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Renewable Energy and Energy Security in Malaysia

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Abstract: ***Robust economic growth, increasing population and personal consumption are the main drivers for the rapid increase of energy demand in Malaysia. Increasing demand has compounded the issue of national energy security due over-dependence on fossil fuel, depleting indigenous domestic conventional energy resources which in turns has increased the country's energy import dependence. In order to improve its energy security, Malaysia has seriously embarked on a renewable energy journey. Many initiatives on renewable energy have been introduced in the past decade. These strategies have resulted in the exploding growth of renewable energy deployment in Malaysia. Therefore, this study investigated the impact of renewable energy deployment on energy security. Secondary data was used to calculate the energy security indicators. The study also compared the results of applying different energy security indicators namely Availability, Applicability, Affordability and Acceptability dimension of energy resources. The evaluation shows that Malaysia will experience improvement in Energy Security, particularly on Availability, Affordability and Acceptability dimensions of energy security. This study suggests that energy security level could be further enhance by efficient utilization of energy, reducing carbon content of energy and facilitating low-carbon industries.***

Keywords: Efficiency, Energy Security and Renewable energy

I. INTRODUCTION

Energy is one of the essential ingredients for economic activities [1]. Various studies such as [2] and [3] indicated that energy and economic development are closely linked. They established that energy supply security is crucial to ensure continuous economic development in any particular country. Due to the importance of energy security, the topic has been widely discussed in literature. For example [4-7] recognized energy security as having four dimensions: availability, accessibility, affordability and acceptability. These four dimensions were further categorized into three fundamental aspects of energy security: physical security, economic energy and environmental sustainability.

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Physical energy security combines both the availability and accessibility dimensions, such as the availability of electricity supply to meet the projected electricity demand or the availability of a particular fuel resource as an input for the electricity production. Economic energy security delves into the affordability of energy resources, such as the cost per unit of the electricity generation or the cost of a particular energy resource as an input for electricity generation. Environmental sustainability deals with the acceptability dimension and particularly with the society impact concerning environmental issues, such as greenhouse gas (GHG) emissions resulting from the utilization of a particular fuel resource.

Energy security has been on the agenda of policy makers in many countries and regions such as Austria [8], United States [9], Europe [10-14] and Malaysia [15 & 16]. For the European region, the main concerns are on diversification and external energy dependence and particularly on natural gas sourced from Russia [10 & 11]. Furthermore, [14] underlined the importance of geopolitical settings in improving energy security by proposing that energy policy becomes a fundamental part of European Union (EU) external trade and foreign relations and security policy. They also suggested that the EU actively invest in dialogues with energy producer countries, such as those within the Persian Gulf, Africa and Russia. In addition, [12] also discussed the importance of the geopolitical dimension in the future energy security for the EU.

Energy security has also been acknowledged as one of the important energy agenda items in the Southeast Asia region [17-19]. ASEAN is relatively well endowed with conventional energy resources, namely oil, gas and coal. However, the resources are unevenly distributed among the countries and sometimes are located away from the demand centers. Apart from the abundance of conventional fossil-fuels, the region is also relatively well endowed with renewable energy sources, particularly in hydro and geothermal as well as other types of renewable energy, albeit the levels and types of renewables may differ from one country to the others [20]. ASEAN is expected to remain heavily dependence to fossil fuel in the years to come. Fossil fuel sources are expected to contribute almost 80% of the total primary energy demand in 2050. Encouragingly, renewable energy is expected to grow at the fastest rate in the same period reflecting the active deployment of renewable energy sources in the region.

Similar to other countries in the region, Malaysia has also recognized the importance of energy security. Sahid et al. [15-16] highlighted that energy security concerns in Malaysia are mainly due to overdependence on fossil fuels and increasing dependence on energy imports.

Malaysia is fortunate that it is well endowed with conventional energy sources as well as renewable sources. As of 2014, the total reserves of oil was reported as 3.8 billion barrels of oil and the total reserves of gas was reported as 1.1 tcm for natural gas. As for coal, Malaysia's reserve is only 1.9 billion tonnes, which is mostly located in Sarawak and Sabah. However, the fast growth rate of the primary energy supply, high dependence on fossil fuels and limited domestic energy reserves will result in Malaysia being in a vulnerable position in the future in terms of energy supply security [15]. 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 2040, increasing from 11 Mtoe in 2013 to 26 Mtoe in 2040 [21].

In terms of electricity generation in Malaysia, coal and natural gas dominated the electricity generation mix in recent years. Coal and gas dominates the electricity generation mix for Malaysia in recent years. In 2013, more than 80% of electricity was generated using natural gas and coal with almost equal shares among the two fuels [21]. The remaining is generated by hydro, fuel oil/diesel and biomass. However, Peninsular Malaysia is faced with limited and depleting gas resources and increasing reliance on imported coal to meet the country's electricity demand. In addition, the current production of electricity by using mixed resources but relying heavily on coal is negatively affecting the environment of Malaysia [22] and is not supporting the target to achieve the voluntary emission reduction of 45 percent carbon intensity by 2030. Furthermore, the current percentages of using coal and gas will affect the Malaysia economy from the international prices of coal and gas, due to the increase in energy imports. To improve the precarious situation, Malaysia has introduced National Renewable Energy Policy and Renewable Energy Act in 2011. The policy also detailed out the target on the renewable energy share to energy mix in Malaysia up to 2040. The introduction of the Policy and subsequent establishment of Feed-In Tariff mechanism particularly have resulted in tremendous increase of renewable energy projects. Various researchers [23-26] have suggested that in renewable energy will affect energy security. Therefore, this study will investigate the impact of renewable energy deployment on energy security in Malaysia.

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.

II. METHODOLOGY

This study used indicator-based assessment to quantify the dynamic changes of energy security in Malaysia. There are 17 indicators in total for all the 4As dimensions. For each of the indicator relevant data was collected and then converted into ordinal values. Rhombus grid was constructed for five-year interval. Ideally the rhombus is a perfect square, however it is difficult to achieve 'perfect' energy security [28]. Different shapes of grids and areas will reflect energy security status for the respective year.

Selecting energy security indicators

A total of 17 energy security indicators is used in this study, the indicators have been categorized into 4 dimensions, namely Availability, Applicability, Affordability and Acceptability, i.e. 4 As. Indicators for each A-category have been selected based on their suitability and data availability.

Availability indicators (AV)

Availability element has been applied by past researchers to evaluate energy security, such as [27-29]. Availability is one of the indicators for physical availability of energy supply. In this study, five availability elements have been analyzed, as listed below:

Table. 1 List of Availability Indicators

Availability Indicators	
AV1	Total Energy Consumption
AV2	Share of Gas Consumption
AV3	Electricity Supply
AV4	Share of Coal Consumption
AV5	Share of Oil Consumption

The first indicator of availability indicators aspect is total energy consumption (AV1). The second indicator is the share of natural gas consumption (AV2). It shows the amount of contribution natural gas contributed in Malaysia energy mix. The third indicator of availability dimension is electricity supply (AV3), it indicates the amount of electricity that being supply to fulfill electricity demand. The fourth indicator is the share of coal consumption (AV4). The fifth or final indicator selected for availability indicator is share of oil consumption.

Accessibility indicators (AP)

Accessibility element has been widely used to evaluate energy security as [27, 28 & 30]. Similar to availability element, Accessibility is used to indicate the physical security of energy supply with an added dimension that is, efficiency aspects of energy utilization. In this study four applicability indicators was examine, as listed below:

Table. 2 Lists of Accessibility Indicators

Accessibility Indicators	
ACS1	Electricity Generation
ACS2	Gas Import Dependency
ACS3	Oil Import Dependency
ACS4	Commercial and Transport Energy Intensity

The first indicator for accessibility dimension is Electricity Generation (ACS1). The second indicator is Gas Import Dependency (ACS2).The third indicator of accessibility dimension is Oil Import Dependency (ACS3).

The fourth indicator is commercial and transport intensity, this indicator is calculated by dividing the Final Energy Demand data by Malaysia Growth Domestic product (GDP).

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 four affordability elements has been analyzed, as tabulated below:

Table. 3 List of Affordability Indicators

	Affordability Indicators
AFF1	Energy Consumption per Capita
AFF2	Energy Consumption per GDP
AFF3	Coal Price
AFF4	Gas Price

The first indicator for energy security from the aspect of affordability is Energy Consumption per Capita (AFF1). The second indicator selected for affordability aspect is energy use or consumption per GDP (AFF2). The third and fourth indicator is for affordability is Coal Price (AFF3) and Gas Price (AFF4), these indicators are related with the first indicator. As the first indicator of affordability is measure the affordability of the citizen, the third and fourth indicators are represent the energy price which is the popular issue among the society. Usually the lower the energy price, it is more affordable for the society.

Acceptability indicators (AC)

Acceptability indicators are used to measure environmental and social elements of energy security [16]. In this study, four Acceptability elements have been examined, as listed below:

Table. 4 Lists of Acceptability Indicators

	Acceptability Indicators
ACP1	CO_2 Emission
ACP2	GHG per Capita
ACP3	Share of Renewable Energy
ACP4	Share of Hydro

The first indicator of acceptability dimension is total CO_2 emission (ACP1). The second indicator of acceptability is GHG per Capita (ACP2), GHG per capita is obtained by dividing CO_2 emission with population of a country. Share of renewable energy (ACP3) have been selected as the third indicator to be used in the evaluation of energy security based on the acceptability dimension. The share of renewable energy will shows the contribution of renewable energy sources in energy mix. The fourth indicator is share of Hydro Energy (ACP4), hydro is known as one of renewable energy as the resources is sustainable [31].

Data

The analysis was based on historical data from year 2005 to 2013, and projection data from year 2014 to 2040. For the energy supply and demand projection 2014-2040, it is assumed that the all renewable targets set by the National Renewable Energy Policy and Renewable Energy Act 2011 are achieved, in addition, the scenario is set. Energy supply and demand data, macroeconomics data and statistics on emissions were retrieved from APERC [21] and Suruhanjaya Tenaga [34& 35]. While energy price data were gathered from World Bank [32& 33].

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 [27] was applied in this study.

$$X' = 1 + (X - MinA)(10-1)/(MaxA - MinA) \qquad (1)$$

Where;

X'= Normalized value based on 1-10 scale

MinA=Minimum value of data range A

MaxA= 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.

$$X' = 1 + (X - MaxA)(10-1)/(MinA - MaxA) \qquad (2)$$

Where;

X'= Normalized value based on 1-10 scale

MinA=Minimum value of data range A

MaxA= Maximum value of data range A

III. RESULTS AND DISCUSSIONS

The results from the quantitative analysis depict the dynamic changes of Malaysia energy security. Table 5 to 8 below show the results of data normalization. The final row data from Table 5 until Table 8 is the average data and also conclude the energy security status for each years based on the category of indicators. Table 9 summarized the four energy security dimensions.

Table. 5 Malaysia Energy Security Status by Availability category

	2005	2010	2013	2020	2030	2035	2040
AV1	1	1.96	3.46	4.75	7.64	8.71	10
AV2	1	6.84	5.42	8.63	10	9.87	9.6
AV3	1	2.54	3.01	4.84	7.4	8.72	10
AV4	10	3.69	5.81	1.83	1.89	1.54	1

AV5	1	4.88	2.96	5.72	7.54	5.8	10
Average	2.8	3.98	4.13	5.16	6.9	6.93	8.12

Table. 6 Malaysia Energy Security Status by Accessibility category

	2005	2010	2013	2020	2030	2035	2040
ACS1	1	2.54	3.02	4.86	7.43	8.71	10
ACS2	10	8.69	8.67	6.68	3.84	2.43	1
ACS3	10	9.52	7.69	5.97	3.49	2.25	1
ACS5	10	10	10	10	1	1	1
Average	7.75	7.69	7.35	6.88	3.94	3.6	3.25

Table. 7 Malaysia Energy Security Status by Acceptability category

	2005	2010	2013	2020	2030	2035	2040
ACP1	10	8.57	7.75	5.98	3.47	2.17	1
ACP2	10	7.66	6.33	5.14	2.81	1.72	1
ACP3	1	2	3	5	8	9	10
ACP4	1	4	4	7	10	10	10
Average	5.5	5.56	5.27	5.78	6.07	5.72	5.5

Table. 8 Malaysia Energy Security Status by Affordability category

	2005	2010	2013	2020	2030	2035	2040
AFF1	1	2.04	6.22	6.87	9.09	9.74	10
AFF2	4	1	4	4	7	7	10
AFF3	-	1	3.21	10	8.71	7.3	5.89
AFF4	-	-	4.79	10	8.42	4.71	1
Average	2.5	1.35	4.55	7.72	8.3	7.19	6.72

Table. 9 Overall Malaysia Energy Security Status from 2005 to 2040

	2005	2010	2013	2020	2030	2035	2040
AV	2.8	3.98	4.13	5.16	6.9	6.93	8.12
ACS	7.75	7.69	7.35	6.88	3.94	3.6	3.25
ACP	5.5	5.56	5.27	5.78	6.07	5.72	5.5
AFF	2.5	1.35	4.55	7.72	8.3	7.19	6.72

The analyses showed that for the period under study energy security level in Malaysia will improve, particularly for Availability, Acceptability and Affordability dimensions. On the other hand Accessibility dimension of energy security showed a mark reduction at year 2040 compared to year 2005. In this study, a benchmark has been set in order to do the comparison of energy security status from year to year. The year of 2005 has been selected as the reference or benchmark for the comparison. The rhombus graph for the four dimensions of energy security was depicted in Figure 1. In an ideal situation. The rhombus is a perfect square, however it is difficult to achieve 'perfect' energy security. Different shapes of grids and areas will reflect energy security status for the respective year.

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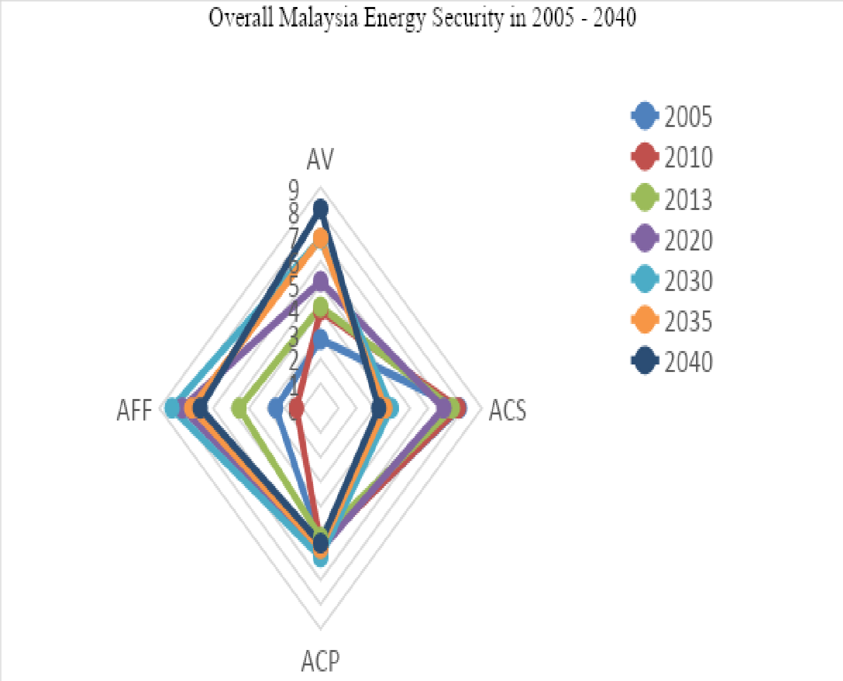

Fig. 1 Malaysia Energy Security Status in 2005 to 2040

Table. 10 Total rhombus area

	2005	2010	2013	2020	2030	2035	2040
Rhombus Area	42.54	43.12	55.93	79.86	79.38	68.25	67.90

The rhombus area in Table 10, indicates the energy security status for the particular year. Overall energy security performance is expected to improve from 42.54 sq. unit in 2005 to 79.86 sq. units in 2020. This is mainly due to the implementation of Renewable Energy Act in 2011 and establishment of Feed-In Tariff mechanism. However, the overall energy security performance shows a decreasing trends from 79.86 sq. units in 2020 to 67.90 sq. units in 2040. This findings provide a signal to the policy makers to take further action to address energy security concerns. The results indicate that renewable energy implementation alone will not be enough to improve the energy security for Malaysia, particularly post-2020. Therefore, other strategies are needed to further improve energy supply security in the country, such as diversifying energy sources, efficient utilization of energy and reducing carbon content of energy.

Figure 2 depicted Energy Security Status in year 2005 and 2010, the rhombus of both years are almost the similar in shape. In terms of rhombus area, the area under the graph for year 2010 is 43.12 sq. units, which slightly higher than the area under the graph in year 2005. This also indicates that the energy security status was slightly better in 2010 compared to 2005. The figure shows that the Accessibility dimensions experienced a slight reduction from 7.75 in 2005 to 7.69 in 2010. The drop of Accessibility category is mainly due to the increase of natural gas import dependency in 2010 compared to 2005. Apart from natural gas, oil import dependency has also increased. The other category that can be observed is Availability dimension, the rhombus shows that Availability dimension experienced slight improvement.

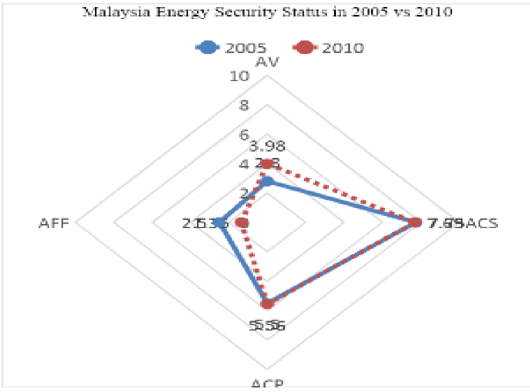

Fig. 2 Malaysia Energy Security Status in 2005 vs 2010

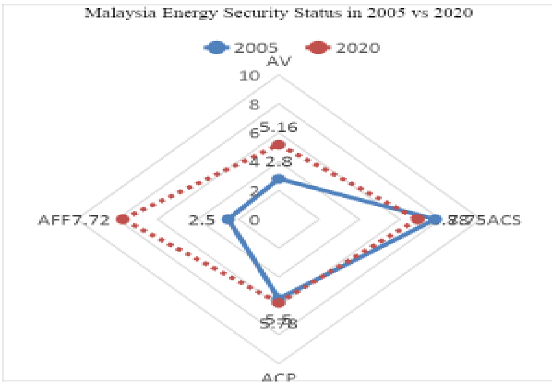

Fig. 3 Malaysia Energy Security Status in 2005 vs 2020

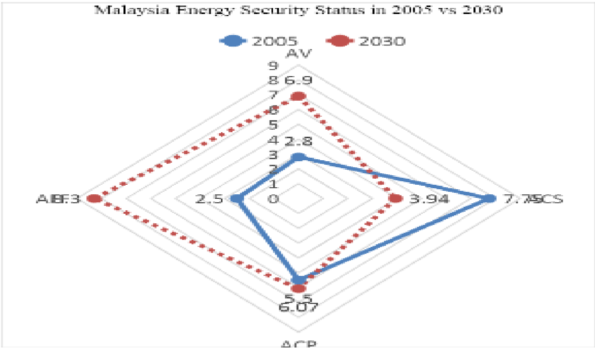

Fig. 4 Malaysia Energy Security Status in 2005 vs 2030

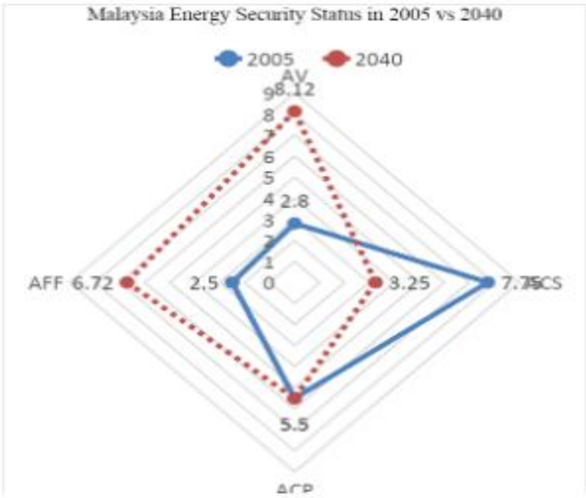

Fig. 5 Malaysia Energy Security Status in 2005 vs 2040

Figure 3 shows that energy security status in 2020 will experience much improvement compared to 2005 The rhombus area for year 2020 was 79.86 sq. units in 2020 compared to 42.54 sq. units in 2005. On the year of 2020, the energy security status for Malaysia has registered the highest value of overall energy security status from year 2005 to 2040. This is mainly due to the success in the implementation of Renewable Energy Policy and Renewable Energy Act 2011. All energy security dimensions evaluated have experienced an improvement except for Accessibility dimensions.

Figure 4 shows that energy security status for Malaysia in 2030 will experience much improvement compared to 2005. The rhombus area for year 2030 is 79.4 sq. units, compared to only 42.54 sq. units in 2005. This is because Availability, Acceptability and Affordability dimensions of energy security are expected to improve. Acceptability and Affordability both obtained the highest ordinal scores for the years under study, at 6.07 and 8.3 ordinal score respectively. The increase of renewable energy share (including hydro) in the energy mix has positively affect the ordinal score of the Acceptability dimensions. On the other hand, Accessibility dimension is expected to worsen, this is mainly due to increase of energy imports.

Figure 5 depicted that energy security status for Malaysia in 2040 will improve compared to 2005. The rhombus area for year 2040 is 67.90 sq. units, compared to only 42.54 sq. units in 2005. This is because Availability and Affordability dimensions of energy security are expected to improve. Availability dimension is expected to reach 8.12 ordinal score in 2040 while Affordability dimension is expected to increase to 6.72 ordinal score in 2040. However, it is interesting to note that compared to year 2030, the performance of energy security in 2040 is expected to decline. Comparing year 2040 and year 2030, all the energy security dimensions show the declining trend except for Availability dimension. In addition, rhombus area for that reflects the energy security status reduced from a high of 79.38 sq. units in 2030 to 67.90 sq. units in 2040. Accessibility dimension is notable scored quite a low value in 2040, at only 3.25 ordinal score, compared to 7.75 ordinal score in 2005. Acceptability dimension recorded at 5.5 ordinal score both in 2005 and 2040. Applicability dimension could be further improved by increasing the efficiency of energy utilization [23]. 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].

IV. CONCLUSIONS

The assessment of Malaysia energy security using indicator analysis has been presented in the above section. The analysis used 17 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 Accessibility. Overall energy security performance is expected to improve from 42.54 sq. unit in 2005 to 67.90 sq. units in 2040. However, a clear trend was identified that is increasing energy security level from 2005 to 2020, and decreasing energy security level from 2020 to 2040. These findings indicate that renewable energy implementation alone will not be enough to improve the Malaysia energy security. 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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