besides that, the results of panel Granger causality test confirmed the unidirectional causal relationship runs from electricity consumption to economic growth. It is therefore recommended that the South Asian countries should consider the development initiative and low-cost mode to produce electricity to enhance economic growth in the region.

Polemis & Dagoumas (2013) find that there was a bi-directional causal relationship between electricity consumption and economic growth in Greece. It shows the notion that Greece is an energy-dependent country and well-directed energy conservation policies could even boost economic growth. Furthermore, the implementation of renewable energy sources should provide significant benefits ensuring sufficient security of supply in the Greek energy system.

Similarly, Bélaïd & Abderrahmani (2013) applied a multivariate co-integration approach to investigate the relationship among economic growth, electricity consumption, petroleum price in Algeria. The result confirmed the bi-directional causal links only between economic growth and electricity consumption both in short-run and long-run. In another study, Sami & Mukun (2011) demonstrated that the country's economic growth is related to export and electricity consumption in the long-run. Gurgul & Lach (2011) did not find any direct causal relationship between the variables.

Aslan (2014) showed that electricity consumption has a positive impact on the economic growth in Turkey. The author applied the Granger causality test and ARDL bound test and found that there was bidirectional causality between the variables. Besides, Solarin & Shahbaz (2013) confirmed the bi-directional causality between economic growth and electricity consumption and, also establish the Granger cause between electricity consumption and urbanization.

Solarin (2011) found one-way causation from electricity consumption to economic growth while electricity consumption is positively linked with economic growth both in short-run and long-run in Nigeria. Again, Shiu & Lam (2004) showed that real GDP and electricity consumption were co-integrated and there was only a unidirectional Granger causality directing from electricity consumption to real GDP but not vice versa. This finding is also consistent with Ke (2012) that shows the asymmetry effects between electricity consumption and economic growth in 1980-2008. Aziz (2011) identified the existence of a long-run relationship between energy consumption, energy prices, and economic growth.

Overall the findings from the previous studies revealed mixed results. In most of the cases, there exists a uni-directional causal relationship between electricity consumption and economic growth, while some others find causality between economic growth and electricity consumption. A few studies have identified no causality between electricity consumption and economic growth. In the case of Malaysia, the findings are also not consistent and lead to a mixed result. Since electricity is one of the main sources of energy in Malaysia, the policymakers should have a clear picture of its relationship with economic growth.

Thus, the objective of this paper is to examine the long run relationship between electricity consumption and economic growth and to observe the causal relationship between these two variables. Given the minimal studies have been conducted in Malaysia, thus it would be still fascinating to carry out research in this dimension. This study uses a very recent dataset ranging from 1971-2010 to lessen the degree of ambiguity in previous research findings on Malaysia. This approach allows the authors to check for the robustness of the empirical causal relationships. By the identification of long-run and causal relationships between these two variables, the research findings enable the policymakers, regulators, and investors to formulate appropriate energy policies and to ensure its reliability and efficiency. The growing demand for electricity consumption allows authors to re-investigate the notion of causality between electricity consumption and economic growth in the context of Malaysia.

Methods

A logarithmic model treating the gross domestic product as an exogenous variable and electricity consumption as an endogenous variable is used in this study. Furthermore, the nominal value of the gross domestic product (expressed in terms of US currency) is converted into the real term as shown in Equation 1.

$$EPC = f(RGDP) \qquad (1)$$

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The EPC is electricity power consumption per kWh and RGDP is a real gross domestic product. To obtain a linear econometric model specification, this study has used logarithmic transformation as shown in Equation 2.

$$LnEPC_t = \beta_0 + \beta_1 LnRGDP_t + \varepsilon_t \quad (2)$$

The β_1 represents the direct elasticity with respect to the real GDP and ε_t is an error term. To analyze the model, the data set which consists of yearly electricity consumption and GDP ranging from 1971 to 2010 has been used. All data retrieved from International Financial Statistics and World Development Indicators (WDI).

The main objective of this study is to estimate the equation of electric power consumption and economic growth in Malaysia and to observe the existence of a long-run relationship among the variables. To achieve the goals, the present study conducts an empirical analysis which has three steps.

First, the unit root test is conducted to examine whether the series have a unit root or not. It is also known as the test for stationary. If there exist unit roots, the results from regression may be spurious. Thus, it is important to conduct the test of stationary which can ensure that the pairs of series do not have a tendency to drift too far apart or move too close together.

This study is conducted on a unit root test in level and first differences by applying the most commonly used tests, the Augmented Dickey-Fuller (ADF) test, and the Phillips-Perron (PP) test. The ADF is applied when the error term is correlated. If error term is not correlated, the Augmented Dickey-Fuller test cannot be applied. ADF is performed by adding the lagged values of the dependent variable, ΔY_t. The null hypothesis under ADF test for unit root test is $\propto_1 = 0$, where there is no stationary. The ADF test can be applied by following Gujarati (2009). The following model as shown in equation 3 indicates for the ADF test:

$$\Delta Y_t = \beta_1 + \beta_{2t} + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-1} + \varepsilon_t \quad (3)$$

where β_1 and β_2 are parameters, t is the time or trend variable, δ indicates drift, ε_t is a pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$ refer to the number of lagged difference term which is empirically determined (Gujarati, 2009).

On the other hand, the Philip-Perron test (PP) is used to control the higher-order serial correlation. PP test uses non-parametric statistical methods and avoids the use of adding lagged difference terms as in the ADF test. The null hypothesis for the PP test is $\beta_1 = 0$, similar to ADF test's null hypothesis. The following equation 4 stands for the PP test:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \varepsilon_t \quad (4)$$

If the series are found to be non-stationary at a level, the unit root test is continued to first differences. When all the series are stationary at first differences, then the series is said to be integrated of order one or I(1) and co-integration test can be conducted. After detecting the series are stationary at I(1), this study proceeded to determine the long-run relationships among the series (LnRGDP and LnEPC) by employing Johansen-Juselius (JJ) co-integration test.

Johansen-Juselius (JJ) test is based on the maximum likelihood estimation of VAR (Ibrahim, 2000). It consists of two likelihood ratio tests, namely, (i) Trace test and (ii) Maximum Eigenvalue test. These two tests are used to identify the presence of r cointegrating vectors.

The main difference between these two test statistics is that the Trace test is a joint test where the null hypothesis is that the number of co-integrating vectors is less than or equal to *r*, against a general alternative that there are more than *r*. Whereas the Maximum Eigenvalue test conducts separate tests on the individual Eigenvalues, where the null hypothesis is that the number of co-integrating vectors is *r*, against an alternative of (*r*+1).

The two statistics are:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g} in(1-\hat{\lambda}_i)$$

$$\lambda_{trace}(r, r+1) = -T\ \ln(1-\hat{\lambda}_{r+1}) \qquad (5)$$

The $\hat{\lambda}_i$ is the estimated value for the *i*th ordered eigenvalue from the π matrix. π can be defined as the product of two matrices:

$$\pi = \alpha\beta' \qquad (6)$$

The matrix β gives the co-integrating vectors, while α provides the amount of each co-integrating vector entering into each equation of the Vector Error Correction Model (VECM), also known as the 'adjustment parameter'. The standard approach to the Johansen-Juselius (JJ) test procedure is first to calculate the Trace and Maximum Eigenvalue statistics, then compare these to the appropriate critical values.

The last step in this study is to examine the short-run dynamic causal interaction between the variables in the system based on the Wald test Granger Causality. Based on Granger theorem, the dynamic relationship of co-integration series can be modeled by using an Error Correction Model (ECM) where the causal relationship from LnGDP to LnEPC can be illustrated as the following equation:

$$\Delta LnEPC_t = \alpha_1 + \sum_{i=1}^{r}\beta_{1i}\Delta p_{t-i} + \sum_{i=1}^{s}\phi_{1i}\Delta LnRGDP_{t-i} + \gamma_1 EC_{t-1} + v_{1t} \qquad (7)$$

where EC is the error correction model which was obtained from linear co-integration of the variables. This will help to identify the deviation of the variables from the equilibrium and the restoration from short-run to the long-run equilibrium position. In addition, by using the Wald test Granger Causality, it also depicts the channel of variables relationship in the systems whether it has to have a bi-directional or unidirectional relationship.

Result and Discussion

The sample period of this study is for (1971-2010) 40 years. Table 1 presents the descriptive statistics of the variables used for the analysis. In these sample period, the average minimum and maximum real GDP is US$4.09 billion, US$0.55 billion, US$346.74 billion, respectively, whereas the average minimum and maximum electric power consumption (EPC) per kWh is US$1657.70, US$313.13 and US$ 4159.64, respectively.

Table 1. Descriptive Statistics of the Variables

Variable	N	Minimum	Maximum	Mean	Std. Dev.
RGDP (In Billion US$)	40	0.55	346.74	4.09	61.80
EPC (In thousand US$)	40	313.13	4159.64	1657.70	1142.46

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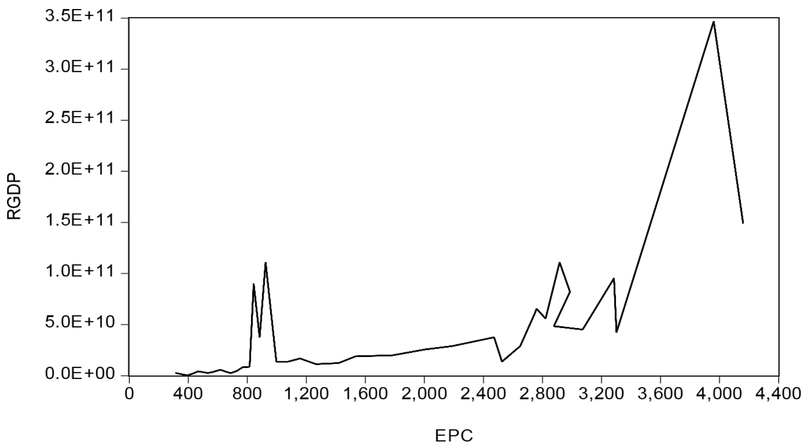
This study examines the correlation between the variables. It would be supportive when we focus on the long-run relationship among the variables by conducting unit root test i.e., the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test, Johansen-Juselius (JJ) co-integration test and Wald test Granger Causality for identifying the short-run dynamic causal interaction between the variables.

Table 2. Correlation Analysis

Covariance Analysis: Ordinary Included observations: 40 Correlation		
Probability	EPC	RGDP
EPC	1.000000	
RGDP	0.653055	1.000000
	0.0000	

In order to detect the extent which Real GDP (RGDP) and electric power consumption (EPC) per kWh fluctuate together, correlation analysis is conducted. As can be observed from Table 2, there is a positive relationship between RGDP and EPC that is also highly statistically significant. This relationship can be further observed from Figure 1.

Figure 1. Correlation between RGDP and EPC



The results of the unit root tests indicate that in both cases, the ADF test and the PP test cannot reject the null hypothesis of a unit root. Thus, two variables namely LnRGDP and LnEPC are non-stationary at level. However, the null hypothesis of non-stationary at the first difference is rejected for all variables at the 1 percent level of significance, which provides evidence that all variables are integrated of order one I(1). The results of the unit root test are given in Table 3.

After finding the series is stationary at I(1), this study continued to examine either there exists a long-run relationship between LnRGDP and LnEPC or not. By employing the JJ co-integration test, the value of the Trace Statistic and Max-Eigen Statistic is compared with 5 percent critical value and it is found that there is only one co-integration in the long run (see Table 4). Therefore, there is a long-run association between electricity consumption and GDP.

Table 3. The results of The Unit Root Test

variable	level		first difference	
	ADF	PP	ADF	PP
ln(EPC)	0.2403	0.7530	0.0000*	0.0000*
	(-2.7061)	(-1.6525)	(-6.8697)	(-6.8356)
ln(GDP)	0.5899	0.5293	0.0015*	0.0021*
	(-1.987122)	(-2.1006)	(-4.9543)	(-4.8269)

Note: Values based on MacKinnon (1996) one-sided p-values. The value in parenthesis refers to t-statistics. *, **, *** denotes significant at 1%, 5% and 10%, respectively.

The co-integrating equation has been normalized for LnEPC in order to get the value of the coefficient. Since these two variables are in logarithm form, the interpretation can be explained in terms of elasticity. For example, 1 percent increment in GDP is equivalent to 115.931 percent increase in electric power consumption in Malaysia. This shows that the elasticity of electricity consumption with respect to GDP is far more elastic and it is significant at 10 percent. The result is also applicable to another country such as Korea. Yoo (2005) found that there is a positive relationship in the long-run between these two variables in Korea.

Table 4. Johansen – Juselius Cointegration Tests

lag intervals	hypothesized no. of CE(s)	trace statistic	max-eigen statistic	critical values (5%) trace	critical values (5%) max-eigen
1	r = 0	18.18961**	17.12013**	15.49471	14.26460
	r ≤ 1	1.069483	1.069483	3.841466	3.841466

Normalized Co-integrating Coefficients:
ln(EPC) = 4.6697 + 1.15931ln(GDP) +εt
(-13.0564)***

Note: *,**,*** denotes significant at 1%, 5% and 10%, respectively.
The Lag length is set to 1.

Since there are at least one co-integrating variables in the long-run association, the VECM enables to detect the convergence of endogenous variables in the long-run and allows a wide series of short-run dynamics. From Table 5, it clearly indicates that the coefficient of error correction term (ECT) of LnEPC is having the correct sign and statistically significant at 5 percent with the speed of convergence to equilibrium of 16.55 percent. Hence, it is assumed that in the short-run, LnEPC will be adjusted by 16.55 percent of the past year's deviation from equilibrium. Furthermore, the coefficient of error correction term of GDP has a positive sign and it is significant at the 10 percent level. This further justifies the stability in the system and convergence into the long-run equilibrium path if any disturbance occurs in the system. The restoration towards long-run equilibrium will moderately fast as the value of ECT(-1) is about 15.65 percent.

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Table 5. Summary Results from VECM Estimation

	Δln(EPC)	Δln(GDP)
Constant	0.0638	0.0324
	(4.7037)**	(1.5091)**
ECT(-1)	-0.1655	0.1565
	(-3.5762)**	(2.1297)***
R-Squared	0.3030	0.1650
Adjusted R-Squared	0.2414	0.0913
S.E of Regression	0.6002	0.0953
F-Stat	4.9256	2.2390

Note: *,**,*** denotes significant at 1%, 5% and 10%, respectively.

After estimating the long-run VECM and ECM model, this study conducted a short-run Granger causality test. This will help in illustrating the short-run relationship between the variables on the χ^2-test of the lagged first differenced terms for each right-hand-side variable and the t-test of the error correction term. In this paper, the selection of lag one has used and the results of the test are presented in Table 6. The result depicts that there is an only unidirectional causal relationship between LnEPC and LnRGDP.

Although our results, the positive relationship between electricity consumption and economic growth, is consistent with Aslan (2014), Bayar (2014), Bélaïd & Abderrahmani (2013), Solarin & Shahbaz (2013), Sami & Mukun (2011), Aziz (2011) most of these studies observed bi-directional relationship between the variables, however, our finding is more similar with Wolde-Rufael (2014), Akinwale et al., (2013), Chandran et al., (2010), and Shiu & Lam (2004) who confirmed unidirectional Granger causality running from electricity consumption to real GDP but not vice versa. The main reasons behind the differences in results from various studies are due to the nature and characteristic of the country under study such as domestic energy supply, political and institutional stability, cultural diversity and most importantly energy policies.

Table 6. Short – run Wald test Granger Causality

short run wald-test granger causality	dependent variable	ln(EPC)	ln(GDP)
	ln(EPC)	-	2.777127
Lag 1 Wald - Statistic			(0.0956)*
	ln(GDP)	0.871438	-
		(0.3506)	

Note: *,**,*** denotes significant at 1%, 5% and 10%, respectively

Since our study confirms the unidirectional causal relationship between electricity consumption to real GDP, it can be assured that the Malaysian economy is energy dependent. The supply of energy sources like electricity is a key factor from electricity consumption affecting economic growth and development. Conversely, any shortage of electricity supply or the high price of electricity per unit may lead to a decline in its consumption level and thus may affect negatively on real GDP and economic development. This will again cause to decline in income and employment. The result of this study in an important indicator for initiating effective energy policies in Malaysia.

This finding is consistent with Altinay & Karagol (2005), Chandran et al., (2010), and Akinwale et al., (2013). The long-run and causality results suggest that Malaysia is an energy-dependent country. It reaffirmed the results of previous studies (Chandran et al., 2010). This dependency perhaps due to the adoption of electrical-based production and consumption in various sources in Malaysia, which later increasing energy intensity. Hence, given this situation, any shock to energy supply particularly electricity will have a negative effect on economic growth.

Conclusion

This paper revisits the relationship between electricity consumption and economic growth in Malaysia. Based on empirical evidence, it indicates that electricity consumption and the economy are in the long-run equilibrium. This study also finds that electricity consumption has a positive and significant impact on economic growth. Indeed, the Granger causality test indicated that there was uni-directional causality between electricity consumption and economic growth.

Therefore, this paper concludes that electricity conservation policies may inversely affect the rate of economic growth and in turn, cause a decline in economic growth. This fact suggests that the Government of Malaysia must focus to support research and development expenditures to meet the rising demand for electricity and adopt more advanced technology to produce and save energy. As an initiative to support national energy policy, the Malaysian government has introduced the New Energy Policy. Under this new policy, it addresses certain dimensions particularly energy pricing, energy supply, energy efficiency, governance and change management. The new policy should be supportive in improving the productivity and efficiency of energy suppliers as well as discouraging wasteful. Indeed, an investment in the energy sector needs to be further developed in order to achieve more economic growth.

Since this sector is mostly capital-intensive, there is a need for inclusive cooperation in developing an appropriate mechanism and institution for the sustainability of energy supply. It is also followed by investments in energy-related infrastructure. This initiative shows the commitment of the Malaysian government in giving ideal priority on the matter related to energy sustainability. Additionally, alternative energies such as solar power, hydropower, and wind power should be seriously considered because these alternative energy production and consumption methods are environmentally friendly compared to the current fossil fuel powered production infrastructure..

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