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Research paper



Energy Security in Malaysia: a Quantitative Analysis

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Abstract

This paper examines the security of energy supply in Malaysia. Analytical framework was used to quantify and assess the progress of energy security of Malaysia in four different categories namely Availability, Applicability, Affordability and Acceptability of energy resources. Key metrics include the documentation of energy reserves, energy access, and CO_2 emissions from year 2005 to 2015. Relevant energy security indicators for Malaysia were identified using high quality historical data from World Bank and Energy Commission. The evaluation findings show that Malaysia has experienced a significant improvement in Applicability dimension, while Availability and Acceptability aspects of energy security only registered slight improvements. On the other hand, Affordability dimension has suffered a slight decline. This study suggests that diversifying energy sources, efficient utilization of energy and reducing carbon content of energy could be enhanced to improve energy security level in Malaysia.

Keywords: *Energy security indicator; Energy policy; Malaysia, Security of supply*

1. Introduction

Energy supply is imperative for economic development. Various literatures has documented that energy security is essential for sustaining economic development of any country [1], [2]. The issue of energy security has been taken seriously by policy makers around the world, such as Austria [3], United States [4], Southeast Asian region [5]-[7] and Europe [8]-[10]. For European region the main energy security agenda are diversification of energy sources and external energy dependence [8], [9]. Which is mainly due to the region's dependence on natural gas supplied from Russia. Correspondingly, Umbach F. [10] has recognized the importance of geopolitical dimension for European region's future energy security.

Similar to other countries, security of energy supply is indispensable for Malaysia's economic activity. However, energy supply security seems to be quite a challenge in the face of limited indigenous energy resource and increasing demand. At current reserve to production rate, oil and natural gas are showing signs of depletion with R/P ratio of about 30 and 40 years respectively. On the other hand, the demand for electricity for the country is expected to double from year 2013 to 2050, increasing from 443 PJ in 2013 to 893 PJ in 2050 [11]. In addition, environmental aspect of energy use is also a concern, this is because Malaysia has ratified to Paris Agreement to reduce 45% of green house gases (GHG) emissions by 2030 relative to 2005 levels.

The issue of energy security was studied extensively by various literatures [12]-[14]. Energy supply security can be assessed quantitatively by applying suitable energy security indicators to a set of high quality data. Extensive review of energy security indicators have been carried out by Sharifuddin [15] and Kruyt et. al. [16]. 4As framework of energy security has been widely used in energy security indicator analysis [17], [18]. In order to examine the progress of energy security in Malaysia, this paper will evaluate the energy supply security of Malaysia with regards to 4As criteria, namely; availability, affordability, applicability and acceptability.

This paper consists of four sections. Following this introduction, Section two describe the methodology and indicators applied to assess the energy security for Malaysia. Section three presents the results and analysis, and Section four will conclude the findings of this study.

2. Methodology

This study used indicator based assessment to quantify the dynamic changes of energy security in Malaysia.

2.1. Selecting Energy Security Indicators

The indicators used in the study has been categorised into 4 dimensions, namely Availability, Applicability, Affordability and Acceptability, i.e. 4 As. Indicator for each A-category has been selected based on their suitability and data availability.

2.1.1. Availability Indicators (AV)

Availability element has been applied by past researchers to evaluate energy security, such as [17]-[19]. Availability is one of the indicators for physical availability of energy supply. In this study, three availability elements has been analysed, as detailed below:

AV-1: Oil reserve-to-production (R/P) ratio

The R/P ratio is used to assess the availability of oil resource in a country [17]. The indicator is the ratio of oil reserve remaining at the end of the year to the production of oil in that year. With the assumption that the production of oil remain constant throughout the years.

AV-2: Natural gas reserve-to-production (R/P) ratio

Similar to oil R/P ratio, natural gas R/P ratio will indicate the availability of natural gas reserve in the country [18]. It is calcu-

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lated by dividing natural gas reserve remaining at the end of the year with natural gas production in that particular year, assuming that the production remain constant.
AV-3: Coal import dependency ratio
Malaysia has been highly dependent on imported coal, particularly for its power generation sector [20]. Energy import dependency ratio is one of the indicators used to measure the security of energy supply [18]. This indicator is used to check how dependent Malaysia is on foreign supply of coal. This indicator is the ratio of net coal import to gross coal primary consumption, which indicates lower energy security at higher raw value. Therefore, inverse normalization methods is applied to the ordinal value.

2.1.2. Applicability Indicators (AP)

Applicability element has been widely used to evaluate energy security [17], [18], [21]. Similar to availability element, Applicability is used to indicate the physical security of energy supply with an added dimension that is, efficiency aspects of energy utilization. In this study two applicability indicators was examine, as detailed below:
AP-1: Energy supply intensity (toe/GDP at 2010 prices, RM million)
This indicator will depict the extent of deployment of energy efficient technology [18]. This indicator measures the amount energy resources needed to produce a unit of gross domestic product (GDP).
AP-2: Energy consumption intensity (toe/GDP at 2010 prices, RM million)
Similar to AP-1, this indicator will measure the extent of penetration of energy efficient technology at demand-side. This indicator is the ratio of total final energy demand to GDP at constant 2010 prices.

2.1.3. Affordability Indicators (AF)

Affordability indicators dealt with the economic security, the indicators are used to reveal whether or not the population can afford to pay for the energy consumed. In this study three affordability elements has been analysed, as detailed below:
AF-1: Energy consumption per capita (toe per person)
This indicator will indirectly reveal whether or not the price of energy is affordable to the population [18]. The indicator is calculated by dividing the total primary energy supply the total number of population.
AF-2: Gasoline price volatility.
Gasoline price volatility is used to indicate the price of the petroleum product. Ex-Singapore prices of gasoline was used in order to reflect the market price of gasoline.
AF-3: Electricity Tariff
This indicator is used to reveal the affordability of electricity to the population [17]. Average electricity tariff for Peninsular Malaysia was applied in this study.

2.1.4. Acceptability Indicators (AC)

Acceptability indicators are used to measure environmental and social elements of energy security [16]. In this study, three Acceptability elements have been examined, as detailed below:
AC-1: CO_2 emissions per capita
This indicator has been widely used to measure acceptability dimension of energy security [5], [15], [17], [19], [22]. It is calculated by dividing the total CO_2 emission to the total number of population. The higher normalised score reflect the higher social acceptance of the impacts of the energy used.
AC-2: Renewable energy output
Renewable energy output indicator is the share of renewable energy output out of the total electricity generation.
The indicators used in this study are summarized in Table 1 below.

Table 1: Indicators under each category

Element	Indicator	Code
	R/P Ratio of Oil	AV-1
Availability	R/P Ratio of NG	AV-2
	Coal Import Dependency Ratio	AV-3
Applicability	Energy Supply Intensity	AP-1
	Electricity Consumption Intensity	AP-2
Affordability	Energy Consumption per Capita	AF-1
	Gasoline Price Volatility	AF-2
	Electricity tariff	AF-3
Acceptability	CO_2 Emission per Capita	AC-1
	Renewable Energy Output	AC-2

2.2. Data

The analysis was based on data from year 2005 to 2015. Primary energy data and statistics on emissions were retrieved from Energy Commissions and World Bank while macroeconomics data were retrieved from Department of Statistics. Crude-oil and natural gas-related data were gathered from BP statistical review of world energy.

2.3. Data Normalization

In order to make the collected data comparable, the data were normalized on the scale of ordinal values. In a range of ordinal value of 1-10, the higher the score conveys to a better energy security performance. The scoring throughout the years under review will reflect the dynamic changes of energy security status of Malaysia.
The data normalization formula used by Tongsopit et. al. [17] was applied in this study.

$$X' = 1 + (X - Min_A)\ (10-1)/(Max_A - Min_A) \quad (1)$$

Where;
X'= Normalized value based on 1-10 scale
Min_A=Minimum value of data range A
Max_A= Maximum value of data range A

Further, for indicators that are inversely related to with the scale, i.e. higher raw value indicates lower energy security; the reverse normalization formula depicted below was used. For this case, the maximum value of the raw scare is considered as the minimum scale value which is equivalent to 1, and vice versa.

$$X' = 1 + (X - Max_A)\ (10-1)/(Min_A - Max_A) \quad (2)$$

Where;
X'= Normalized value based on 1-10 scale
Min_A=Minimum value of data range A
Max_A= Maximum value of data range A

3. Results and Analyses

The results from the quantitative analysis depict the status of Malaysia energy security. The findings are discussed in following four sub-section, categorised by each energy security dimension.

3.1. Availability (AV)

Availability of Malaysian energy resources has experienced a slight improvement from 2005 to 2015, as depicted in Fig.1. The average score of Availability element increased from 4.9 in 2005 to 5.4 in 2015. The energy resource availability had peaked in year 2007 and 2014 with average score of 7.1 and 7.0 respectively. This trend can be rationalized by analysing the detail data in Table 2. It can be seen that R/P Ratio of Oil (AV-1) has a high score in year 2007, while both R/P Ratio of Natural gas (AV-2) and Coal import dependency ratio (AV-3) have high ordinal value score in

year 2014. Availability dimension could be improved by diversifying energy sources and efficient utilization of energy [23].

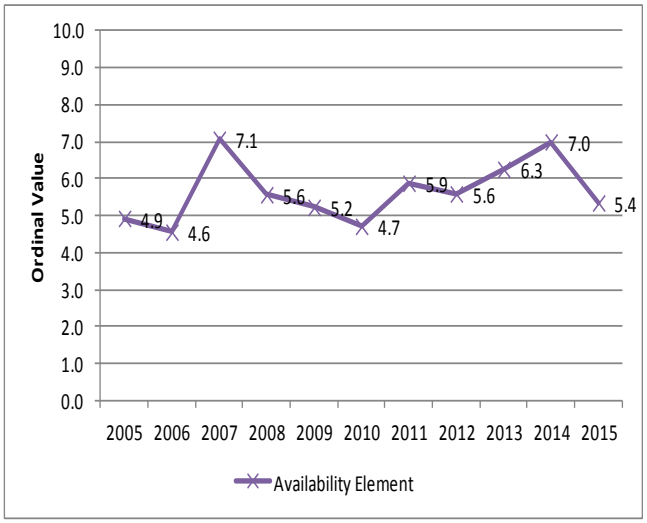


Fig. 1: Availability metric for Malaysia from 2005 to 2015

Table 2: Normalized data for availability element

Year	Indicator (Code)			Availability average value
	AV-1	AV-2	AV-3	
2005	7.8	1.0	6.0	4.9
2006	10.0	2.7	1.0	4.6
2007	9.4	4.6	7.2	7.1
2008	9.6	1.9	5.2	5.6
2009	1.1	4.6	10.0	5.2
2010	1.0	4.4	8.8	4.7
2011	2.8	6.5	8.3	5.9
2012	2.4	5.6	8.8	5.6
2013	4.0	6.8	7.9	6.3
2014	2.4	10.0	8.6	7.0
2015	1.0	7.5	7.5	5.4

3.2. Applicability (AP)

Malaysia saw an improvement in Applicability element of energy security from 2005 to 2015, as shown in Fig.2. The average score of Applicability element increased from 4.2 in 2005 to 7.7 in 2015. However, the energy resource applicability has dip in year 2013 a low of 2.6 ordinal values. This trend can be seen by examining the detail data in Table 3. It can be seen that Electricity consumption intensity (AP-2) has the lowest score of 1 ordinal value in year 2014. Applicability dimension could be further improved by increasing the efficiency of energy utilization [23].

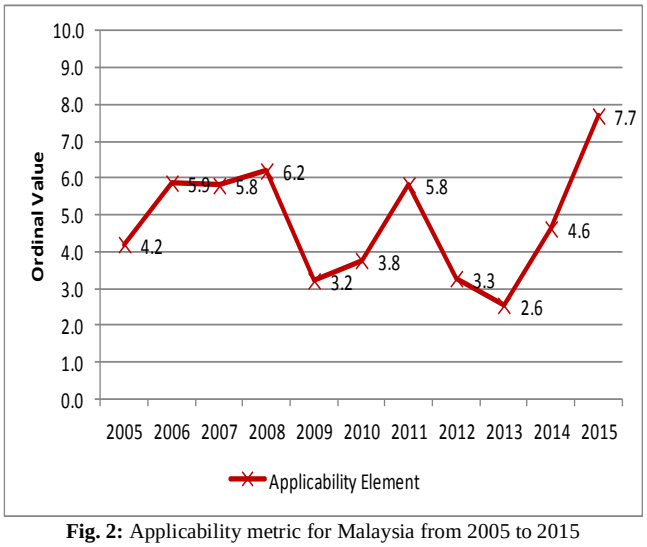


Fig. 2: Applicability metric for Malaysia from 2005 to 2015

Table 3: Normalized data for applicability element

Year	Indicator (Code)		Applicability average value
	AP-1	AP-2	
2005	1.0	7.4	4.2
2006	3.4	8.3	5.9
2007	2.5	9.1	5.8
2008	2.4	10.0	6.2
2009	2.6	3.8	3.2
2010	5.0	2.6	3.8
2011	6.0	5.6	5.8
2012	4.2	2.3	3.3
2013	4.1	1.0	2.6
2014	6.2	3.0	4.6
2015	10.0	5.4	7.7

3.3. Affordability (AF)

Affordability of Malaysian energy resources has decreased from 2005 to 2015, as depicted in Fig.3. The average score of Affordability element decreased from 6.4 in 2005 to 5.5 in 2015. The energy resource Affordability was the lowest in 2011with average score of 3.2. This can be further analysed looking at the detail data in Table 4. It can be seen that Gasoline price volatility (AF-2) has the lowest ordinal score in year 2011, which implies that the actual price of gasoline was the highest in that year. In addition, the steady reduction of ordinal score for Electricity Tariff (AF-3) indicates that the electricity tariff has been increasing each year from 2005 through to 2015.

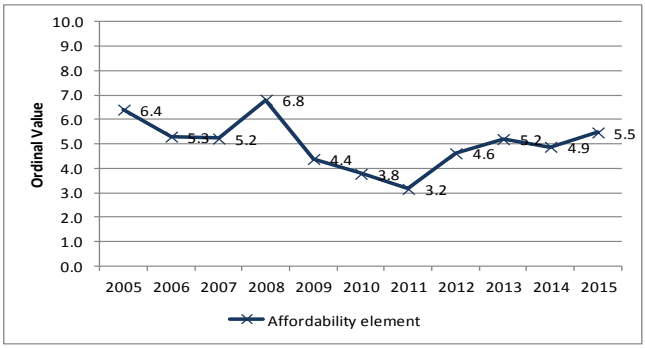


Fig. 3: Affordability metric for Malaysia from 2005 to 2015

Table 4: Normalized data for affordability element

Year	Indicator (Code)			Affordability average value
	AF-1	AF-2	AF-3	
2005	1.7	7.5	10.0	6.4
2006	1.0	6.4	8.5	5.3
2007	4.1	3.0	8.5	5.2
2008	3.4	10.0	7.0	6.8
2009	1.0	6.7	5.5	4.4
2010	1.0	4.7	5.6	3.8
2011	2.7	1.4	5.4	3.2
2012	8.6	1.0	4.2	4.6
2013	10.0	1.5	4.1	5.2
2014	10.0	2.3	2.3	4.9
2015	8.6	6.8	1.0	5.5

3.4. Acceptability (AC)

Malaysia saw a slight improvement in Acceptability element of energy security from 2005 to 2015, as shown in Fig.4. The average score of Acceptability element increased from 5.2 in 2005 to 5.5 in 2015. However, the energy resource Acceptability has dip in year 2010 to a low of 2.4 ordinal values. This trend can be examining the disaggregated data in Table 5. It can be seen that Renewable energy output (AC-2) has the lowest score of 1 ordinal value in year 2010. The Acceptability dimension could be improved by reducing carbon content of energy, facilitating low-carbon industries and diversification of energy source, i.e. further deployment of renewable energy sources [23].

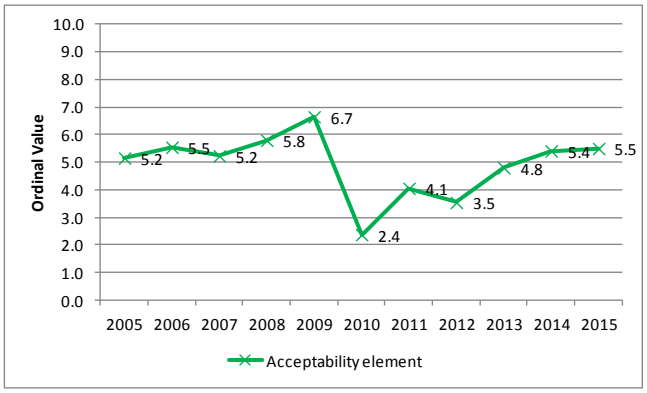


Fig. 4: Acceptability metric for Malaysia from 2005 to 2015

Table 5: Normalized data for acceptability element

Year	Indicator (Code)		Acceptability average value
	AC-1	AC-2	
2005	8.7	1.7	5.2
2006	7.4	3.7	5.5
2007	8.0	2.5	5.2
2008	6.9	4.7	5.8
2009	10.0	3.0	6.7
2010	3.8	1.0	2.4
2011	5.5	2.6	4.1
2012	2.9	4.2	3.5
2013	2.7	6.9	4.8
2014	1.4	9.4	5.4
2015	1.0	10.0	5.5

4. Conclusion

The assessment of Malaysia energy security using indicator analysis has been presented in Section 3 above. The analysis used 10 individual indicators to quantitatively measure four aspects of energy security, namely Availability, Applicability, Affordability and Acceptability. Based on the evaluation, the energy security performance of Malaysia has improved for all aspects of energy security except for Affordability. This paper suggests that energy security level of Malaysia could be enhanced by diversifying energy sources, efficient utilization of energy and reducing carbon content of energy. This paper provides a preliminary analysis of energy supply security progress in Malaysia, future research could be done to carry out more in-depth review on each energy security dimension.

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