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The Effect Of Urbanizaation, Industrialization, And Economic Growth On Renewable Energy Consumption In Asean-6 Period 1994-2020

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ABSTRACT

This research aims to analyze the influence of urbanization, industrialization, and economic growth on renewable energy consumption in ASEAN-6 (1994 - 2020). The data used in this research is annual data for period 1994 – 2020 taken from the World Bank Data. The estimation tool used in this research is the Vector Error Correction Model (VECM) using EViews 12. The research results show that in the short term, urbanization, industrialization, and economic growth reveal insignificant effect on renewable energy consumption in ASEAN-6. Meanwhile in the long term, variables show varying results. Urbanization and Economic Growth have a negative and significant effect with coefficient numbers -0.138775 and -0.364414, while Industrialization has a positive and significant effect with a coefficient of 0.423784. These findings indicate that ASEAN-6 must prioritize deploying renewable energy sources to meet its mix energy target. Therefore, the reliance on non-renewable energy can shift and create sustainable energy development and anticipate energy security issue.

Keywords : *Urbanization, Industrialization, Economic Growth, Vector Error Correction Model (VECM)*

INTRODUCTION

Association of Southeast Asian Nations (ASEAN) is a developing region yet an emerging economic market. ASEAN's consistent economic growth with high cumulative GDP has attracted global attention to its economic market. Projected to grow to USD 4.800 billion, with average annual growth reaching almost 5% until 2026, this region will become the fifth largest economy behind large countries namely the US, China, Japan, and Germany (ASEAN, 2022).

Table 1 GDP in 2020, Member of ASEAN-6

Sources: IMF, 2023

Country	GDP, current prices (Billions of U.S. Dollars) in 2020
Indonesia	1.06 thousand
Thailand	500.53
Philippines	361.75
Singapore	348.39
Vietnam	346.31
Malaysia	337.61

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The presented data shows those are the six biggest GDPs among other ASEAN members in 2020. With 1.06 thousand billion U.S. dollars, Indonesia is leading the way followed by Thailand, Philippines, Singapore, Malaysia, and Vietnam. Even still be categorized as a developing country, the annual growth of this region representative was relatively high. Furthermore, presenting a good record and growing rapidly in recent years, its success can be attributed to several driving factors. One of the essential keys is the advancement of industrial sectors within ASEAN members.

Industrialization not only contributes to economic development, but conversely, it also impacts the massive increase in urbanization. Urbanization which is based on social factors such as economics, culture, basic facilities, and a better standard of living, is also triggered by the growth of this industrial sector, thereby providing opportunities or creating new jobs (Thanaporn et al., 2022). ASEAN stands as the global third-largest labor force after India and China, with a collective population exceeding 600 million individuals. At the same time, 31 cities exceeded one million and achieved nearly half of the entire populace, where approximately 49.5% of residents live in the cityside (ASEAN, 2022). Moreover, the rise of urbanization levels worldwide has put attention to its rapid increase in Asia, 64%, and Africa, anticipated with 56% of the urban population by the middle of this century. People's Republic of China (PRC), followed by Bangladesh, India, Indonesia, Thailand, and Vietnam will be projected as the most significant decrease in rural population.

Besides this vast number, industrialization and urbanization pose a challenge to national economic development. Numerous effects occur, such as urban production, mobility, transportation, infrastructure, urban density, and private household consumption. Moreover, the emergence of these two phenomena leads to an economical operation center within an urban and metropolitan zone that promotes efficient gains in output level. Consequently, this transformation requires shifting from non-energy-based agriculture to becoming more energy-dependent in manufacturing or industrial processes (Ming, 2014). Thus, energy plays a crucial role; it encompasses economic growth that involves both consumption and production aspects.

Figure 1 Energy demand trends of ASEAN by scenario on 2020-2050

Sources: Southeast Asia Energy Outlook, 2022

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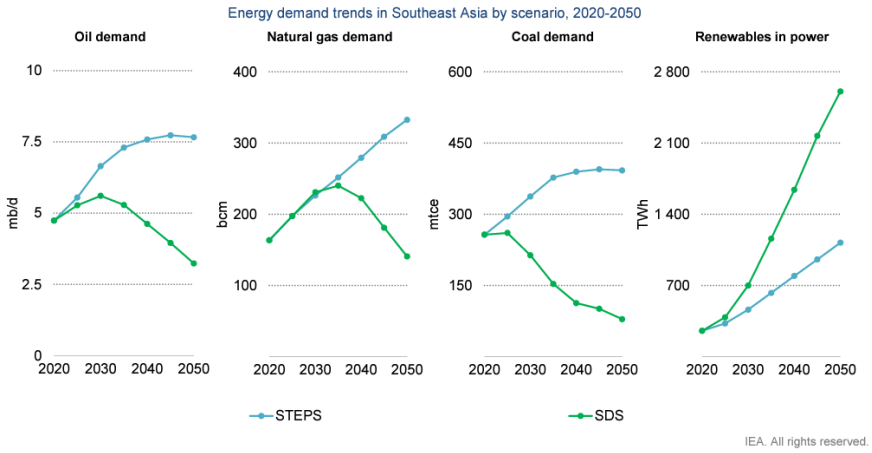

Figure 1 shows the future projection based on previous trends in energy demand. Although the dependence on oil, gas, and coal is still increasing, the trend of renewable energy is consistently increasing far beyond. Currently, ASEAN depends heavily on fossil fuels, with projections indicating that approximately the world's primary energy supply in 2025 will be fulfilled around 80% by fossil fuels. At the same time ASEAN is working on the deployment of renewable energy sources. As growing urbanization and industrialization continue to rise in emerging economies, subsequently will impact energy consumption. The dependance on non-renewable energy sources is increasingly proven to be unsustainable. Therefore, prioritizing renewable energy can dominate the final energy consumption. Hence, the utilization of clean energy can help accelerating energy transition that will mitigate the overcoming problems related to energy security challenges. Additionally, can ensure a more sustainable and resilient future energy. Thus, this study would examine the effect of urbanization, industrialization, and economic growth on renewable energy consumption in ASEAN-6 (Indonesia, Thailand, Philippines, Malaysia, Singapore, And Vietnam) 1994-2020.

RESEARCH METHODOLOGY

This study examined the urbanization, industrialization, economic growth, and renewable energy consumption in 6 ASEAN countries (Indonesia, Thailand, Singapore, Philippines, Malaysia, and Vietnam) in 1994-2020 period. Quantitative secondary data was applied in this research. The secondary data used to examine the relationship between these variables uses a combination of time series and cross-section series data. The data in this research was obtained from the World Bank Data. The scope of this research was conducted to determine the existence of short and long-term effects on dependent variable. Hence the VECM model applied. The author used EViews software version 12 to process the data.

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The independent variable used in this research are urbanization (X1), industrialization (X2), and economic growth (X3), while the dependent variable is renewable energy consumption (Y). Renewable energy consumption defined as total energy consumption comes from renewable resources of total final energy consumption. While urbanization refers to the total population concentrated in cities or urban areas. Additionally, industrialization can be known as the total output comes from manufacturing industry as the value added to GDP. Further, economic growth defined as economic activities that generate income for society in a certain period. Bellows are the variable operational definition:

Table 2 Variable Operational Definition

Source: World Bank Data

Variable name	Code	Description
Renewable energy consumption	REC	Renewable energy consumption (% of total final energy consumption)
Urbanization	UB	Urban population (Total people living in urban areas)
Industrialization	IND	Industry (including construction), value added (current US$)
Economic Growth	EG	GDP (current US$)

According to previous studies, there are very diverse variables, time periods and research objects. The study focuses on developed countries and countries outside ASEAN. However, there are not many studies that examine urbanization, industrialization and economic growth as independent variables and renewable energy consumption as the dependent in regions such as ASEAN. Therefore, this study focuses on the influence of urbanization, industrialization, and economic growth on renewable energy consumption in ASEAN-6 (Indonesia, Thailand, Philippines, Singapore, Vietnam, and Malaysia) over a larger period, 1994-2020. The hypotheses of this research will be:

H1: Urbanization has a positive and significant effect on renewable energy consumption in ASEAN-6 in the short and long term.

H2: Industrialization has a positive and significant effect on renewable energy consumption in ASEAN-6 in the short and long term.

H3: Economic Growth has a positive and significant effect on renewable energy consumption in ASEAN-6 in the short and long term.

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RESULTS AND DISUCSSION

Unit Root Test

In this research, unit root test of Augmented Dickey-Fuller (ADF) is being used. The ADF test will indicate whether they are stationary or non-stationary in their level and first differences stages. The results must show that all are stationary at the same level, meaning in the first difference.

Table 3 Unit Root Test

Source: Data processed

Test	ADF					
Variables	Level	Prob	Note	1st Difference	Prob	Note
	Trend & Intercept			Trend & Intercept		
REC	15.6845	0.2061	Non-Stationary	66.5815	0.0000	Stationary
UB	18.7215	0.0955	Non-Stationary	37.8423	0.0002	Stationary
IND	7.98339	0.7864	Non-Stationary	43.9993	0.0000	Stationary
GDP	9.72890	0.6397	Non-Stationary	34.3762	0.0006	Stationary

The presented results indicate that all variables have p-values lower than $\alpha = 5\%$ (0.05), suggesting that all variables are stationary in the first difference. It concluded that all variables are non-stationary at the level but then becomes stationary after taking its first difference test.

Lag Length Criteria

The selection of an appropriate lag length is crucial in time series analysis, as it impacts the model's accuracy and effectiveness. The table presents various statistics and criteria for different lag lengths to aid in selecting the optimal model.

Table 4 Lag Length Criteria

Source: Data processed

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1068.020	NA	2.34e-13	-17.73366	-17.64074	-17.69593
1	1146.721	150.8451	8.22e-14	-18.77869	-18.31811*	-18.59002*

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2	1159.153	22.99816	8.73e-14	-18.71921	-17.88297	-18.37961
3	1179.236	35.81419*	8.17e-14*	-18.78726*	-17.57935	-18.29672
4	1194.081	25.48485	8.37e-14	-18.76802	-17.18844	-18.12654
5	1206.296	20.15423	8.97e-14	-18.70493	-16.75369	-17.91252
6	1222.810	26.14784	8.99e-14	-18.71350	-16.39059	-17.77016

The table above presents results for lag lengths ranging from 0 to 6. The symbol (*) indicating the optimum lag. The analysis reveals that that the Likelihood Ratio (LR), Final Prediction Error (FPE), and Akaike Information Criterion (AIC) tests consistently point to lag 3 as the optimal choice. The selection of an appropriate lag length is crucial for building a reliable and effective time series model. Consequently, the following estimation will be carried out using lag 3 as an optimal lag.

Stability VAR Model Test

The stability of VAR model indicating the data being used have no experiencing fluctuation over time. This test is crucial in time series analysis to assess the stability of a model's roots, which can affect the model's reliability and predictive capabilities.

Table 5 Test of VAR Stability

Source: Data processed

Root	Modulus
0.885080	0.885080
0.716867	0.716867
-0.326983 - 0.575157i	0.661607
-0.326983 + 0.575157i	0.661607
0.073622 – 0.591722i	0.596284
0.073622 + 0.591722i	0.596284
0.415981	0.415981
-0.160340 – 0.358994i	0.393174
-0.160340 + 0.358994i	0.393174
0.106105 – 0.375444i	0.3903174
0.106105 + 0.375444i	0.3903174
0.334155	0.334155

A stable VECM model typically has roots with moduli less than 1, while roots with moduli greater than 1 may suggest instability in the model. The data analysis indicates

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that most roots have moduli less than 1, indicating a favorable condition for model. Similarly, as demonstrated in the table 5, the modulus of 0.885080 further supports the stability of the VAR, means that it qualifies the VAR stability test criteria.

Co-Integration Test

The presented information relates to a Johansen cointegration test, which is commonly used in econometrics and time series analysis to examine the existence of cointegration relationships in a panel vector error correction model (Panel VECM). This test is particularly useful for assessing the long-run relationships among variables within a panel dataset. The empirical cointegration equation result is as follow:

Table 6 Co-Integration Test

Source: Data processed

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.404616	133.0099	47.85613	0.0000
At most 1*	0.254010	64.56151	29.79707	0.0000
At most 2*	0.133368	25.87974	15.49471	0.0010
At most 3*	0.051542	6.985081	3.841465	0.0082

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.404616	68.44840	27.58434	0.0000
At most 1*	0.254010	38.68177	21.13162	0.0000
At most 2*	0.133368	18.89466	14.26460	0.0086
At most 3*	0.051542	6.985081	3.841465	0.0082

The results indicate cointegration relationships under all the hypotheses in trace and maximum eigenvalue. The trace test of "None*" with the probability values of (0.0000), "At most 1*" with (0.0000), "At most 2*" with (0.0010), and "At most 3* with (0.0082). The following maximum eigenvalue test of "None*" with the probability values of (0.0000), "At most 1*" with (0.0001), "At most 2*" with (0.0086), and "At most 3* with (0.0082). All the (*) sign indicates that there is no rejection of cointegration among variables. In table 5. 4, all hypotheses meet the significant value under α = 5% (0.05). Therefore, it can be inferred that cointegration exists among the variables.

Granger Causality Test

Granger causality is a statistical test used to examine the causal relationship between two time series variables. In each test, there is a null hypothesis that states that

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one variable does not Granger cause the other. The results indicate whether the null hypothesis can be rejected or not. This model is projecting to know whether the endogen variable can play a role as exogen variable and vice versa. From this result also can be seen if there is a causality occurred.

Table 7 Granger Causality Test

Source: Data processed

Null Hypothesis:	Obs	F-Statistic	Prob.
UB does not Granger Cause REC	144	0.11040	0.9539
REC does not Granger Cause UB		1.36196	0.2571
IND does not Granger Cause REC	144	0.43312	0.7296
REC does not Granger Cause IND		0.51378	0.6735
GDP does not Granger Cause REC	144	0.45632	0.7133
REC does not Granger Cause GDP		0.60031	0.6159
IND does not Granger Cause UB	144	1.05479	0.3706
UB does not Granger Cause IND		2.92278	0.0362
GDP does not Granger Cause UB	144	1.80437	0.1493
UB does not Granger Cause GDP		2.63998	0.0520
GDP does not Granger Cause IND	144	4.05274	0.0085
IND does not Granger Cause GDP		2.41079	0.0696

The table above shows that only UB has a unidirectional relationship with IND followed by GDP which has a unidirectional relationship with IND indicating by the significant number in 5% means < 0.05 so the null hypotheses are rejected. Where UB, IND, and GDP have no causal relationship with REC, which means that null hypothesis is accepted as indicated by the insignificant number.

Vector Error Correction Model Estimation

The VECM estimation results below will show whether all variables have a significant or insignificant effect. This section will show the short and long-term effect from the independent variables to dependent variable. This test uses lag 3 as the optimum lag length selection.

Table 8 VECM Estimation Result – Short Term

Source: Data processed

Short Term		
Variable	Coefficient	T-Statistic

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CointEq1	-0.065868	[-3.92703]**
D(REC(-1))	0.098095	[1.11098]
D(REC(-2))	-0.107832	[-1.18743]
D(REC(-3))	0.013060	[0.14255]
D(LOG(UB(-1)))	0.111744	[0.46714]
D(LOG(UB(-2)))	-0.022510	[-0.07187]
D(LOG(UB(-3)))	0.058947	[0.25731]
D(LOG(IND(-1)))	0.010817	[0.27346]
D(LOG(IND(-2)))	0.021142	[0.54726]
D(LOG(IND(-3)))	-0.018339	[-0.45606]
D(LOG(GDP(-1)))	0.001429	[0.03638]
D(LOG(GDP(-2)))	-0.027380	[-0.70732]
D(LOG(GDP(-3)))	0.027174	[0.67107]
C	-0.010115	[-2.27691]

** significant in 5%

In short-term relationship, only UB has a significant negative impact on REC. Knowing that in short-term relationships, among all variables being examined with optimal lag 3, revealed that there are no variables significant affecting Renewable Energy Consumption in 1994-2020.

Table 9 VECM Estimation Result – Long Term

Source: Data processed

Variable	Coefficient	t-Statistic
LUB(-1)	-0.138775	[-5.46238]**
LIND(-1)	0.423784	[2.93516]**
LGDP(-1)	-0.364414	[-2.52745]**

** significant in 5%

The long-term outcomes reveal a significant positive impact of IND on REC. This implies, that a 1% increase in IND corresponds to improved REC rates by 0.423784. Conversely, both UB and GDP show a negative and significant effects on REC. Specifically, an increase in UB will decrease REC by 0.138775, while the increase in GDP will reduce REC by 0.364414.

Impulse Response Function (IRF)

In this stage, it will be tested using the impulse response function which aims to determine shock in endogenous variables from other variables during a certain period. The analysis of impulse response depicted below explains how a variable responds to a shock of 1 standard deviation originating from either the variable itself or other variables.

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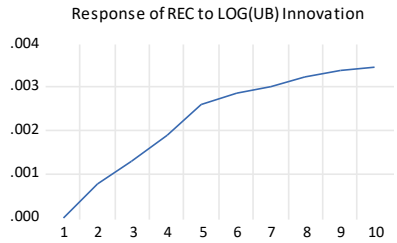
a. REC response on Urbanization

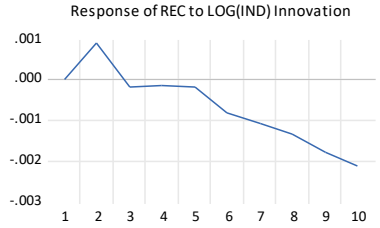
Figure 2 Response of REC to UB



The response of REC to UB showed a growing trend, characterized by a consistently rising curve and stay stable at period 4 and 5. Followed by slow increase in period 6 to 10.

b. Response of REC on Industrialization

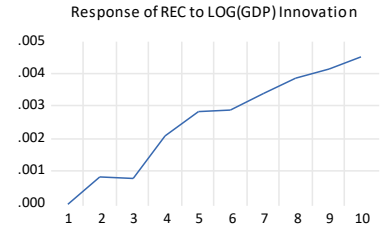
Figure 3 REC response on Industrialization



The table above illustrates a fluctuate response of REC to IND. This finding is revealed that in 1 to 2 it is a growing curve but slowly show a declining trend but stable from periods 3 to 5, which continues to show a down curve condition from periods 6 to 10.

c. Response of REC on Economic Growth

Figure 4 Response of REC on GDP



The result presented regarding the response of REC to GDP is the growing curve. This result shows slightly rise conditions starting from periods 2 to 6. Followed by stable growing curve from 6 to 10.

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Variance Decomposition

Forecast Error Variance Decomposition (FEDV) serves as a valuable tool for forecasting the percentage of variance contribution by individual variables in response to changes in specific factors. Typically, the most significant impact on the variability of each variable arises from the variable itself, a pattern discerned through FEDV analysis. This stage arises result on how urbanization, industrialization, and economic growth variables influence the renewable energy consumption.

Table 10 The Result of Variance Decomposition

Source: Data processed

Variance Decomposition of LOG(REC)					
Period	S.E	LOG(REC)	LOG(UB)	LOG(IND)	LOG(GDP)
1	0.014863	100.0000	0.000000	0.000000	0.000000
2	0.021267	99.52953	0.130878	0.183272	0.156317
3	0.024809	99.27941	0.373583	0.140190	0.206813
4	0.027523	98.35974	0.782000	0.117086	0.741169
5	0.029828	96.96085	1.417946	0.102918	1.518285
6	0.031761	95.61917	2.053638	0.157114	2.170079
7	0.033454	94.11111	2.654500	0.243023	2.991368
8	0.034949	92.37022	3.293478	0.367096	3.969206
9	0.036275	90.48120	3.936213	0.586829	4.995763
10	0.037487	88.44343	4.545951	0.874933	6.135690

According to the results obtained from the Forecast Error Variance Decomposition (FEVD), it is discerned that during the initial period, only REC reveals an impact on its own variable, with no influence from other variables on REC. Continuing to the next period, all independent variables are gradually influence. To conclude, the horizon projection from the 1st to the 10th period indicates that REC influences its own variable by 88.4%, accompanied by influence from UB at 4.55%, IND at 0.87% and GDP at 6.14% on REC.

VECM in Short and Long Term

The finding reveals that urbanization has an insignificant effect in the short run and shows a negative and significant impact on renewable energy consumption in ASEAN-6. The negative effect occurred as ASEAN energy consumption still reliance on

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non-renewable energy. While the existence of energy subsidies in ASEAN is quite challenging. However, the effort to create affordable energy hinders the utilization of renewable energy since non-renewable energy is still dominant (Chattopadhyay & Jha, 2014). The other factors affecting are the high cost, lack of awareness and public support cause the reduction in renewable energy consumption while urbanization arise. Enhancing public awareness and support is essential for fostering a transition towards a more sustainable energy mix. This finding is in line with the study by (Baye et al., 2021), (Islam et al., 2022), and (Liddle, 2004) which found that urbanization has a negative impact on renewable energy consumption.

The further result implies that industrialization has insignificant impact on renewable energy consumption in ASEAN-6 in the short run. While it shows a positive and significant impact the long run. This finding caused by the heavy reliance of ASEAN industrialization on non-renewable energy consumption that cause it has no serious impact in the short run. However, with the fluctuations of oil and gas price, unstable energy prices can impact the economics of producing goods and services thus affect the industrial sectors. In the next decade, the sector will become considerably less reliant on fossil fuels, which currently dominate the sector's energy supply. Instead, industrial process heat will transition towards the use of electricity, biomass, and green hydrogen. ASEAN industry can also benefit from the technologies. With a significant supply of critical materials needed for many energy transition technologies, the region could become a powerhouse of manufacturing (IRENA & ACE, 2022). In addition, the future business projection dedicates to adopting low-carbon energy sources, acknowledging the limitations of solely depending on traditional energy options. Consequently, the shift towards low-carbon energy gains momentum with the expansion of industries. Government regulations further endorse this initiative for industrial players (Chien et al., 2023). These findings are supported by (Malik et al., 2014), that said the Pakistan government has recognized one of the threats to energy security and believes that the only way to address this issue is by striving for an energy mix and reducing dependence on non-renewable energy, mainly imported oil and fossil fuels, as a long-term solution.

Lastly, the economic growth demonstrates insignificant impact on renewable energy consumption in ASEAN-6 in the short run and reveals a negative and significant effect in the long run. This finding aligned with the current uneven policy in providing affordable energy through renewable sources. Followed by the lack of investment in the development of renewable energy, the government of ASEAN-6 still struggling to meet the target set of energy mix in the future. Deploying renewable energy is also crucial for producing employment, reducing poverty, and promoting community well-being (Rehman et al., 2022). Planning for energy resources is crucial to economic growth

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and sustainable development because sustainable development relies on an appropriate energy supply.

IRF Analysis

The impulse response function exhibits different shocks on each variable over time. Given the study's focus, the impulse response function for the reaction of urbanization, industrialization, and GDP to renewable energy use is explored in turn. The reaction of renewable energy consumption to urbanization is a rise curve but stable. In response to a shock in industrialization, renewable energy usage shows fluctuate curve rising in the initial period and slowly declines and stabilizes over time. Furthermore, renewable energy use reacting to an economic growth shock indicates a growing trend. With a shock in 2, 3 and period 5 yet continue by a stable and slow growing till the end of period.

FEVD Analysis

Variance decomposition indicates the proportion of the variation in the dependent variable explained by the independent factors over time, revealing the degree to which the independent variables explain the variability in the dependent variable. It calculates the degree of future uncertainty in a one-time series caused by random shocks to each other endogenous variable. It assesses the relative significance of each random shock. The results for 10-year forecast horizon, the renewable energy consumption is affecting by 4.55 impact from urbanization, 0.87 impact from industrialization and 6.14 contribution from economic growth (GDP). It can be observed that urbanization and GDP shock account for a large portion of the future uncertainty in renewable energy consumption.

CONCLUSION AND SUGGESTION

The study analyzed the effect of urbanization, industrialization, and economic growth on renewable energy consumption in ASEAN-6 from 1994-2020. The results showed that the existence of energy subsidies is one of the challenges for utilization of renewable energy. Also, the high cost, and lack of awareness and public support may influence the reducing of renewable energy consumption. While the industrialization's dependence on non-renewable energy sources, followed by unstable price of oil and gas will shift the industry sector in deploying the renewable energy for their energy supply in the future. As the business commitment in adopting low-carbon sources encourage government to further regulate this sector. Further, the lack of government support in providing the affordable clean energy as the result of current uneven policy and

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insufficient investment to the advancement renewable energy in ASEAN-6 still dominant for its economy.

The government should utilize the renewable energy to increase the mix of energy in the future. It is also suggested to promote the sustainable renewable energy development, so that dominate the household consumption and industry sector as the main contributor in energy use. In addition, the deployment of renewable energy can attract global investment that led to the high infrastructure and technology capabilities in green energy sector.

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